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Project no.: 511254 (STREP)

Acronym: SEDBARCAH

Project title: SEDiment BioBARriers for Chlorinated Aliphatic Hydrocarbons in groundwater reaching surface water

Instrument type: Specific Targeted Research Project (STREP)

Priority name: STREP

D28: Publishable project summary

Due date of deliverable: Month 0

Actual submission date: 03/03/2005

Start date of project: 01/01/2005 **Duration: 2 years**

Organisation name of lead contractor for this deliverable: VITO

D28 contains a publishable project summary and the information published on the EUGRIS web site.

Publishable project summary

Polluted groundwater in urban and industrial areas often represents a continuous source of (diffuse) contamination of surface waters. However, the fate of infiltrating groundwater pollutants might be influenced by the sediment in eutrophic water bodies. Such sediments form an interface between groundwater and surface water and possesses characteristic biological and physico-chemical degradation properties. Knowledge on natural attenuation of passing pollutants and the potential to stimulate and sustain occurring degradation processes are however scarce or non-existent. This is especially due to the lack of appropriate monitoring devices and tools to measure *in situ* mass balances of pollutants and reactants. In the SEDBARCAH project, we want to investigate the boundaries of the sediment zone as a barrier against the infiltration of chlorinated aliphatic hydrocarbons (CAH) into surface water and how we can turn this zone into a sustainable and efficient (stimulated) biobarrier technology for protection of surface waters from groundwater contamination. We will (i) determine the role of the microbial community present in sediments in the biodegradation of groundwater pollutants infiltrating a river bed; (ii) explore the boundary conditions and the possibility to increase and sustain removal activities in the sediment zone and (iii) select tools to follow such removal activities *in situ*. Therefore a thorough investigation both in the field and in the laboratory of the physico-chemical and microbial processes occurring in these sediments will be performed and coupled to the CAH-degradation potential present in the sediment interface of two selected contaminated areas. In addition, methodologies to increase this degradation will be examined. The final goal of SEDBARCAH is to investigate the potentials of these (stimulated) sediment biobarriers as a groundwater remediation technology and a surface water pollution and risk prevention technology.

Information published on the EUGRIS website (http://www.eugris.info/Projects.asp?eugrisid=85&Category=Content_Digests&Title=Sediments&showform=None&ContentID=85&CountryID=0):

SEDBARCAH SEDIMENT BIOBARRIERS FOR CHLORINATED ALIPHATIC HYDROCARBONS IN GROUNDWATER REACHING SURFACE WATER

Country: Belgium

Duration: 24 months

Contract Number: 511254

Main Program: EC Framework 6 Programme

Main Program Link: http://fp6.cordis.lu/fp6/call_details.cfm?CALL_ID=78

Project Type: RTD

Stakeholder Type: Local or regional authorities and agencies

Project Abstract:

Polluted groundwater in urban and industrial areas often represents a continuous source of (diffuse) contamination of surface waters. However, the fate of infiltrating groundwater pollutants might be influenced by the sediment in eutrophic water bodies. Such sediments form an interface between groundwater and surface water and possesses characteristic biological and physico-chemical degradation properties. Knowledge on natural attenuation of passing pollutants and the potential to stimulate and sustain occurring degradation processes are however scarce or non-existent. This is especially due to the lack of appropriate monitoring devices and tools to measure in situ mass balances of pollutants and reactants. In the SEDBARCAH project, we want to investigate the boundaries of the sediment zone as a barrier against the infiltration of chlorinated aliphatic hydrocarbons (CAH) into surface water and how we can turn this zone into a sustainable and efficient (stimulated) biobarrier technology for protection of surface waters from groundwater contamination. We will (i) determine the role of the microbial community present in sediments in the biodegradation of groundwater pollutants infiltrating a river bed; (ii) explore the boundary conditions and the possibility to increase and sustain removal activities in the sediment zone and (iii) select tools to follow such removal activities in situ. Therefore a thorough investigation both in the field and in the laboratory of the physico-chemical and microbial processes occurring in these sediments will be performed and coupled to the CAH-degradation potential present in the sediment interface of two selected contaminated areas. In addition, methodologies to increase this degradation will be examined. The final goal of SEDBARCAH is to investigate the potentials of these (stimulated) sediment biobarriers as a groundwater remediation technology and a surface water pollution and risk prevention technology.

