INEOS ChlorVinyls

Tessenderlo, January 2014

Newsletter LIFE+ project '*LVM-BIOcells*' | 3

"Using Hydrogeobiocells (HGBcells) for the in-situ biological treatment of CAH contaminated groundwater in areas with low hydraulic gradients."

CONTENT

The LIFE+ project

Introduction

In December 2010 the first edition of this newsletter was published. The first newsletter gave an overview of the objectives of the LIFE+ project with information about the project organisation and a presentation of the project partners. Furthermore the activities of 2010 were described including the set-up and preparation of the first HGB cell. In the second edition of this newsletter the realisations between January 2011 and June 2012 were published: the results of the growth of the dechlorinating microbial culture (Multidechlorobac) and the installation and operation of the first HGB cell for biostimulation.

In this third edition you will read about our realisations between June 2012 and December 2013. Main topics are the results of the growth of the dechlorinating microbial culture (Multidechlorobac) on industrial scale and the monitoring of the activated HGB cell for biostimulation.

Summary project description

At the INEOS ChlorVinyls (ICV B) site a groundwater contamination with chlorinated aliphatic hydrocarbons (CAHs) is present. These compounds are very difficult to remediate because of their physical and chemical characteristics. In most cases traditional remediation techniques are often inadequate, time-consuming and expensive.

The project's objective is to demonstrate the applicability of a remediation technique using HGBcells (hydrogeobiocells) for the bioremediation of groundwater contaminated with CAHs at a site characterized by low natural groundwater flow velocities. Hereby a unique multispecies dechlorinating culture that degrades 12DCA as well as other CAHs is applied. In addition, its purpose is to develop an anaerobic bioreactor for the growth of bacteria on large scale at the ICV B-site. This bacteria can subsequently be injected in the HGBcells.

Overview realisations

▶ Successful growth of dechlorinating microbial culture

1. Fermentor (10L scale) and growth reactor (500 – 1000L scale)

The growth of the dechlorinating culture in an optimized medium was successfully realized on 10 L scale in a lab fermentor and on 500 L scale in an industrial reactor. The 10 L batch, as well as the 500 L batch had showed a very good dechlorinating capacity. Stable values of the physico-chemical parameters were obtained (pH and redox potential). Furthermore, molecular analyses showed high concentrations of dechlorinating bacteria.

The results of the chemical analyses during growth are given in Figure 1.

