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Potential of Ozonation and Phytoremediation to Reduce Hydrocarbon Levels Remaining after the Pilot Scale Microbial Based Bioremediation (Land-Farming) of a Heavily Polluted Soil

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Abstract : Petroleum contamination of sandy soils is a severe environmental problem in Libya, but relatively little work has been carried out to optimize the bioremediation of such heavily contaminated soil, particularly at a pilot scale. The purpose of this research was to determine the potential for the microbial-based bioremediation of hydrocarbon-contaminated soil obtained from an oil refinery in Libya and to assess the potential of both ozonation and phytoremediation (both applied after initial bioremediation) to reduce residual hydrocarbon levels. Plots containing 500 kg soil (triplicates) (contaminated soil diluted with clean soil 50% volume) were set up, (designated as Land Treatment Units; LTUs) containing five different nutrient levels and mixtures (Urea + NPK (nitrogen; phosphor; potassium) mixtures) to obtain C:N:P ratios 100:10:1, and monitored for 90 days. Hydrocarbon levels, microbial numbers, and toxicity (EC50 using luminescent microbial based tests) were assessed. Hydrocarbon levels in non-diluted and diluted soil ranged from 20 733-22 366 mg/kg and from 16 000-17 000 mg/kg respectively. Although all the land treatment units revealed a significant hydrocarbon reduction over time, the highest reduction in hydrocarbon levels obtained was around 60%. For example, 63% hydrocarbon removal was observed using a mixture of urea and NPK with a C:N:P ratio of 100:10:1). Soil toxicity (as assessed using luminescence based toxicity assays) reduced in line with the reduction in total petroleum hydrocarbons observed. However, as relatively high residual TPH (total petroleum hydrocarbon) levels (ranging from 6033-14166mg/kg) were still present after initial bioremediation two 'post-treatments' (phytoremediation and ozonation) were attempted to remove residual hydrocarbons remaining. Five locally grown (agriculturally important) plant species were tested. The germination of all plants examined was strongly inhibited (80-100%) and seedlings failed to grow well in the contaminated soil, indicating that the previously bioremediated soils were still toxic to the plants. Subsequent ozonation followed by another bioremediation of soil was more successful than phytoremediation. But even the most promising successful treatment in this study (ozonation for 6 hours at 25ppm followed by bioremediation) still only removed approximately 31% of the residual hydrocarbons. Overall, this work showed that the bioremediation of such highly contaminated soils is difficult and that a combination of treatments would be required to achieve successful remediation. Even after initial dilution and bioremediation the soils remained toxic to plant growth and were therefore not suitable for phytoremediation.

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