

Biodegradation of Hydrocarbons Assisted by Arroyo Willows in Controlled Mesocosms Conducted at the Former Guadalupe Oil Field

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Willows trees were grown under controlled conditions to quantify the influence of roots on biodegradation rates of hydrocarbons in groundwater. These experiments were conducted on two scales: small laboratory microcosms in glass containers and large mesocosms in polypropylene containers, operated at the field site. Both studies were conducted under controlled conditions closely mimicking the Guadalupe Oil Field (GOF) site. Diesel range oil (DRO) was used as a diluent to facilitate pumping viscous crude oil during production at this site from 1950-1991. Leaking tanks and pipes used for the containment and transportation of diluent contaminated the soil and groundwater directly beneath the GOF site.

The laboratory study used 4-L glass jars with groundwater continually recirculated through the saturated zone of the soil for 100 days. The mesocosm study used 100 times more groundwater than the laboratory studies and was conducted on-site to more closely match field conditions. Large 1500-liter polypropylene boxes were filled with clean sand from the GOF. Five boxes were planted with Arroyo Willow cuttings and five boxes were filled with only sand, to serve as controls. 400 liters of affected groundwater per box was circulated in a five-month equilibration period, to establish the willow trees and microbial communities in each box. Terminal restriction fragment (TRF) bioassays were performed periodically to map changes in the microbial community. After the equilibration period, affected water was added and the hydrocarbon degradation rates, in the absence and presence of willows were monitored to evaluate the efficacy of plant enhanced hydrocarbon biodegradation. Change in concentration of total petroleum hydrocarbons characterized degradation rates. The laboratory experiments showed a statistically significant improvement of diluent hydrocarbon biodegradation in former groundwater with either willows or lupines planted compared to controls without plants. Residual total petroleum hydrocarbon (TPH) concentrations in chambers with willows present were about half that of the controls without plants. The TRF analyses showed a distinct microbial community in the chambers with plants than the controls suggesting that the root zone stimulated growth of different microbial populations than those found for the controls. Collectively, the lab and mesocosm experiments showed that plant roots lead to a significant improvement in hydrocarbon biodegradation under conditions closely matched to the field.