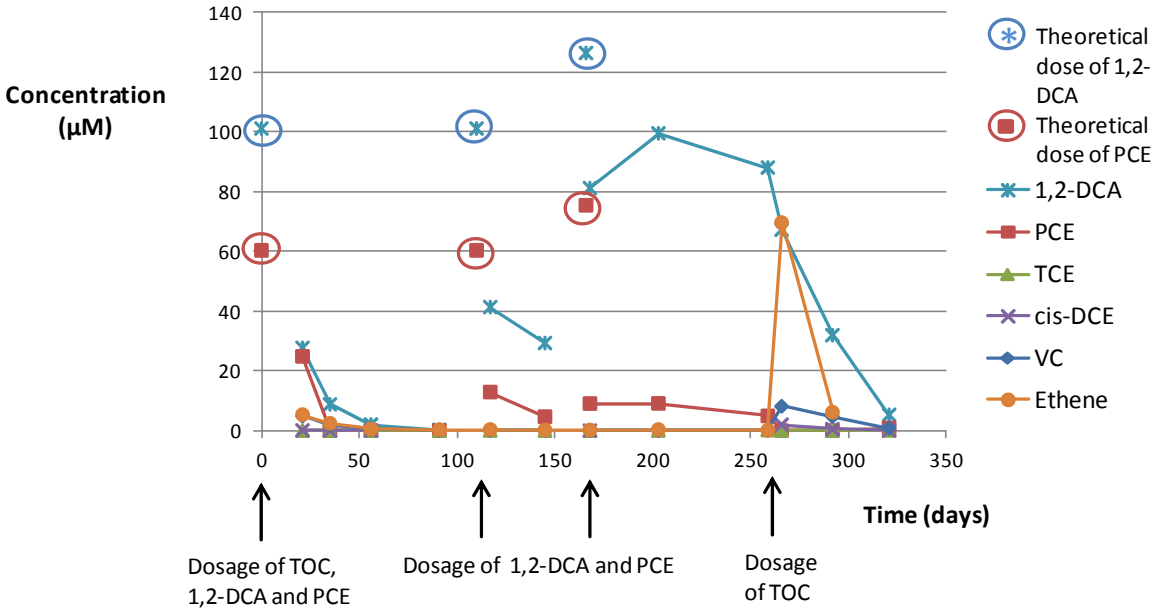

Figure 1 Theoretical additions and evolution of the measured concentrations of the different chlorinated compounds and ethene in the liquid phase of the bioreactor. TOC was dosed on day 0 and 259. 1,2-DCA and PCE were added on day 0, 110 and 166.

Three doses of CAH were added to the industrial reactor during the 11.5 months of follow-up. The chemical analyses indicated that the chlorinated compounds were effectively degraded in the bioreactor. After each dose, as expected, a significant decrease of the CAH concentrations was observed. Moreover, after 11.5 months, an increase of the concentration of the *Dehalococcoides,* as monitored by the 16S-rRNA gene density, was observed.

During the growth of the 500 L batch, Avecom performed regularly activity tests to investigate the dechlorinating capacity of the culture towards CAH.

The sample of Multidechlorobac taken after 11.5 months (end of production) showed no lag phase and a good degradation of 1,2-DCA and TCE (Figure 2). Moreover, no accumulation of VC was observed.

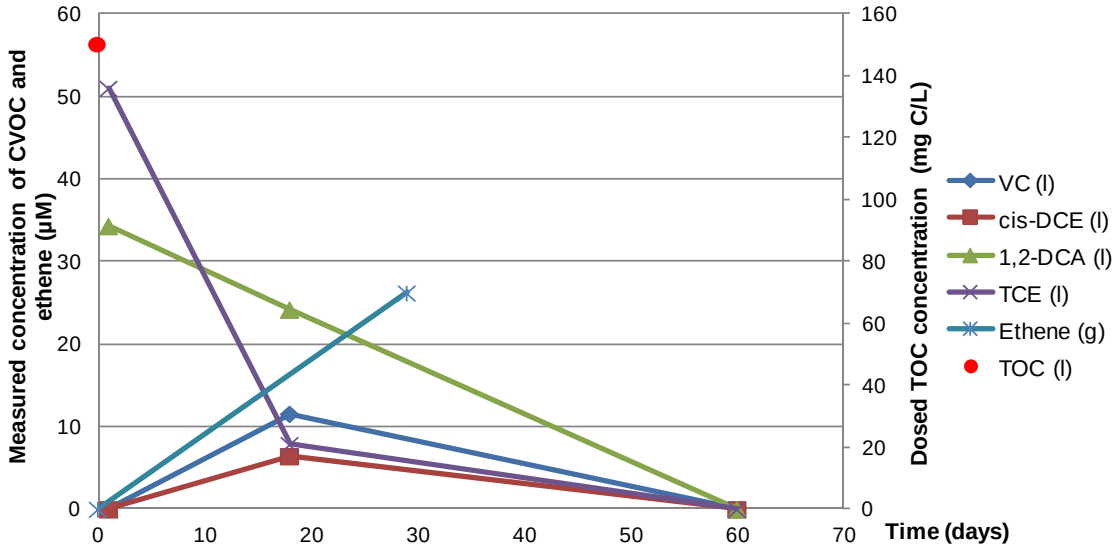

Figure 2 Results of the standard activity tests of the Multidechlorobac sample after 11.5 months of growth (l: liquid phase; g: gas phase)

These results confirmed that the culture had sufficiently grown in the industrial reactor and contained high concentrations of active dechlorinating bacteria after 11,5 months. These tests clearly demonstrated that the bacteria were sufficiently grown at the time the production was finished.

