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Mechanisms for phytoremediation of PAH compounds: A long-term field investigation

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An eight-year study was conducted to assess the effectiveness of hybrid poplar trees to remediate polycyclic aromatic hydrocarbon (PAH) compounds in soil and groundwater at a creosote-contaminated site. A reduction in the areal extent of the PAH plume was observed in the upper half of the 2-m thick saturated zone beginning with the third and fourth growing seasons, which coincided with the propagation of the tree roots to the water table region. Remediation was limited to naphthalene and several 3-ring PAHs (acenapthylene and acenapthene). PAH concentration in soil samples also declined over time; however levels of four-ring PAHs persisted at the lower depths during the study period. The naphthalene to total PAH concentration ratio in the most contaminated groundwater decreased from $>$ 0.90 at the beginning of the second growing season to approximately 0.70 at the end the study. Aerobic push-pull tests were performed to assess the contribution of hybrid poplar trees to the remediation of PAHs. Maximum first-order aerobic respiration rates (1.25 1/hr) occurred in the planted area and during the third month of the growing season (June). Test results suggest that enhanced rhizosphere bioremediation enhanced by the poplar trees is a significant mechanism even during the winter months.

Addition plant-induced remediation mechanisms for naphthalene investigated include 1) plant uptake with removal by phytovolatilization, 2) volatilization and biodegradation in the vadose zone, and 3) direct surface volatilization of contaminants through the subsurface and into the atmosphere. Direct transpiration rates ranged from 4-8 Lpd per tree during the second growing season to a maximum of 15-49 Lpd per tree during the seventh growing season. Yearly mass loss rates represented approximately 0.5% of the aqueous phase plume. Peak naphthalene soil gas concentrations were observed in the late summer, corresponding with peak naphthalene aqueous concentrations and the minimum saturated zone thickness. Results showed that overall naphthalene mass flux

due to volatilization at the water table was enhanced by vadose zone biodegradation and was significant relative to plant uptake. Surface volatilization of naphthalene was measured in August of the eight growing season in the most contaminated area when the saturated thickness and soil moisture were at minimums. These latter remediation mechanisms were enhanced by transpiration and canopy interception resulting from the phytoremediation system at this site.