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Hydraulic Property Alterations due to Wettability Induced Changes by Diesel Fuels

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The remediation of non-aqueous phase liquid (NAPL) contaminated sites is impeded due to subsurface complexities, including wettability. Wettability quantifies which of two immiscible fluids preferentially coats a solid. At most contaminated sites water-wetting conditions are typically assumed despite mounting evidence that is not always the case. In this study, wettability was examined for two NAPL samples of contrasting origin: a fresh and a field sample. Wettability was assessed through (i) cyclical, 'cumulative elapsed contact time' intrinsic contact angle measurements, (ii) interface jar tests, and (iii) cyclical, pseudo-static capillary pressure-saturation curves. The work as a whole demonstrated that while the fresh diesel sample was consistently water-wet, the field diesel sample exhibited repeatable cycles of wettability reversal between water drainage and imbibition. And while wettability hysteresis increased with contact time for the field diesel, the occurrence of wettability reversal at each change of saturation direction was independent of contact time. Such behavior is not easily assessed by standard wettability indices. Moreover, it contrasts with the permanent wettability alteration observed for complex organics (e.g., coal tar) observed in most studies. It is hypothesized that the cyclical wettability reversal is related to cyclical changes in intermediate pore wettability due to sorption of surface active compounds (causing NAPL-wetting imbibition) and rupturing of the the soil grain water film (causing water-wet drainage). The wettability differences between the two NAPLs may be due to additives (i.e. a surfactant) in the original formulation and/or byproducts from subsurface weathering. These results support better characterization of site-specific wettability, improved model development and more realistic site conceptual models for improved remediation efforts.