AQUAREHAB

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

NEWSLETTER JULY 2012

Topics

Announcement:
Collaboration with the FP7 STREAM project resulted in an illustrative **AQUAREHAB video**

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

AQUAREHAB has now been running for 3 years, having had its Kick-Off Meeting in May 2009. Since the Fourth General Meeting, which was held in the Helmholtz Zentrum in Munich (23-24 November 2011), we have concentrated on continuing the round up of the Technology and Modelling Developments Work Packages and the development of the Generic Guidelines. In addition, the work to extrapolate the developments of AQUAREHAB to other areas (Work Package 8) has also started in earnest this will fully reported in the next Newsletter. We are now in full swing to prepare for the External Workshop that will be held in Barcelona 25th and 26th September 2012.

In this Newsletter we provide news on the technology and modelling developments from Work Package 7 - Development of models to connect technologies to water management tool and Work Package 6 - Integration of remedial actions into river basin management. In addition, we provide information concerning the outcome of the Fourth General Meeting and the preparations for upcoming External Workshop.

Technology and modelling developments

Development of models to connect ground water remediation technologies to a water management tool (AQUAREHAB WP7)

The implementation of in-situ groundwater remediation technology requires substantial knowledge of the behaviour of the groundwater system and its interaction with the technology. In this workpackage AQUAREHAB is aiming to use a common modelling strategy to evaluate the effectiveness of the technologies and to link the various rehabilitation technologies with the river basin management tool (WP6). The work package is an important cornerstone between the technological developments at the local scale and the management tool at the river basin scale.

Examples of the modelled technologies are reactive barriers, reactive zones at the interaction zone between groundwater and rivers, the use of wetlands, and specific carrier materials with enhanced degradation potential. The research work is being carried out by 6 research institutes. The work is being led by the Flemish Institute for Technological Research (VITO) – the Environmental Modelling Unit, which is responsible for developing the framework for implementation of technologies in river basin management models. The University of Copenhagen (UCPH) is developing a reactive transport model for nitrate and pesticide removal in riparian zones and wetlands, for a section of the Odense River. Ben Gurion University of the Negev (GBU) is developing a model

that identifies the hydraulic parameters and predicts the groundwater fluxes for a complex, arid, and karstic region downstream from a heavilily polluting industrial site. The University of Sheffied (USFD) is developing an approach to model the pollutant flux reduction due to mitigation technologies, such as sediment capping and anaerobic bioreactive zones, to protect rivers from shallow groundwater pollution plumes.The Technische Universiteit Delft (TUD) is developing a modelling approach to assess the short and long term impact of in-site measures such as permeable reactive barriers and injecting Fe-based materials to reduce groundwater contamination. The UNESCO-IHEInstitute for Water Education (IHE) is responsible for incorporating reduced technology models into river basin management models, thereby assuring the link between the work carried out in Workpackages 7 and 6.

During the project, a consistent framework for model development and testing has been used (Figure 1). In a first stage, model reaction networks were setup and tested using dedicated laboratory experiments that allowed to discern reaction processes in the groundwater and to determine the dominant (or most sensitive) parameters.

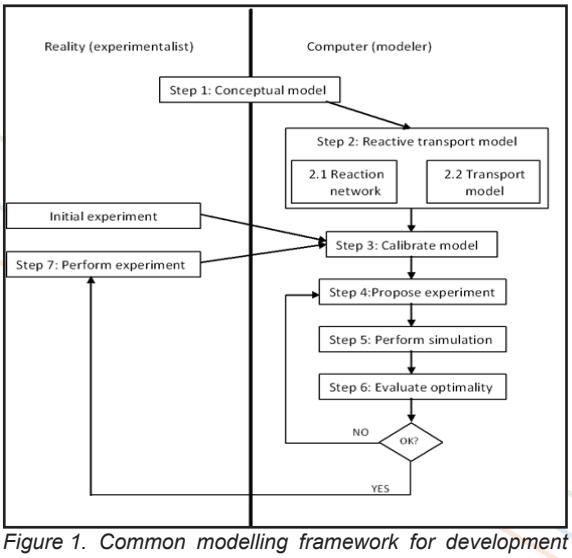

Figure 1. Common modelling framework for development and testing of technology models

Subsequently, the developed models are being evaluated using monitored field data from various project sites, including; a wetland receiving water that has passed through agricultural soils containing nitrates in the Odense catchment (DK), a drained area in an industrial site contaminated with a mixture of pollutants in the Sechor Besor basin (IL), a CAH contaminated groundwater-surface water interaction zone in the Zenne subbasin (BE) and a CAH contaminated site treated with a Fe-PRB in Antwerp (BE). The models being thoroughly evaluated through laboratory and field experiments (Figure 2) are now at a stage where they can be used to simulate the effects of management scenarios at the regional or river basin scale.

