Remediation of Perchlorate-Impacted Vadose Zone Hydraulically Upgradient of an Industrial Site

Mehrnoosh Behrooz (Mehrnoosh.Behrooz@WaterBoards.Ca.Gov)
(California Regional Water Quality Control Board - Santa Ana Region)

Historical activities in an industrial site in Santa Ana, California (Site) resulted in release of perchlorate-containing rinse water into the subsurface. Subsurface investigations at the Site indicated the presence of perchlorate at concentrations greater than 100,000 micrograms per kilogram (µg/kg) in vadose zone at the source area. Concentrations of perchlorate greater than 1,000,000 micrograms per liter (µg/L) were detected in groundwater samples collected from the first water-bearing zone beneath and hydraulically down-gradient of the source area. In addition, further investigations revealed the presence of perchlorate at concentrations exceeding 6,200 µg/kg in the vadose zone of the adjacent property located hydraulically upgradient of the Site. No perchlorate was, however, detected in the groundwater samples from the upgradient property. The presence of perchlorate in that area was explained through existence of sandy layers within predominantly clayey deposits beneath the Site which has facilitated lateral migration of perchlorate within the vadose zone to the upgradient property.

In situ bioremediation, using horizontal wells to deliver organic amendment and enhance microbial degradation of perchlorate in the vadose zone of the adjacent property, was applied between April 2013 and January 2015. An extraction system was designed and constructed to capture the water used for amendment delivery to that target vadose zone. The volume of the amendment solution used to treat the impacted soil was the equivalent of 50 years of average annual precipitation at the Site. Movement of the amendment solution from vadose zone to groundwater resulted in a noticeable rise of groundwater levels in the target area.

Confirmation soil sampling was conducted in the target area after water levels had subsided to near the pre-remediation elevations. Soil sampling results indicated a significant reduction of perchlorate concentrations in the target area, with non-detect in the higher permeability zones. Concentrations of residual perchlorate in the target area appears to be limited to low permeability sediments. This study also revealed that back diffusion of perchlorate from the low-permeability sediments is a very slow process that may occur over a period of several years.