A pilot test in Eastern Bohemia for chlorinated aliphatic hydrocarbons groundwater remediation

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Abstract

The bioremediation of chlorinated solvents is considered as cheap and eco-friendly approach, among the bioremediation techniques the stimulation of organohalide-respiring bacteria by adding substrates is considered as one of the most popular methods. Application of cheese whey was performed in three separate rounds via direct-push technique. Monitoring of groundwater was performed once before the first injection of cheese whey in November 2017 and then monthly until April 2019. Groundwater samples were analyzed for chlorinated ethenes, its bioremediation byproducts and this analysis were correlated with the biological activity on the site that was assessed with the use of PCR and next-generation sequencing tests.

Keywords: Bioremediation, Cheese whey, BMT, Groundwater

1. Introduction

Perchloroethene (PCE) and trichloroethene (TCE) were used for many years as degreasing agents, industrial solvents and in dry cleaning, their massive use makes the chlorinated solvents between the most commonly pollutants detected in groundwater (Lai et al. 2017). The chlorinated aliphatic hydrocarbons (CAHs) decontamination can be carried out by different types of treatment which can be divided in physical, chemical and biological treatment. The bioremediation of CAHs is considered between the most eco-friendly approaches, it's well known that the degradation of CAHs by bacteria may be done in both aerobic and anaerobic condition.

The present study is focused on bioremediation of CHAs by direct push injection of cheese whey, remediation process was monitored using by different chemical physical parameters (ORP, ions, CHAs, COD and others) in addition by BMT analysis, the relative amount and species of bacteria present in the groundwater was monitored.

2. Methods

2.1. Pilot test

Application of cheese whey in Novy Bydzov, Eastern Bohemia, was performed in three separate rounds via direct-push technique (Fig. 1) in the inflow area of the monitoring wells. Particular application rounds were performed in November and December 2017 as well as May 2018. Direct-push technique was used with aim to cover as large area as possible.

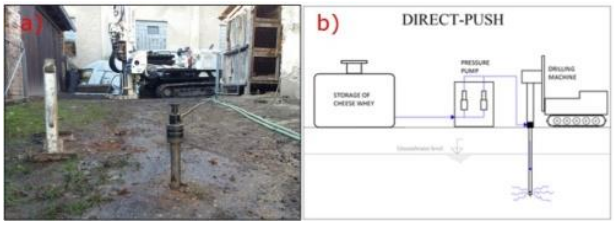

Figure 1. a) photo of a direct-push application at Novy Bydzov site and b) schematic representation of the process.

2.2 Groundwater monitoring

Groundwater samples were collected in dynamic state, , after stabilization of physico-chemical parameters. Monitoring of groundwater was focused especially on the wells in the application area and surroundings, samples from other wells were collected sporadically. The groundwater samples were analyzed in the analytical laboratory of Technical university of Liberec on following chemical parameters: chlorinated ethenes (VC, DCE, TCE, PCE), chemical oxygen demand (COD), methane, ethane, ethane.

2.3 BMT analysis

For monitoring the total bacterial biomass there was performed qPCR of all sampling. U16SRT was chosen as marker for the relative quantification of the total bacterial biomass.

3. Results

4.1. ORP and COD

Oxidation/reduction potential (ORP) shows the reductive state of the groundwater. The most important change in ORP of groundwater in Novy Bydzov was observed after the first cheese whey application in November 2017. ORP drops in average from -50 mV (October 2017) to -150 mV

(December 2017). Chemical oxygen demand (COD) shows the presence of biologically degradable substrate in the groundwater. The second cheese whey application caused strong increase of COD value, instead after the last application of cheese whey the COD change was not observed.

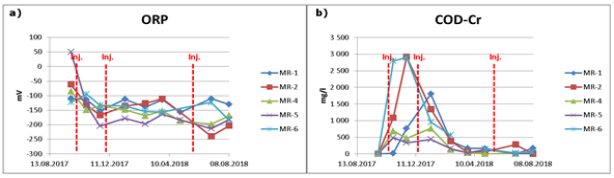

Figure 2. a) ORP and b) COD analysis, the red dashed lines indicate the cheese whey injection.

4.2. Degradation products

MR-1 and MR-2 were the most contaminated wells. Well MR-1 recorded a 100% reduction of CAHs after first two applications.

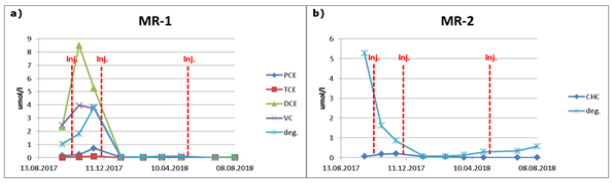

Figure 3. CAHs and clean degradation products concentrations in the area of wells a) MR-1 and b) MR-2.

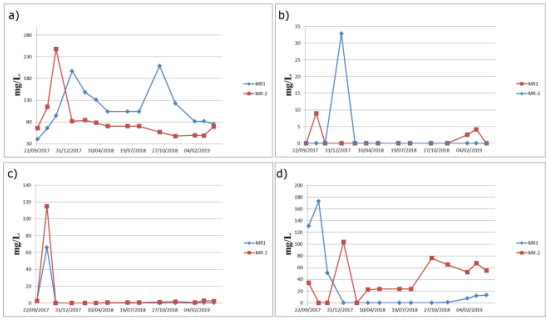

Figure 4. a) Chlorides, b) nitrates, c) NH_4 and d) sulfates analysis

Chlorides, nitrates, NH_4 and sulfates were monitored during throughout process (Fig. 4).

4.3. BMT

In order to get information about total bacterial biomass there was performed qPCR analysis (Fig. 5), the marker used for qPCR was U16SRT (Clifford et al. 2012), it was chosen because it is considered as universal marker of 16S rDNA.

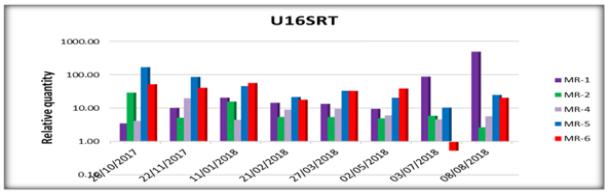

Figure 5. Relative quantification of the total bacterial biomass (U16SRT marker) in bioremediation monitoring of Novy Bydzov site. Purple – MR-1, green – MR-2, grey – MR-4, blue – MR-5 and red – MR-6 sample.

4. Conclusion

In Novy Bydzov there was performed a pilot test for groundwater remediation of CAHs, in which cheese whey was injected by direct-push to enhance the native bacteria grow. It was found that the combination of chemical and BMT monitoring can be very helpful for a proper assessment of the situation on site. It was possible to divide whole pilot test area to two sub-areas with different behavior, in the first sub-area there was observed a very strong decomposition of CAHs, while in the second sub-area there was continuous and accelerating increase of concentration of their "clean" degradation products. The validity of the conclusions formed based on the chemical analyses was confirmed by the rapid increase of abundance of organohalide-respiring bacteria.

Acknowledgements

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