Rapid and Non-Destructive Raman Characterization of Contaminants in Soils Impacted by Produced Water Spills in the Permian Basin

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The rapid development of continuous U.S. hydrocarbon resources over the past decade has resulted in large volumes of associated produced water which require reuse or disposal, currently estimated at 14 billion barrels per year. Produced water is commonly reused by injection into geologic reservoirs for enhanced oil recovery or pumped into underground disposal wells. However, spills or illegal dumping of produced water are of enviromental concern given their high salinities, which can greatly exceed 35 g/L total dissolved solids (seawater equivalent), elevated radium content, and presence of dissolved organic constituents. The ability to rapidly identify contamination of soils by produced water, especially within field settings, is thus desirable.

Here we present results of initial efforts to resolve the environmental impacts of produced water contamination within soils from illegal dump sites in the Permian Basin using Raman spectroscopy. Raman spectroscopy is a rapid and non-destructive method based on the inelastic scattering of light and has been widely applied to the study of environmental contaminants. The ability of Raman to resolve soil contamination by produced water exposure relies on the strong response from polyaromatic hydrocarbons (PAHs) common in these liquids; although, in some instances, it is also possible to observe associated inorganic spectral signals (e.g., SO_4^{2-}). Beyond identifying non-specific produced water contamination in soil samples, this work also highlights Raman as an effective screening tool to select the best candidates to analyze by more selective organic characterization analyses such as GC-MS. Our findings serve as an initial evaluation of Raman as a tool to reveal produced water soil contamination and motivate future efforts at mapping produced water spill footprints in field settings with Raman spectroscopy.