

Long-term effect of bio-barrier as enhanced natural attenuation technology for CVOCs in groundwater

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At a groundwater contamination site where source zone treatment is difficult, it is effective to use the land while maintaining a state that the contamination groundwater prevented from flowing out from site boundary and the human's health risk is in the allowed level. For preventing contaminated groundwater to flow out, cut-off wall and barrier wells are often installed. But, there is a case where the use of these technologies is difficult in urban area because these facilities interrupt the groundwater flow around the site. In this case, a passive method of attenuating contaminant in the groundwater by using natural groundwater flow is effective.

As the prevention measure technology of tetrachloroethylene (PCE) contaminated groundwater diffusion, a bio-barrier was installed, and an enhanced natural attenuation (ENA) of chlorinated volatile organic compounds (CVOCs) in groundwater was tried. The CVOCs concentrations in down-gradient well W2 before bio-barrier installation were: 0.28mg/L(PCE), 0.10 mg/L (TCE: trichloroethylene) and 0.37 mg/L (cis-1,2-DCE: cis-1,2-dichloroethylene). And calculated half-lives of CVOCs were: 1700 days (PCE), 320 days (TCE) and 1300days (DCEs: dichloroethylens). The bio-barrier was formed by injecting hydrogen release compound (Regenesis, HRC) which is mainly composed of poly-lactate ester from seven injection wells every year.

In this study, about eight years groundwater monitoring has been performed routinely in the up-gradient well (W1) and W2, and long-term effectiveness of bio-barrier was evaluated.

The concentration of each CVOC in W1 showed the decrease trend. But the concentrations of PCE and cis-1,2-DCE had been exceeding the Environmental Quality Standard of Groundwater (EQSG) for almost whole period. On the other hand, the concentrations of PCE and TCE in W2 showed the decrease trend immediately after the bio-barrier installation, and the concentration of cis-1,2-DCE and trans-1,2-DCE in W2 has increased until day 36 and had changed to decreasing trend on day 107. The second hydrogen release compound injection were carried out on day 423 after confirming life-span of the ENA effect by the first hydrogen release compound injection, and the hydrogen release compound has been injected every year since the third hydrogen release compound injection. In W2, the concentrations of PCE and cis-1,2-DCE had become to be suitable for the EQSG respectively after day 1807 and day 1989, and the concentration of TCE had been exceeding the EQSG from day 400 to day 1198. After day 2332, all CVOC had been not detected in W2. The long-term changes of first-order degradation coefficients and the half-lives of CVOCs in groundwater were estimated by natural attenuation analysis code (Groundwater Servies, BIOCHLOR). After bio-barrier installation, the half-life of each CVOC had been greatly shortened. At the stage of day 379, the half-lives of CVOCs were: 4.6 days (PCE), 3.4 days (TCE), 13 days (DCEs) and 1.3 days (VC: Vinyl chloride). After day 463, the first-order degradation coefficients and the half-lives of CVOCs were steady with the time passage, the half-lives of CVOCs from day 463 to day 1934 were: 6.7 to 13 days (PCE), 4.5 to 12 days (TCE), 20 to 65 days (DCEs) and 1.6 to 6.3 days (VC). On day 2024 (year 5.5), the first-order degradation coefficients of CVOCs had rose again, and the half-lives of CVOCs from day 2024 to day 2934 were: 2.3 to 4.5 days (PCE), 2.1 to 3.9 days (TCE), 1.6 to 3.4 days (DCEs) and 0.8 to 3.8 days. The latest first-order degradation coefficients of PCE, TCE and DCEs on day 2934 (year 8.0) were 433 times, 130 times and 655 times of natural condition on day 0, The natural attenuation were greatly enhanced by the bio-barrier installation.

These results show that the ENA effect by the bio-barrier continuously lasted for eight years, and the effect level has been changing a little along time.