Microbial Augmentation with Heating for the Degradation of Total Petroleum Hydrocarbons and other Organic contaminants in Soils

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Background/Objectives. Environmental releases of Total Petroleum Hydrocarbons (TPHs) are widespread and present significant challenges to the remediation of approximately 100 million tons of TPH contaminated soil that are excavated each year in the U.S. We report on the use of a bioremediation approach based on the ex-situ treatment of TPH contaminated soils with a thermophilic bacterial strain. This strain previously was shown to be capable of degrading a variety of organic compounds including the larger poly-aromatic hydrocarbons (PAHs) that characterize the more recalcitrant fractions of TPH. The objectives were to evaluate the ability of this process to: 1) reduce the volatile and semi-volatile fractions that complicate incineration; 2) reduce the concentrations of extremely toxic components such as Benzo[a]pyrene (BaP); and 3) identify a cost-effective approach that can be used commercially.

Approach/Activities. Most tests were done in 55-gallon, steel drums containing ~200 lbs. of soil heated to 150˚F with electric blankets. A series of 2 x 2 factorial design experiments were done to evaluate the impact of soil pH, moisture, aeration methods and other factors on the degradation rates of TPH and PAHs. Larger-scale experiments also were done on soil piles of 1 ton in nylon bulk bags. Experiment durations ranged from 5 to 10 days. Aeration approaches included turning the soil daily with an auger and alternately aerating through vertical tap wells and the moisture content was monitored and adjusted to 15-20% if needed. TPH levels were measured with EPA method 8015B and 19 PAHs were measured using EPA method 8270D.

Results/Lessons Learned. TPH concentrations decreased in 8 out of 9 soil samples treated with the thermophilic bacteria solution and 4 of the decreases were significant at the 95% significance level. The concentrations of 7 PaHs on the EPA's list of priority pollutants decreased in all five of the treatments in which they were measured and 4 changes were statistically significant. Microbial activity was optimum at neutral soil pH and 15-20% moisture, and under these conditions, TPH degradation rates of 13.8-21.9% d^{-1} and degradation rates for the 7 priority PaHs of 18.5-23.4% d^{-1} were achieved. Thermal desorption is a significant loss process for PaHs with large vapor pressures such as naphthalene and 2-methylnaphthalene, but microbial degradation dominates the loss of the components with high boiling points such as the PaHs on the EPA's list of priority pollutants. Cost estimates for taking this process to the commercial scale include soil preparation, cost of bacteria and support media, and maintaining incubation conditions for the approximately 2 weeks it would take to achieve a 90% reduction in contaminant levels.