The expected outcome of this work package will be that AQUAREHAB technology models will improve our understanding of innovative groundwater remediation technologies and bridge the gap between technology development and implementation and management in the field.

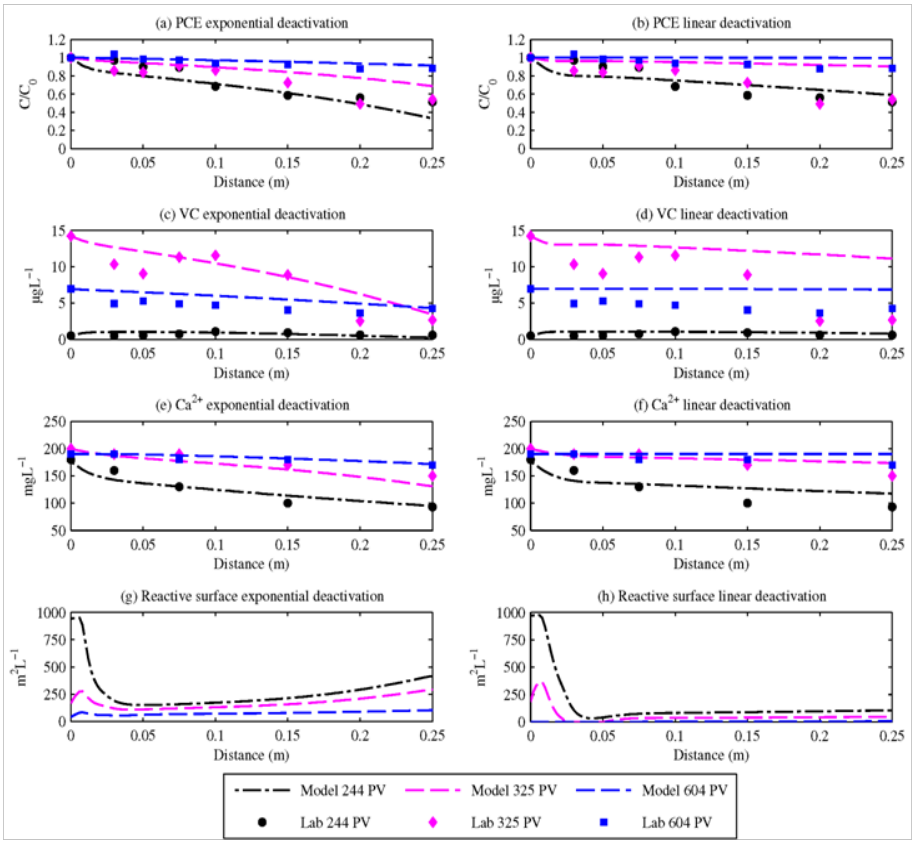

Figure 2. Evaluation of groundwater plume migration at a CAH contaminated site

Integration of remedial actions into river basin management (AQUAREHAB WP6)

In this workpackage AQUAREHAB is aiming to develop a collaborative management tool 'DSS REACH-ER' that can be used by stakeholders, decision makers and water managers to evaluate the ecological and economical effects of different remedial actions on river basins. The work has been broken down into four major tasks: the development of fate models to integrate the fluxes of chemicals at the river basin scale; an assessment of the ecological effects of chemicals in river basins; an economic analysis of the rehabilitation technologies (costs and benefits); and the integration of fate, effects assessment and economic analysis tools into a collaborative management tool or DSS REACH-ER.

The research work is performed by five Institutes. The UNESCO-IHE Institute for Water Education (IHE), is leading the work package and is responsible for development of the fate modelling tools in the Odense River Pilot Area, and the development and operation of the the DSS REACHER tool. The Flemish Institute for Technological Research (VITO) is developing fate modelling tools in the

Scheldt River Pilot Area and is providing input for assessing the cost-effectiveness of AQUAREHAB technologies. The Masarykova Univerzita (MU) is responsible for assessing the eco-toxicological effects of chemicals in selected parts of the Odense and Scheldt River Pilot Areas, with the Environmental Institute (EI), carrying out complementary water quality monitoring work. The Institut National de l'Environnement Industriel et des Risques (INERIS) is responsible for assessing the cost-effectiveness of AQUAREHAB techonolgies. This is clearly a multi-disciplinary workpackage involving hydrologists, eco-toxicologists, economists and software developers to develop a management tool that can assist water managers.