It was the first time that the growth of Multidechlorobac was realized at industrial scale. Initially, a relatively low growth rate was observed in the pilot reactor. Yet, the limiting factor could be identified (lack of electron donor H_2) and removed by an additional dosage of carbon source. The lack of H_2 resulted from the replenishment of the headspace of the industrial reactor, which did not occur for the growth on smaller scale. It is expected that future growths will take less than 11,5 months as additional dosages of carbon source can be foreseen in an earlier stage.

2. Growth of dechlorinating microbial culture with site-polluted groundwater

In view of an onsite reactor to grow the bacteria in groundwater, labscale feasibility tests were programmed in the project. Avecom performed a first series of preliminary tests to determine the feasibility of growing the culture with site-polluted groundwater. Those tests gave interesting findings concerning the needs of the microbial culture for growth in groundwater. Indeed, different nutrient requirements were identified for the 1,2-DCA-degrading bacteria and the bacteria that dechlorinate the chloroethenes. The results suggested that the latter was probably due to the activity of the sulphate reducing bacteria. Based on these results, the dosage of nutrients was selected to start a 1 L fed-batch reactor in which the culture is grown in groundwater. Currently,

this 1 L reactor is operated to determine predominant reactor characteristics, i.e. optimal residence time and frequency of nutrient dosage.

▶ Monitoring HGB cell biostimulation

The monitoring results of the HGB cell for biostimulation have shown that during the start-up phases not only favourable biodegradation conditions were created within the HGB cell, but also that 12DCA biodegradation along the expected degradation pathway was taking place. During the monitoring of the HGB cell in 2012 and 2013 the concentration levels for 12DCA in the monitoring wells dropped almost below detection level as well as the concentration of other CAH's. Moreover, this drop was accompanied with by a rise in ethylene concentration, the aimed degradation product. As a result, it can be concluded that the operation of the first activated HGB cell for biostimulation can be regarded as successful! In figure 3 the monitoring results of the CAH concentration in monitoring well LV102 are shown.

