Remediation and hydrological implications of oil-induced soil hydrophobicity in the Evrona nature reserve, Israel

Ravid Rosenzweig¹, Zheng Li¹,², Faina Gelman¹, Onn Crouvi¹, Gilboa Arye³, and Zeev Ronen²

¹Geological Survey of Israel, Jerusalem Israel (rravid@gsi.gov.il)
²Zuckerberg Institute for Water Research, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer, Israel
³French Associates Institute for Agriculture and Biotechnology of Drylands, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer, Israel

Soil hydrophobicity was extensively investigated in the context of fire-induced, naturally-occurring and wastewater related hydrophobicity. Oil-induced soil hydrophobicity, however, received much less attention and was not yet investigated under regions characterized by hyper-arid climate. In this study, we investigate the hydrological effects and the persistence of oil-induced soil hydrophobicity in Evrona nature reserve located in the hyper-arid region of southern Israel. The Evrona nature reserve has experienced two oil spills that occurred in 1975 and 2014, providing a unique opportunity to study the hydrophobicity of oil-polluted soils over time. In this study, we 1) apply field monitoring to investigate how the severe hydrophobicity affects water flow in the polluted soils, and 2) conduct laboratory incubation experiments to assess the natural attenuation of hydrophobicity and its relation with the content and composition of hydrocarbons.

We set up two monitoring stations in two adjacent streams, of which one is polluted and the other is clean. In each section, an array of water content sensors was installed. Analyses of data measured during two years reveal that during rain and runoff events infiltration in the oil-contaminated soil was much lower relative to the clean soil. Furthermore, infiltration in the oil-contaminated stream showed highly preferential patterns, typical of hydrophobic soils. The reduced infiltration and the establishment of preferential flow paths may lead to negative consequences including increased runoff and erosion, reduction in the water available to native plants, and the generation of fast conduits for contaminant transport.

In the second part of the research, incubation experiments were conducted with contaminated soils from the 2014 and 1975 sites. Soils were treated with the addition of either water alone or different combinations of water, nutrients and surfactant. Treated soils were sampled periodically to assess soil hydrophobicity and hydrocarbon content. The results show a concomitant decrease in the hydrophobicity and hydrocarbon content in soils to which water or water and nutrient and/or surfactants were added. The fastest hydrophobicity reduction was observed in soil to which both nutrients and surfactants were added, while when only water was added to 50% saturation, degradation and hydrophobicity reduction were very slow. Overall, during the one year and a half incubation, the total petroleum hydrocarbon of the treated soils decreased by 40% in the 2014 soil
and by up to 80% in the 1975 soil. However, although hydrophobicity was reduced during incubation, the soils still remained severely hydrophobic. This suggests that considering the concentration of hydrocarbons as the sole criterion for the endpoint of soil remediation is not sufficient and the degree of soil hydrophobicity should be evaluated as well.