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:

- AQUAREHAB's Second Open End-User Meeting will take place 18 January 2011 in Copenhagen (Denmark).
- AQUAREHAB results will be presented at: European Geosciences Union, General Assembly 2011 (Vienna, Austria 03 – 08 April 2011)

Coordinating institution:
VITO NV
Boeretang 200
B-2400 Mol
Belgium
www.vito.be

Coordinating team:
Dr. Ir. Leen Bastiaens
Dr. Ir. Piet Seuntjens
Dr. Paul Campling
Dr. Ir. Winnie Dejonghe
email: ip.coordinators@vito.be

AQUAREHAB
http://aquarehab.vito.be

Introduction

The AQUAREHAB project has now been operating for 18 months. Since the Second General Meeting at UNESCO (Delft, the Netherlands) in January 2010, we have been working further on technology and modelling developments, and we are preparing now for the Second Open End User Workshop (18th January 2011) and the Third General Meeting (19th – 20th January 2011) with all partners at the Geological Survey of Denmark and Greenland (GEUS) (Copenhagen, Denmark).

In this Newsletter we provide news on the technology and modeling developments from Work Package 1 - Development of Activated Riparian Zones for mitigating pesticide and nitrate diffuse pollution into surface water and Work Package 5 - Remediation of groundwater with injectable Fe-based materials. In addition we provide information concerning the agenda of the forthcoming Second Open End User Workshop at GEUS.

Technology and modelling developments

Development of Activated Riparian Zones for mitigating pesticide and nitrate diffuse pollution into surface water (AQUAREHAB WP1)

The installation of wetlands in the riparian zone is considered as a very promising approach for mitigating the diffuse pollution of agricultural pollutants. The re-establishment of wetlands has been used in many countries as a restoration technology to reduce the load of nitrates to rivers and lakes. Recent work indicates that wetlands might also be successful in lowering the transport of pesticide residues but most work has been done with strongly sorbing pesticides. There is also not much information on the importance of deep subsurface flow on the global effectiveness of the system and on the robustness and resilience of such systems as a response to naturally occurring season-bound temporal environmental changes, both for nitrate and pesticide removal. In this part of the AQUAREHAB project, we study and quantify how wetland zones mitigate pesticide and nitrate diffuse pollution into surface water and how this can be possibly activated and maximized. The processes contributing to nitrate and pesticide removal in wetlands are therefore being studied at the field and at lab scale and these data are being used for modelling the fate of nitrate and pesticides in wetland riparian zones. The Odense River Basin District (Denmark) was selected as the field site study area since several wetlands have been recently re-established in that area and a comprehensive amount of physico-chemical data related to wetland restoration is available.

Figure 1: Aerial view of a part of the Odense River Basin in Denmark

The research work is performed by five Institutes. The Geological Survey of Denmark and Greenland, Denmark **(GEUS)** and the University of Copenhagen, Denmark **(UCPH)** are carrying out the hydrological and geophysical characterization as well as the field-monitoring of the selected field study site in the Odense River Basin. The Environmental Institute, Slovak Republic **(EI)** is surveying the ecological status of the river basin as a response to wetland restoration. The Catholic University of Leuven, Belgium **(KULeuven)** and the CTM Centre Tecnologic, Spain **(CTM)** are focusing on the understanding of the processes involved in the removal of pesticides and nitrates in wetlands and the effect of season-bound changes on wetland pollutant removal activity, respectively, through dedicated lab work. **UCPH** is responsible for developing models which describe and predict the fate of nitrate and pesticides in wetlands using the selected field sites as model systems.