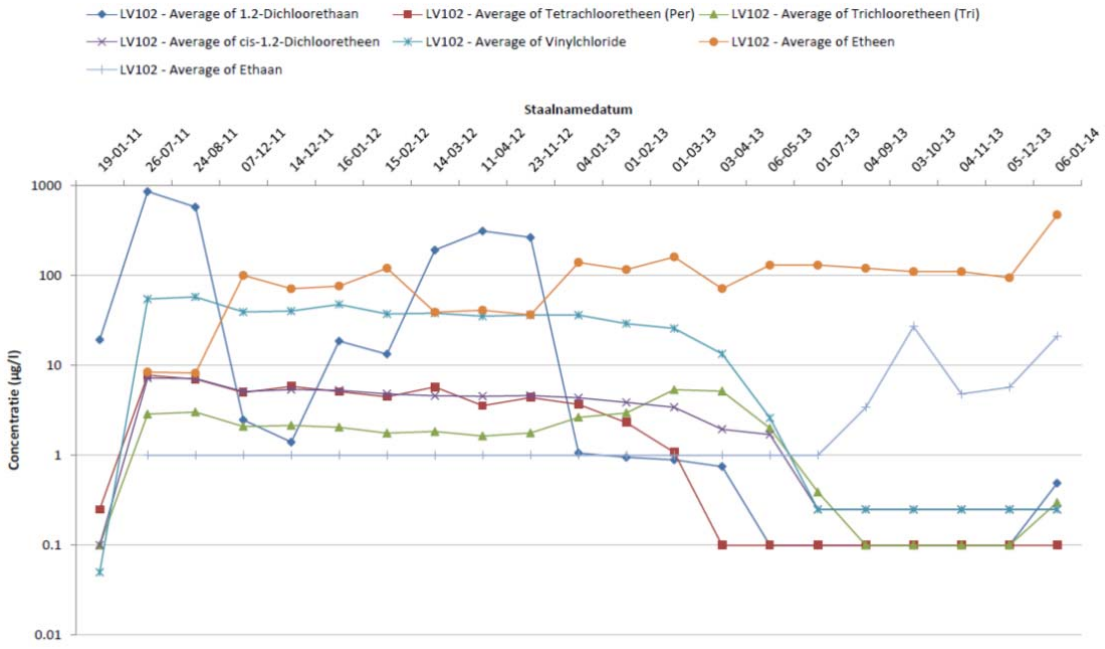

Figure 3 Monitoring CAH concentration in monitoring well LV102 (logarithmic scale)

In July 2013 the HGB cell halted due to pressure built-up in filter and injection wells. Analyses of sludge and observations during cleaning of the piping and wells of the HGB cell show that this last pressure built-up was only due to the accumulation of FeS. The formation of FeS is an integral part of the chemical reactions taking place in the aquifer within the radius of influence of the HGB cell. The sulphates present in the groundwater are reduced to sulphides which subsequently precipitate with Fe2+. This was the first time that the formation accumulation of FeS in the filters was observed. Before the start-up of the HGB cell in November 2013 the installation, pumping and injection wells were cleaned thoroughly. The HGB cell operates now at a flow rate of 18 m^3/h.

In the coming months more investigation will be done regarding the FeS issue.

▶ Groundwater model

As a first step in the modeling of the performance of an HGB cell, a detailed model has been constructed in 2013. Simulation runs have been done with HYDPARIDEN and MOCBAC3D software. The HYDPARIDEN software allows a simulation of the evolution of the hydraulic heads in the aquifer during the operation of a HGB cell (see figure 4). The MOCBAC3D software simulates a working HGB cell once an equilibrium situation in the aquifer has been reached and allows for the simulation of transport of a marker in the groundwater (see figure 5).

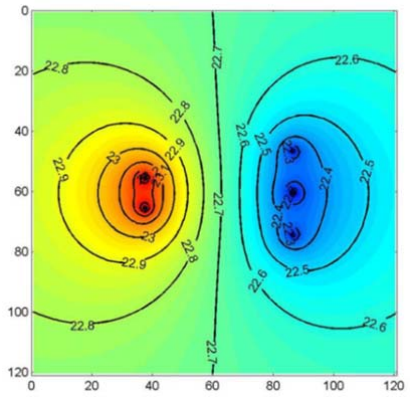

Figure 4 Hydraulic heads along the well screen

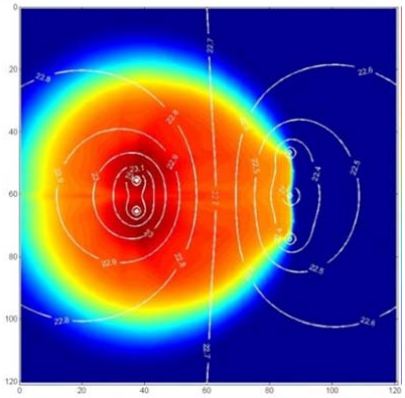

Figure 5 Marker concentration along the well screen from low (blue) to high (red) marker concentration

The most important observation of the first model simulations is that the HGB cell has a vertical influence reaching almost the base of the aquifer. This leads to the conclusion that a vertical upscaling of the HGB cell for biostimulation within the project will not be needed.

The next step in the construction of the groundwater model will be to incorporate the monitored data (e.g. injection and pumping rates) to simulate the working HGB- cell. Together with this, also the central pumping well will be inserted into the model.

More information

Do you want more information about this project? Contact Tom Claes via:

- email : tom.claes@ineos.com
- phone : +32 13 612300
- website: http://biocells.merchanttech.co.uk/en/