PhD Dissertation Defense

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Physicochemical Approaches for the Remediation of Manufactured Gas Plant Tar in Porous Media

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Tars produced as a by-product of coal and oil gasification at former manufactured gas plants (FMGPs) during the 19th and early 20th centuries were often released into the environment through poor disposal practices or leaks in holding tanks and piping. These tars are persistent contaminants, leaching polycyclic aromatic hydrocarbons (PAHs) into groundwater and posing a significant risk to human and ecological health. FMGP tars also have several properties that make them notoriously difficult to remediate. They are dense non-aqueous phase liquids (DNAPLs), so they can migrate to depths which make removal by excavation difficult or impossible, and their relatively high viscosities and ability to alter the wetting characteristics of porous media result in inefficient removal by traditional pump-and-treat methods. This work investigates the relationship between tar composition and properties, and explores several remediation approaches. The interfacial tension (IFT) of a set of FMGP tars was measured as a function of pH and correlated with compositional features. It was observed that IFT is a strongly decreasing function of pH, suggesting the potential use of high pH (alkaline) solutions to mobilize FMGP tar in porous media systems. Laboratory column experiments were conducted to investigate the use of alkaline solutions, alone and in combination with natural polymers (xanthan gum) and surfactants, to remediate tar-contaminated porous media. The results of these experiments indicated that alkaline-surfactant-polymer (ASP) solutions could efficiently remove 95% of residual tar. Surfactant-polymer (SP) solutions removed an even greater fraction of residual tar, over 99%, but required a larger flushing volume to do so. These experiments also illustrated that both ASP and SP flushing significantly reduced dissolved-phase PAH concentrations, which are often the primary concern at contaminated FMGP sites.

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