Fate Models

A great deal of effort has been put into the development of fate models for the Odense and Scheldt River Pilot Areas. A SWAT simulation framework was developed for the Odense river basin to simulate the hydrological behaviour and nitrogen transport and transformation. The performance of the SWAT model was then compared to existing DAISY-MIKE SHE (DMS) simulation results for streamflow and nitrate fluxes, especially regarding the performance of the subsurface tile drain components used in the two models. The results show that SWAT accurately predicted flow for both daily and monthly time steps while the simulations of nitrate fluxes were more accurate at a monthly time step. In comparison to the DMS model which takes into account the uncertainty of soil hydraulic and slurry parameters, SWAT results for both flow and nitrate fit well within the range of DMS simulated values in high flow periods while they were slightly lower in low flow periods. In spite of the similarities of simulated flow and nitrate fluxes at the basin outlet, the two models predicted very different separations into flow components (overland flow, tile drainage and groundwater flow) as well as nitrate fluxes from flow components. It was concluded that the assessment on which model provides a better representation of the reality in terms of flow paths should not only be based on standard statistical metrics for the entire river basin, but needs to consider additional data, field experiments and opinions of field experts.

In the Scheldt River Pilot Area a fate model called SECOMSA (Spatially Explicit Conceptual Model for Scenario analysis), programmed in Python using PCRaster libraries, is developed to predict the fate of diffuse pollutants such as nitrogen and pesticides at the river basin scale with a spatial resolution of 1 km2 and a temporal resolution of 1 month (Figure 3). A separate fate model for contaminated sites, called COMFRACS (COnceptual Model FRAmework for a regional assessment of Contaminated Sites), is developed to assess the effects of regionally distributed contaminated sites on groundwater quality at the groundwater body scale. The model is demonstrated for chlorinated aliphatic hydrocarbons (CAH) for a 1 km grid.

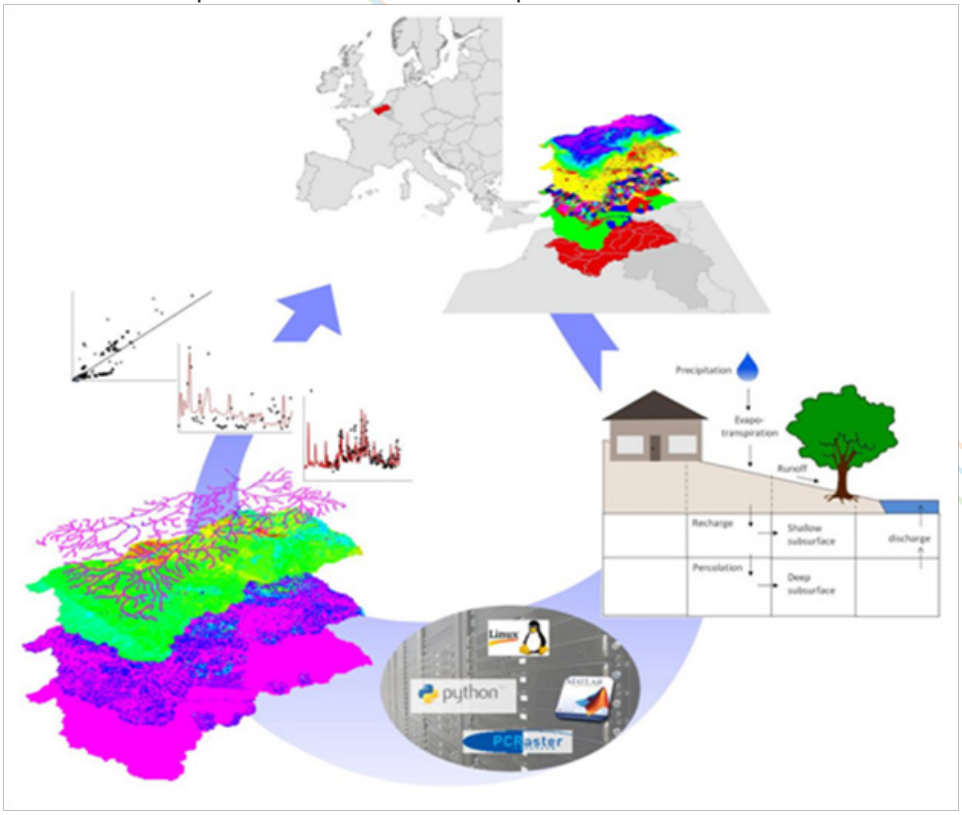

Figure 3. General modelling framework of SECOMSA

The fate models will serve as management tools for water managers to understand better the likely outcome of adopted measures to reduce diffuse pollution from nitrates and pesticides, and also to run scenarios for the DSS-REACHER tool, so that the short and long impact of different measures can be assessed.

Ecological Effects

In terms of assessing the eco-toxicological effect of chemicals in rivers new approaches have been developed to provide better information with respect to (a) sensitivity of individual species towards specific chemical contamination and (b) recovery potential of respective species. Both are included in the SPEAR concept (SPEcies at Risk - www.systemecology.eu/SPEAR), which is currently being validated within AQUAREHAB.