Currently two wetland field sites have been selected. The “Brynemade” site, as a model of a well-established wetland, has been largely characterized regarding geology, geochemistry and geophysics. The “Skallebanke” site is a freshly restored wetland and the site has only recently been equipped for field monitoring. Two ecological surveys of the study area have taken place. In the laboratory, work has concentrated on batch, continuous column and other dynamic experiments to mimic the vertical and horizontal elimination of nitrates and pesticides in groundwater. The geochemical results at the “Brynemade” site, suggest the occurrence of an aerobic-denitrification-iron oxidation zonation as the ground water flows to the river. Field and lab work suggest the removal of nitrate in the “Brynemade” wetland in deeper layers. In addition, some pesticide degrading capacities were found at the site. The FeFlow pesticide transport model was implemented for predicting the fate of pesticides at the Brynemade site and using data from literature to feed the model. The model clearly demonstrates the effects of different fluxes (ground water discharge, infiltrating rainwater, floods from the river, and vertical leakage) on the transport of pesticides at the site. Feflow was also used to describe nitrate reactive

Figure 2: View on the “freshly” restored “Skallebanke” wetland field site (Summer 2010)

Figure 3: Monitoring groundwater at Brynemade field site

transport at the “Brynemade” site based on literature data regarding denitrification rates. The model was calibrated to the groundwater nitrate concentrations observed in the field. The model shows that the nitrate plume moves through the aerobic zone and that high denitrification rates in the anaerobic zone, ensure rapid nitrate removal.

In the coming year we expect to acquire more information on the transport of nitrate and pesticides in wetlands and on the processes involved in their removal. In addition, we expect detailed information on the effect of season bound environmental changes, such as drought and freezing temperatures on pesticide and nitrate removal. The expected outcome of the research performed in this WP will be (i) improved models that predict the overall effectiveness of a wetland in removing pollutants taking into account possible effects of seasonal disturbances and (ii) improved guidelines for wetland restoration aiming at optimal pollutant removal. End-users interested in our work include especially policy-making entities and drinking water production companies.

Remediation of groundwater with injectable Fe-based materials (AQUAREHAB WP5)

Zerovalent iron fillings are being used throughout the western hemisphere for in situ remediation of groundwater containing chlorinated compounds. Granular particles (millimeter size) have been used mostly and are installed in Permeable Reactive Barriers (PRBs) where soil material has to be excavated and replaced by the reactive particles. PRBs are

relatively cheap in operation, but they require a substantial initial investment and their use is restricted to contaminated zones in the upper reaches of an aquifer that are accessible from the surface. However, the technology has proven to be cost-effective in the longer term for several cases.

Figure 4: Advantages and disadvantages of different iron particles

Small sized reactive particles (nano and lower micro scale) can be injected in the subsurface, creating reactive zones) and can have a number of advantages compared to granular ones. As for injectable small sized reactive particles no excavation is required, their application is as such less invasive and potentially economically more attractive. In addition, smaller particles have higher specific surface areas and are more reactive. Not only higher degradation rates are measured, but also a wider range of pollutants can be abated. On the other hand, smaller sized particles themselves are more costly and have a shorter life time.

The general objective of AQUAREHAB WP5, is to focus on the effectiveness and socio-economical acceptance of in-situ remediation technologies based on injection of small sized reactive particles.. We would like to answer the following questions: what are the requirements for Fe-based reactive particles? under which conditions is the technology efficient? can the distribution of particles in the subsurface be detected? what is the impact of the small particles on the environment? The particles that are considered comprise on the one hand reducing particles (zerovalent iron and iron sulphides) for abiotic destruction of chlorinated compounds, where nano-scale particles are compared with micro-scale particles. The latter may be less reactive than nano scale particles, but are cheaper, more stable and have a longer life time. On the other hand, Fe-oxides are considered suitable for stimulating the biodegradation of mono-aromatic oil compounds like toluene.

In a first stage, several nano and micro-scale particles have been tested at lab scale tests to deduce parameters controlling reactivity of the particles towards pollutants as well as the mobility of the particles in the subsurface. Nanoparticles showed to be the most reactive and mobile, but are less stable and have a shorter life time. However, lower micrometer scale particle were also found to be very reactive and were shown to be mobile when using a stabilizer during injection.

