

Comparative Analysis on the Evolution of Chlorinated Solvents Pollution in Granular Aquifers and Transition Zones to Aquitards

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Abstract : Chlorinated solvents belong to the group of nonaqueous phase liquids (DNAPL) and have been involved in many contamination episodes. They are carcinogenic and recalcitrant pollutants that may be found in granular aquifers as: i) pools accumulated on low hydraulic conductivity layers; ii) immobile residual phase retained at the pore-scale by capillary forces; iii) dissolved phase in groundwater; iv) sorbed by particulate organic matter; and v) stored into the matrix of low hydraulic conductivity layers where they penetrated by molecular diffusion. The transition zone between granular aquifers and basal aquitards constitute the lowermost part of the aquifer and presents numerous fine-grained interbedded layers that give rise to significant textural contrasts. These layers condition the transport and fate of contaminants and lead to differences from the rest of the aquifer, given that: i) hydraulic conductivity of these layers is lower; ii) DNAPL tends to accumulate on them; iii) groundwater flow is slower in the transition zone and consequently pool dissolution is much slower; iv) sorbed concentrations are higher in the fine-grained layers because of their higher content in organic matter; v) a significant mass of pollutant penetrates into the matrix of these layers; and vi) this contaminant mass back-diffuses after remediation and the aquifer becomes contaminated again. Thus, contamination sources of chlorinated solvents are extremely more recalcitrant in transition zones, which has far-reaching implications for the environment. The aim of this study is to analyze the spatial and temporal differences in the evolution of biogeochemical processes in the transition zone and in the rest of the aquifer. For this, an unconfined aquifer with a transition zone in the lower part was selected at Vilafant (NE Spain). This aquifer was contaminated by perchloroethylene (PCE) in the 80's. Distribution of PCE and other chloroethenes in groundwater and porewater was analyzed in: a) conventional piezometers along the plume and in two multilevel wells at the source of contamination; and b) porewater of fine grained materials from cores recovered when drilled the two multilevel wells. Currently, the highest concentrations continue to be recorded in the source area in the transition zone. By contrast, the lowest concentrations in this area correspond to the central part of the aquifer, where flow velocities are higher and a greater washing of the residual phase initially retained has occurred. The major findings of the study were: i) PCE metabolites were detected in the transition zone, where conditions were more reducing than in the rest of the aquifer; ii) however, reductive dechlorination was partial since only the formation of cis-dichloroethylene (DCE) was reached; iii) In the central part of the aquifer, where conditions were predominantly oxidizing, the presence of nitrate significantly hindered the reductive dechlorination of PCE. The remediation strategies to be implemented should be directed to enhance dissolution of the source, especially in the transition zone, where it is more recalcitrant. For example, by combining chemical and bioremediation methods, already tested at the laboratory scale with groundwater and sediments of this site.

Keywords : chlorinated solvents, chloroethenes, DNAPL, partial reductive dechlorination, PCE, transition zone to basal aquitard

Conference Title : ICHEE 2018 : International Conference on Hydrology, Ecology and Environment

Conference Location : Vancouver, Canada

Conference Dates : August 09-10, 2018