Case Study: Biodegradation Potential Assessment at a Site Contaminated by a Chlorobenzene, BTEX, and Pharmaceuticals

Ondrej Lhotský (lhotsky@dekonta.cz) (DEKONTA a.s., Prague, Czech Republic)
Tomáš Cajthaml (Charles University, Prague, Czech Republic)

Background/Objectives. This work consisted of a remediation feasibility study on a typical contaminated site in the Czechia polluted by a mixture of chlorobenzene, monoaromatic hydrocarbons, pharmaceuticals and chlorinated ethenes. Commingled plumes containing various pollutants with differing chemical nature represent a difficult task for remediation. The locality is situated in the town of Olomouc, io the grounds of an old chemical and pharmaceutical plant where production started in 1934. During previous remediation attempts, non-aqueous phase liquids were removed and the concentrations of contaminants decreased but the residual contamination is still high. The aquifer is developed in quaternary sandy gravels with clayey admixture and has a saturated thickness of approximately 4 m. The groundwater is significantly affected by long-term contamination, characterized by elevated mineralization, neutral pH, oxidation–reduction potential ranging from -110 to 0 mV, absence of dissolved oxygen and a temperature of around 14.5°C. Six months before the test started, the main contaminant concentrations varied as follows: benzene 10 to 1,310 $\mu g \cdot L^{-1}$, toluene 630 to 20,500 $\mu g \cdot L^{-1}$ and chlorobenzene 2740 to 15,930 $\mu g \cdot L^{-1}$.

Approach/Activities. A pilot remediation test of a commingled plume was performed using a combination of remediation approaches consisting of a pump and treat (P&T) system with an advanced oxidation process and targeted direct-push injections of calcium peroxide for in situ biodegradation enhancement. The remediation process was monitored intensively and extensively throughout the pilot test using various conventional and passive sampling methods, including next generation amplicon sequencing.

Results/Lessons Learned. The results showed that the injection of oxygen saturated water from the P&T with residual hydrogen peroxide and elevated temperature enhanced the removal of monoaromatics and chlorinated pollutants. Especially in combination with the injection of calcium peroxide, the conditions facilitated bacterial in situ biodegradation of majority of pollutants. Three months after the calcium peroxide injections mean groundwater concentrations of benzene dropped to 3 $\mu g \cdot L^{-1}$; chlorobenzene to 36 $\mu g \cdot L^{-1}$ and toluene to 2 $\mu g \cdot L^{-1}$. Furthermore, significant degradation of the contaminants bound to the soil matrix in less permeable zones was observed. Based on a developed 3-D model, 90% of the toluene and 88% of the chlorobenzene bound to the soil were removed, with benzene being almost completely removed. On the other hand, although the psychopharmaceuticals were effectively removed from the treated water by the employed advanced oxidation process, their concentrations in the groundwater remained stagnant due to their inflow from surroundings and absence of their in situ degradation.