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Phytoremediation and Microbial Degradation Pilot Studies for a Former Waste Water Pond in Northern California

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Background/Objectives. A former 73-acre waste water treatment pond is located adjacent to a coastal estuary with surrounding wetlands. The site contains a surficial layer of historically-discharged material composed of fine-grained material with total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs), and metals as chemicals of concern (COCs). Due to the site setting and history, the surface material exhibits high salinity and sodicity. Pilot studies are currently being performed to evaluate the effectiveness of phytoremediation and microbial degradation for achieving remedial goals, with eventual restoration as an estuarine wetland similar to that which surrounds the area. Microbial degradation in the rhizosphere and uptake by plants are expected to produce long-term reductions in TPH/PAH concentrations and redistribution/bioavailability reduction of metals. The results of the ongoing pilot studies document microbial degradation processes/rates and plant uptake with different plant types, soil amendments, soil aeration methods, and irrigation approaches.

Approach/Activities. The pilot study involves dewatering a 10-acre portion of the former pond to construct irrigated test plots ranging from 1-acre to 10,000 square feet. Some of the plots were used to evaluate the influence of different native plants (*Distichilis spicata* [saltgrass], *Jaumea carnosa* [jaumea], *Atriplex patula* [fat hen], and *Sporobolus airoides* [alkali sacaton]), compost, fertilizer, and gypsum on COC degradation and uptake. Other plots underwent different types of mechanical soil aeration (plowing, discing, plugging, rototilling), amendment addition (mulch, compost, worms, and food-grade surfactants), and irrigation with oxygenated water. Plant survival and root zone characteristics were documented. Time series analyses for COCs in the waste material and plants and environmental molecular diagnostics (EMDs) were used to evaluate microbial degradation processes/rates and plant uptake. The EMDs included advanced metagenomics to characterize indigenous microbial communities under the various test conditions, including Next Generation Sequencing (NGS) DNA analysis, QuantArray Petro analysis, and Stable Isotope Probing (SIP). The study also included analyses to estimate degradation rates by employing fingerprint time-series sampling and compound specific isotope analysis (CSIA).

Results/Lessons Learned. The results demonstrate that native plants can be established in the former waste water pond, with plant diversity, density, and root zone penetration varying with plant type, composting, soil conditioning, irrigation, and meteorological conditions. Indigenous microbial communities were characterized, including population density related to the presence of roots, mechanical aeration, and amendments. COC degradation and pathways were documented. The results provide direct evidence for microbial degradation based on observed reductions in COC concentrations and the EMDs. Changes in COC concentrations over time allowed for regression-based estimates of first-order degradation rate constants. The pilot studies demonstrate that phytoremediation with microbial degradation represent a potentially effective remedy for restoring the site. These results will be used in a forthcoming Corrective Action Plan for comparison to more traditional remedial strategies such as excavation, chemical oxidation, and/or capping.