Control of the Effectiveness of Source Removal and ZVI Barrier Treatment in a DNAPLs Contaminated Site Using CSIA

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INTRODUCTION

The study site is polluted with dense non aqueous phase liquids (DNAPLs): tetrachloroethylene (PCE), trichloroethylene (TCE) and dichloroethene (cis-DCE). Contamination was caused by a poor management of waste generated by an automotive industry, which was discharged into a seepage pit. As a result, soil contamination was produced in the seepage pit area and a plume of contaminated groundwater by DNAPLs was generated along the Can Ninou torrent (Granollers, Barcelona) (Fig. 1).

As a remediation strategy, a dual action was necessary: the removal of the source of contamination and the treatment of the groundwater plume of DNAPLs. The source removal consisted of a selective excavation of the seepage pit and an offsite management of the contaminated soil. To restore the groundwater quality, a passive treatment system using a Permeable Reactive Barrier (PRB) of Zero-Valent Iron (ZVI) was implemented, in order to remove DNAPLs from groundwater via abiotic reductive dechlorination.

As a valuable tool for monitoring a ZVI-PRB in the field, compound specific isotopic analysis (CSIA) has been proposed. When the chlorinated compound is degraded, a carbon isotope fractionation occurs producing an enrichment in 13C in the residual compound (Slater et al., 2002; Prommer et al., 2008). The carbon isotopic composition of the residual compound can be related to the amount of compound degraded using the Rayleigh model (Prommer et al., 2008). Therefore, stable carbon isotope analysis permits the evaluation of the extent of degradation, excluding all the processes that produce a decrease in concentration but not a degradation (dilution, diffusion, dispersion, sorption), which don’t generate a significant isotope change. In consequence, carbon isotopic composition permits to determine the specific efficiency of the degradation produced by the PRB in the field.

OBJECTIVES

The aim of this study is a) to monitor the pollution attenuation of a site contaminated by DNAPLs after the source removal; b) to determine the efficiency of the ZVI reactive barrier treatment already installed.

METHODOLOGY

A total of eleven piezometers of 10-12 m deep were installed along the Torrent de Can Ninou between May 2009 and March 2010 (Fig. 1) -Pz1 to Pz11-; other piezometers had been previously installed in 2005 (MW17, 0MW5 and OMW6B). An initial sampling campaign of the wells was done before the removal of the source, in May 2009; and a total of four sampling campaigns were done approximately every six months since the removal of the source, from June 2009 until April 2011. Within this period of time, in March 2010, the ZVI barrier of 5 m high, 20 m long and 0.6 m thick was placed at a 7 m depth. Concentration of PCE, TCE and cis-DCE was determined from all the campaigns.

palabras clave: Barrera reactiva permeable, Fe(0) metálico, Fraccionamiento Isotópico, Etilenos Clorados

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The last campaign, in April 2011, also included the carbon isotopic analyses of PCE, TCE and cis-DCE. In March 2012, 5 additional piezometers were installed, two upstream of the barrier and three downstream of it. The new piezometers were multilevel piezometers with sampling tubes every half meter, until a total depth of 14 m.

RESULTS

The source removal have produced a general decrease of all the compounds, that is more pronounced in the case of cis-DCE, which is the compound that, before the source removal, was found in a considerable higher concentration than the others. Before the removal of the source the concentration of cis-DCE was of 43000 µg/L in OMW5 (just before the source removal on May 2009) and was reduced to 100 µg/L in April 2011.

Moreover, the isotopic results obtained from the April 2011 campaign from the wells located before the barrier show that biodegradation is occurring after the source removal. δ13C values obtained show an isotopic enrichment of TCE and cis-DCE, with values from -19.9% for both TCE and cis-DCE in the source area to -16% and -15.5% (Figs. 2 and 3) for TCE and cis-DCE respectively just before the PRB.

With regards to the ZVI-PRB performance, δ13C_{\text{PCE}} values analyzed upstream and downstream of the barrier in old piezometers don’t show isotopic changes (values are around -20% in all the sampling points) suggesting that PCE is not abiologically removed. In the case of TCE slight isotopic changes have been observed in the water flow in a far distance after the barrier (-15.4%) (Fig. 2). Positively, cis-DCE showed increasing δ13C values upstream to downstream of the barrier (from -15.5% to -11.5%) (Fig. 3) indicating that a possible abiotic degradation due to the ZVI-PRB is being produced.

CONCLUSIONS

Source removal has produced a significant reduction of the contaminant compounds, indicating successful pollution attenuation. Isotope values have proved that natural TCE and cis-DCE degradation is occurring in the field.

Preliminary concentration and isotopic results seem to indicate that the PRB does not intercept the whole contaminated plume. The multilevel piezometers constructed around the PRB will let us know in detail the underground sections most affected by pollution and help to define patterns of DNAPLs migration in the subsurface, giving the possibility to improve the design of the ZVI-PRB.

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