At t = 200 s, tracer (uranine, green) precedes iron (black)

At t = 6300 s, iron distribution quasi static

Figure 5: Movement of nano-iron particles in a radial flow field - while iron is "retarded" appreciable distances may be achieved during injection

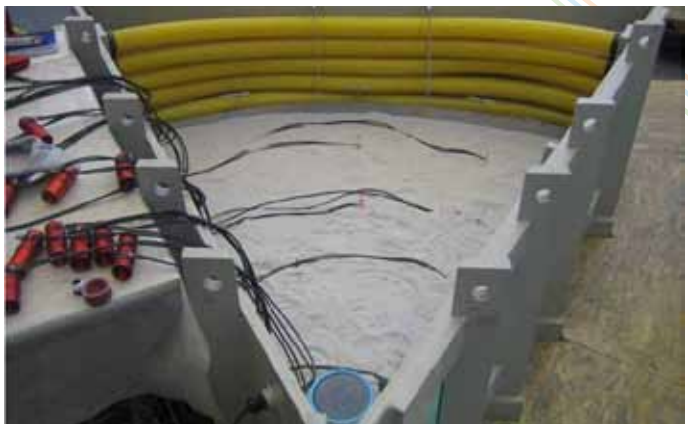

Figure 6: Triangular container for the positioning of sensors in the "field" to detect Fe-based reactive materials

Future research will focus on the potential and cost-effectiveness of a number of selected zerovalent irons (nano & lower micro scale) and Fe-oxides for in-situ treatment of pollutants.

An innovative technique to monitor the fine Fe-based materials in the subsurface after injection is under development. It will allow us to study and improve the travel distance (radius of influence) of the injected particles in the subsurface. The technique has been proven effective at lab-scale and is being adapted for in-situ field measurements. In the coming year tests at pilot scale in the lab and in the field are foreseen.

In parallel to the laboratory work, a field scale test in being prepared; A test site in Belgium has been selected and characterised; The design of the pilot test is ongoing and the injection is foreseen for the second half of 2011. We expect that the outcome of our work after 3.5 years should give a more in-depth view on the possibilities and limitations that are associated with the AQUAREHAB remediation technology.

Recent papers

Buchau, A., Rucker, W., De Boer, C.V., and Klaas, N. (2010). Inductive detection and concentration measurement of nano sized zero valent iron in the subsurface, IET Science, Measurement & Technology, Volume: 4 Issue: 6 Pages: 289-297.

Presentations

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

- PRB-RZ-2010 (Antwerp, organised by VITO, 6-7 July 2010) www.vito.be/english/
- CONSOIL-2010 (Salzburg, 22-24 September 2010) www.consoil.olanis.de

AQUAREHAB meetings

AQUAREHAB's Third General Meeting

The AQUAREHAB project will be having its Third General Meeting at the Geological Survey of Denmark and Greenland (GEUS) in Copenhagen, Denmark on 19th to 20th January, 2011. The meeting is an opportunity to discuss the progress of the Project in its second year, present the results achieved in 2010, and have detailed Work Package meetings to define the tasks and deliverables for the next 6 to 12 months. Other issues such as how the work of the project is being disseminated and the involvement of end users will also discussed. The next AQUAREHAB General Meeting will be held in Barcelona (Spain) in 2012.

AQUAREHAB's Open Second End User Meeting

This meeting will of particular interest to experts, managers, and consultants involved in developing rehabilitation technologies and water management support systems. On the one hand innovative in situ remediation technologies will be demonstrated to technology providers. On the other hand, tools to integrate the remediation technologies in catchment water management will be emphasized. The meeting will comprise of AQUAREHAB flash presentations and a dedicated stakeholder session where different stakeholders will give their requirements towards the project. In addition there will also be a poster session to provide an overview of particular case studies and research developments.

The programme can be downloaded at the AQUAREHAB website: http://aquarehab.vito.be/home/Documents/FLyer%20copenhagen%202011v2_website.pdf

AQUAREHAB in a nutshell

AQUAREHAB is a large scale Integrated Project with 19 partners that is largely being funded by the European Union (Framework Programme 7). The project is being coordinated by VITO. It started 1st May 2009 and will finish at the end of 2013. Within this project, different innovative rehabilitation technologies for soil, groundwater and surface water are being 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.