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# Bioremediation of Phenol Plume in Groundwater

Rubens Spina (rubens.spina@geoklock.com.br), Rodrigo Coelho (rodrigo.coelho@geoklock.com.br) and ***Victor Vanin Sewaybricker*** (victor.vanin@geoklock.com.br) (GEOKLOCK, São Paulo, SP, Brazil)

**Background/Objectives.** An agrochemical plant located in the São Paulo State, Brazil, operated between 1974 and 1990, producing furfural from sugarcane bagasse. The environmental site assessment conducted in this area indicated the presence of up to 11 mg/L of phenolic compounds in groundwater. The local aquifer is constituted by a layer of silty and sandy clay from basalt rock alteration, with thickness ranging from 5 to 20 m, overlapping the fractured basalt rock. The objective of the installed remediation system was to reduce phenol concentrations in the aquifer to prevent off-site migration and to allow the proper occupation of the area for other uses, such as commercial or residential uses.

**Approach/Activities.** The environmental site assessment indicated that the local aquifer has low hydraulic conductivities ($10^{-5}$ cm/s), with an average groundwater flow velocity of 3 m/year. The mass balance carried out from the collected soil and groundwater samples indicated that the majority of phenolic compounds has already migrated to the groundwater, posing a potential risk of off-site migration. The human health risk assessment carried out did not indicate potential unacceptable risks to human health for an industrial occupation scenario.

Although phenol has an elevated potential for natural attenuation in the aquifer, historical groundwater monitoring data indicated that, even after the deactivation of the plant which originated the contamination, the reduction trend of phenol concentrations in the aquifer would be insufficient to prevent off-site migration of the plume.

A three-dimensional mathematical model was developed to evaluate remediation scenarios. The proposed remediation concept was based on the installation of six pumping wells in the hot spots of the phenol plume and pumping the groundwater into two bioreactors on the surface, where the addition of the nutrients sodium nitrate and sodium tripolyphosphate would take place, with the subsequent upgradient reinjection of the groundwater into the aquifer through nine injection wells, with the aim of accelerating the biodegradation processes of the phenolic compounds. The groundwater pumping associated with the upgradient reinjection also increased the hydraulic gradient, thereby increasing the groundwater flow velocity.

**Results/Lessons Learned.** After 6 years of operation of the bioremediation system, the concentrations of phenolic compounds in the aquifer reached the intervention levels defined by the local environmental agency, ensuring the protection of the external areas and the safe future occupation of this site for other land uses.

A groundwater monitoring program was carried out for three years after the remediation system shut down, which indicated no increase in the concentrations in the aquifer. The monitoring data and the absence of risks to human health on the site, supported the request for the rehabilitation of the area for residential use, which is currently under review by the environmental authorities.