INEOS ChlorVinyls

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Newsletter LIFE+ project '*LVM-BIOcells*' | 2

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

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The LIFE+ project

Introduction

On August 1st 2011, the Limburgse Vinyl Maatschappij (LVM) was taken over by INEOS. Hence, the name of the company changed into INEOS ChlorVinyls Belgium (ICV B). That explains the different lay-out of this newsletter.

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 with the set-up and preparation of the first HGB cell.

In the second edition of this newsletter you will read all about our realisations between January 2011 and June 2012. Main topics are the results of the growth of the dechlorinating microbial culture (Multidechlorobac) and the installation and operation of the first HGB cell for biostimulation.

Summary project description

At the 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.

Avecom developed a multispecies dechlorinating culture that degrades 12DCA as well as other CAHs. This culture is based on a unique bacterial strain '*Desulfitobacterium dichloroelimans strain DCA-1*' which can biodegrade 12DCA to ethene without the formation of toxic intermediate products.

The project's objective is to demonstrate the applicability of a remediation technique using HGBcells (hydrogeobiocells) for the bioremediation of groundwater contaminated with CAHs for a site characterized by low natural groundwater flow velocities. 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.

Activities from Jan 2011 to Jun 2012

► Successful growth of dechlorinating microbial culture

In the project, a stepwise upscaling of the production of the multidechlorinating culture (Multidechlorobac) by Avecom is foreseen, namely from 10 to 100 L and from 100 to 1000 L scale.

1. Fermentor (10l scale)

In the first months of 2011, Avecom started with the **production** of a 10 L batch of culture in a fermentor and with the production of 1 L batches which serve as spare culture in case more inoculum would be required.

For the 10 L batch, a fermentor was adapted in order to enable growth of the anaerobic culture and working with chlorinated solvents. In the fermentor the parameters of interest such as pH, redox potential and temperature can be followed easily by data logging. The degradation of CAH by the culture is monitored by headspace analysis with a GC-FID (Gas Chromatograph with Flame Ionisation Detector).

Figure 1 shows a picture of the fermentor.

Figure 1: The fermentor

After 43 days, a significant degradation of the CAH was obtained. The batch showed an average degradation rate of 338 µg CAH/L.d (complete degradation of PCE and 1,2-DCA into ethene). Moreover, analysis showed that the culture contained relatively high concentrations of dechlorinating bacteria.

In February 2012 a new batch was started in the fermentor. After three months of follow-up, this second 10 L batch showed a slightly higher average degradation rate than the first batch, namely 480 µg CAH/L.d (complete degradation of PCE and 1,2-DCA into ethene). During the growth of the first and second batch, the 10 L fermentor showed a nearly constant pH (6,6) and redox potential (between -300 mV and -400 mV). This is important because anaerobic bacterial dechlorination of CAH requires a pH optimally between 6 and 8, and a negative oxidation reduction potential (optimally <-200 mV)

As the culture in the fermentor showed a **good degradation capacity** and a high concentration of dechlorinating bacteria, it was decided to take the next step in the upscaling. Because of the high concentrations of dechlorinators in the fermentor, the 10 L of culture of the fermentor was used directly to grow on 500 L-1000 L scale.

2. Growth reactor (500l – 1000l scale)

In February 2012, Avecom started the growth of Multidechlorobac in a 630 L reactor, which is part of the pilot lab of Tessenderlo Chemie in Tessenderlo. Hereby, the 10 L of culture from the fermentor was used as inoculum. The first results indicate that degradation of the CAH in the 630 L reactor has started. However, **further follow-up** is needed to confirm that the bacteria are activated and growing.

Figure 2 and Figure 3 show pictures from the start-up of the growth in the 630 L reactor.

Figure 2: Addition of inoculum to the growth reactor

Figure 3: 630 L Growth reactor

▶ Installation & operation HGB cell biostimulation

3. Installation and start-up

In August 2010, all the extraction, injection and monitoring wells were installed on-site and in January 2011 the filters of the HGB cell 2 were developed. After approval of the final detailed design, the construction of all piping and equipment of HGB cell 2 started. The civil works were carried out in February and March 2011. Figure 4 and 6 show some of the equipment of the HGB cell.

Figure 4: View of injection filter equipment and manhole cover in construction

Figure 5: View of extraction filter equipment and manhole cover finished

Figure 6: Inner view of container with substrate tank to the left, substrate feed pump in the middle and filter column to the right

During the first start-up of HGB cell 2 it turned out that the pressure in the injection filter built-up too quickly. A second and better development of the filters of the HGB cell was necessary before starting up again. This was needed to prevent extraction of very small particles coming from the aquifer during the operation of the HGB cell. After the thorough development of the filters the second start-up in June was **successful**. The system was able to extract, transport to the injection filters and inject groundwater without pressure building up.

Then an amount of nutrolase (50%) was added to the extracted groundwater as energy source. This operation also caused a pressure building up in the injection filters in every possible configuration. Conclusion? Using nutrolase is not feasible, probably because of the characteristics of the aquifer . Tests with sodium lactate (60%) were very positive though. Injection of groundwater together with sodium lactate (60%) went smoothly without

any change in pressure in the filter bags or in the injection filters. Hence we decided to use sodium lactate (60%) as alternative energy source for the initial phase of the HGB cell. The HGB cell operates at a flow rate of 20m³/h.

4. Monitoring operation HGB cell

During the first operational phase of the HGB cell sampling and analyses events took place. Concentrations of CVOC, chloride, iron, nitrate, sulphate, TOC, ethane, ethylene and methane were monitored by analysis. Also in-situ measurements were performed. The parameters measured were pH, electrical conductivity (Ec), oxidation-reduction level (redox), temperature (T) and oxygen content (O_2 in mg/L and as % saturation).

The results of TOC and sulphate combined with the in-situ measurements in the monitoring wells showed that **favourable biodegradation** conditions were created in a big circle around the injection wells. Biodegradation of 12DCA was proven in monitoring wells in which 12DCA concentrations dropped below 10 µg/l and this drop was accompanied with a rise in ethylene concentration. So the first operational run of the HGB cell an be regarded as successful!

Planned activities

During the next period:

- the fermentor, the culture bottles and the growth reactor will stay monitored. When the culture is successfully grown in the growth reactor, the cost-efficiency of this production will be evaluated. Also the growth of dechlorinating microbial culture with site-polluted groundwater will be investigated;
- all the water level measurement results and supporting concentration data of the HGB cell in operation will be used for calibration of the groundwater model. If necessary, adjustments will be made to the groundwater model;
- scaling up the use of HGB cells for biostimulation will be prepared and implemented.

More information

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