Project Project Summary:

In the SEDBARCAH-project we want to investigate the boundaries of the sediment zone as a barrier against the infiltration of chlorinated aliphatic compounds (CAHs) from the groundwater into the surface water and how we can turn this into a sustainable and efficient biobarrier technology for protection of surface waters from groundwater contamination. Therefore a thorough investigation of the physico-chemical and microbial processes occurring in these sediments will be performed and coupled to the CAH-degradation potential present in these sediments. Hence, the project should comprise a description of the physico-chemistry of the aquifer/sediment/river water compartments at the model sites and its dynamics including description of (i) the relationship between compartment physico-chemistry, their dynamics and fate of CAH and (ii) evaluation of the potential of in situ degradation of CAHs infiltrating into the river bed via the groundwater by sediment microbial communities. Therefore, physico-chemical parameters will be determined by different measuring devices. In addition, a relationship between these physico-chemical dynamics and the microbial community dynamics will be determined. This will be done by studying the dynamics of the "active" microbial community and "active" catabolic gene composition at different depths of sediment samples both obtained in situ or studied in batch and column experiments. Additional information will be obtained from the isolation, identification, and physiological characterization of bacteria from these CAH contaminated sediments. In addition, strategies to increase the degradation potential in the groundwater-sediment-surface water interface will be tested on these isolated bacteria and in batch and column tests. Finally, all the obtained data will be used in a modelling tool for the investigation of natural barriers describing the relevant bio-chemical processes. This will result in a guideline to measure, describe and stimulate natural attenuation processes present in the sediment zone of a surface water body receiving contaminated groundwater. In this guideline the comments and recommendations of the Flemish and Czech environmental authorities about the use of the stimulated biobarrier technology as a remediation technology will also be integrated.

Achieved Objectives:

The SEDBARCAH project will (i) determine the role of the microbial community present in sediments in the biodegradation of groundwater pollutants infiltrating a river bed; (ii) explore the boundary conditions and the possibility to increase and sustain removal activities in the sediment zone and (iii) select tools to follow such removal activities in situ. The project will focus on degradation of chlorinated aliphatic hydrocarbons (CAH) and will investigate the Zenne river in Belgium and a river in Czech Republic.

The main objectives of the SEDBARCAH project are:

- To set up a monitoring campaign with a duration of 18 months of the in situ physico-chemistry of relevant compartments (aquifer, sediment, river stream) at the studied sites in Belgium and Czech Republic. Water and core samples will be analyzed on a regular base during an 18 months period in order to get a picture of the dynamics and seasonal variations of the different parameters in the different compartments of the two systems. Relationships between compartment physico-chemistry, its dynamics and fate of CAH will be explored. In addition, this data will indicate if biological removal of infiltrating CAH by sediment communities occurs. In addition, kinetic parameters to be used in the modelling of the in situ degradation potential will be obtained from these in situ measurements.

- To select the most appropriate sampling instruments to measure the physico-chemical parameters of the groundwater that passes through the sediments. These instruments (e.g. suction cups, multi-sensor probes, frozen undisturbed core samples, ...) will have to be able to measure the physicochemical parameters in the groundwater that is going in, going through and coming out of the sediments.
- To characterise the composition of the "active" sediment microbial community structure and of relevant "active" catabolic genotypes of the examined sites in space and time. Microbial community/catabolic gene expression dynamics will be determined by different molecular techniques ((RT)-PCR-DGGE, real time PCR, FISH and DNA array), on both the DNA or RNA level, in sediment samples. In addition, additional data will be available indicating whether or not biological removal of infiltrating CAHs by sediment communities occurs based on quantitative detection of expressed catabolic genes.
- To characterize the degradation potential of infiltrated pollutants in the sediment zone by means of batch and continuous column experiments. The degradation of CAHs in batch and column set-ups will be studied using sediment material obtained from locations receiving and not receiving input of contaminated groundwater at the test sites. The structure and the catabolic activity of the (active) microbial community will be determined. Congruency between "active" microbial community composition of field and microcosm samples might further indicate the existence of similar activities in the field. This will allow to validate the microcosm system as a tool to study the degradation potentials of the sediments in the future. In addition, kinetic parameters to be used in the modelling of the in situ degradation potential will be obtained from these batch and column degradation experiments.
- To isolate, identify and physiologically characterize CAH-degrading/dechlorinating organisms and halo-respirers from the river sediments. Microbial populations able to degrade/dechlorinate CAH in the sediments will be isolated by enrichment from well-performing batch and column set-ups. The CAH degradation rates of the cultures will be examined under different environmentally relevant conditions in order to get knowledge on the influence of these parameters on degradation rates.
- To explore in batch and column set-up the possibility to increase sediment CAH degradation kinetics by various amendments (nutrients, electron-donors, electron-acceptors).
- To model the reactive transport of pollutants in CAH polluted and non-polluted aquifer/sediments/river water compartments. The developed model will comprise both biological degradation and a-biotic chemical reactions leading to the reduction of pollutants in the system of groundwater-sediment-surface water. Scope of the model is the dynamical simulation and forecast of the system consisting of several types of biocoenosis and sediment types in river beds.
- To develop guidelines on how to measure, describe and stimulate degradation of groundwater contaminants infiltrating the sediment zone.
- To examine the position of the Flemish and Czech environmental authorities towards the implementation of the stimulated biobarrier technology as a remediation technology.
- Dissemination of the obtained SEDBARCAH results to the scientific and industrial public.

Product Descriptions:

- Sampling instruments to measure the physico-chemical parameters of the groundwater that passes through the sediments.
- CAH-degrading bacteria that are partially physicochemically and genetically characterized.
- Guidelines on how to measure, describe and stimulate degradation of groundwater contaminants infiltrating the sediment zone.
- Scientific articles, reports and presentations.