Bioremediation of Petroleum Pollution in Complex Geological Soils

Tracey Hsu and Daniel Chang (Taiwan Environment Scientific Co., Ltd., Tainan, Taiwan [R.O.C.])
Peter Yu (Provectus/TED Technology Corp., Taipei, Taiwan [R.O.C.])

Background/Objectives. Underground oil pipelines at a site in Taoyuan County, Taiwan, were damaged by thieves, causing soil and groundwater pollution by gasoline and diesel fuel. The geological composition includes coarse-grained gravel and fine-grained red clay soil containing iron oxide. An estimated 27,000 tonnes of unsaturated soils impacted by total petroleum hydrocarbon (TPH) were excavated from 0 to 6 m bgs and transported to an on-site biotreatment area. Enhanced bioremediation was used to reduce the TPH content in the soil from >3,000 mg/kg to below the Taiwan regulatory standard of <1,000 mg/kg.

Approach/Activities. Provect-ABR® Aerobic Bioremediation Reagent was first evaluated under laboratory conditions. In brief, the remedial amendment was added at 1% to 3% soil weight basis; soils were irrigated and routinely aerated via physical tilling for 8 weeks. Performance was assessed by weekly measurements of TPH and the total number of bacterial colonies. A successful, cost effective treatment regime was identified for full-scale implementation. Excavated soils were first screened to remove cobbles followed by addition of Provect-ABR supplemented with additional hydrophilic organic amendment to increase the mixing efficiency by increasing the porosity of the clay soil. The stockpiled soils were left in place and mixed at least 3 times a week for 6 weeks. Any soil with TPH concentrations greater than 1,000 mg/kg were moved to the indoor soil remediation plant for the second stage test. Here, irrigation and automated mechanical mixing of the soil was used regularly until the TPH concentration falls below 1,000 mg/kg.

Results/Lessons Learned. In the laboratory test the TPH concentration in treated soil quickly reduced to dropped < 1,000 mg/kg samples while the un-treated control remained >2,000 mg/kg after 8 weeks. The total number of TPH-degrading bacterial colonies in the treated soil were also higher than that in the control group, indicating that Provect-ABR® can improve the bioremediation process. Under field conditions, challenges include temperature between 7.0 and 35.5 degrees Celsius (the annual average temperature is 22.6 degrees Celsius) and the annual rainfall > 1,415 mm. During the pre-treatment stage, TPH concentration in soil was reduced to about 1,500 mg/kg after 6 weeks under stockpiled conditions. In the second stage of biotreatment, TPH concentrations decreased to < 1,000 mg/kg after 3 days. The complex geology of cobbles, gravel and clay represented process challenges which were mostly overcome through engineering modifications and process optimization. Whereas efficiency of bioremediation was higher in the indoor remediation plant with automated machinery the space is not large enough to accommodate all contaminated soil. In response, most of the soil was first remediated in the outdoor storage area and a small part (estimated 15% volume) of the soil required secondary treatment.