Economic analysis

The economic analysis in AQUAREHAB focuses on the cost of effectives of technologies developed during the project. The main achievements so far have been the collection of data on substances and associated conventional remediation measures. Technico-economic data have been collected for: Isoproturon, Nonylphenol, DEHP, Simazine, Trichloroéthylène, Benzene and Toluene. It is expected that the economic analysis will contribute specifically to helping practitioners or water managers to select or promote suitable technologies.

Management tool

The development of the DSS REACHER has followed two major lines: 1. a light-weight, probabilistic alternative to complicated, process-based fate models, based on the Bayesian Belief Network (BBN) approach. This approach repre-

sents model results in a comprehensive and probabilistic way without having the same (high) computing demand of many process-based models, and can therefore be used as a management tool. 2. A WEB-based front end version of REACHER that can be used to present scenario-based model results and interact with stakeholders, so as to build and analyse scenarios with different rehabilitation measures. This is an on-going process in AQUAREHAB involving active collaborations with other partners of the project.

Conclusions

Key issues of this work package are therefore developing a better understanding of the issues around subbasin and river basin scale, and how a body of groundwater (incl. drinking water abstraction areas) can be adversely affected by contaminated industrial sites. Another key issue is the development of tools to assess Environmental Quality Standards (EQS) and Ecotoxicological Standards (ETS) for water bodies that are in danger of being contaminated by priority substances (PS). Finally we need to be able to implement cost-effective measures – which means assessing the cost and the effect of certain technologies.

AQUAREHAB meetings

AQUAREHAB's Fourth General Meeting

The Fourth General Meeting was held at the Helmholtz Zentrum in Munich (23-24 November 2011). The two day meeting gave the participants the opportunity to discuss the progress of the Project in its third year, present the results achieved in 2011. Key issues were the interaction between the different parts of AQUAREHAB and the finalisation of the preparations for the work to extend the project to other regions in Europe.

AQUAREHAB's External Conference in Barcelona

The AQUAREHAB Conference is happening on 25-26th September 2012 in Barcelona, Spain, and is titled: a European Symposium – **Remediation Technologies and their Integration in Water Management**. The symposium is being organised jointly by the FP7 project AQUAREHAB , FP7 project UPSOIL and PRB/RZ-2012. The purpose is to bring together pioneers and experts from all over the world to exchange information and new experiences. AQUAREHAB results will be presented via platform and poster presentations by different partners. In addition, a separate AQUAREHAB session will be organised where the work will be presented in a more general way, focussing on links between the different parts and interactions with potential end-users.

AQUAREHAB in a nutshell

AQUAREHAB is an EU financed large scale 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.

Papers & Presentations

Papers

- Bosch, J., Lee, K.Y., Jordan, G., Kim, K.-W. and Meckenstock, R. (2012). Anaerobic, nitrate-dependent oxidation of pyrite nanoparticles by Thiobacillus denitrificans. Environmental Science & Technology 46, 2095-2101.
- Braunschweig, J., Bosch, J., Heister, H., Kuebeck, C. and Meckenstock, R. (2012). Reevaluation of colorimetric iron determination methods commonly used in geomicrobiology. Journal of Microbiological Methods 89, 41-48.
- Comba, S. and J. Braun (2012). An empirical model to predict the distribution of iron micro-particles around an injection well in a sandy aquifer. Journal of Contaminant Hydrology, Volume 132.
- Fritzsche, A., Bosch, J., Rennert, T., Heister, K., Braunschweig, J., Meckenstock, R.U. and Totsche, K.U. (2012). Fast microbial reduction of ferrihydrite colloids from a soil effluent. Geochimica et Cosmochimica Acta 77, 444-456
- Lee, K.-Y., Bosch, J. and Meckenstock, R. (2012). Use of metal-reducing bacteria for bioremediation of soil contaminated with mixed organic and inorganic pollutants. Environmental Geochemistry and Health 34, 135-142
- Mueller, N. C.; Braun, J.; Bruns, J.; Černík, M.; Rissing, P.; Rickerby, D. and Nowack, B. (2011): Application of nanoscale zero valent iron (NZVI) for groundwater remediation in Europe. Environmental Science and Pollution Research.
- Tosco T., Bosch J., Meckenstock R., Sethi R. (2012). Transport of ferrihydrite nanoparticles in saturated porous media: role of ionic strength and flow rate. Environmental Science & Technology, 46 (7), pp 4008–4015, DOI: 10.1021/es202643c.

Presentations

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

- 8th International Conference on Remediation of Chlorinated and Recalcitrant Compounds, 21-24 May, 2012, Monterey, California.
- Pollutant biodegradation under environmental stress: towards rational bioaugmentation, 29-30 March, 2012, Amsterdam.
- European Geosciences Union General Assembly 2012, Vienna, Austria, 22-27 April, 2012.

Edition July 2012