Bio-Raptor™ Field Demonstration at Signal Hill Petroleum Company's Landfarm

Six Week Results

Edited by

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Bio-Raptor™ Field Demonstration at Signal Hill Petroleum Company's Landfarm (Synopsis)

Introduction

Signal Hill Petroleum Company (Signal Hill), an oil production company, has been landfarming crude oil impacted soil for years. These generally contain crude oil and mixed clays/silt soils. The aim of the landfarm is to remediate soils by natural attenuation, that is, to allow the indigenous microflora to digest the crude oil. However, Signal Hill has found this to be a lengthy process, in the order of years if left alone with no further manipulation.

In late 1999, as a joint demonstration project with Signal Hill Petroleum Co. and Sub-Surface Waste Treatment, the California Avenue Treatment Plot (Signal Hill, CA) was chosen for the bioremediation project. The aim of this project was to process 3000 tons of crude oil contaminated soil through the Bio-Raptor™ and to stack the processed soil in windrows at various depths with no additional aeration or material handling and to measure resultant hydrocarbon degradation.

Objective

The objective of this field application was achieve longer chain (C22-C35) petroleum hydrocarbon degradation to that of below 1000 ppm within six weeks using a minimum of equipment and labor resources.

Process

The Bio-Raptor™ is a shredder, conveyor, sprayer system, that is used to particalize soil so that maximal surface area is achieved for a spray application of water containing activated microbial blends. After the contaminated soil passes through the Bio-Raptor™ system it is stacked onsite, where the microbes degrade the hydrocarbon chains into carbon dioxide, water and other innocuous substances. In many cases, the concentration of the offending contaminants can be reduced to non-detectable levels or levels that meet or exceed governmental standards for a non-contaminated classification. As compared to alternative thermal burning processes, the Bio-Raptor™ process does not release noxious gases into the atmosphere, minimizes offsite transportation and liability of contaminated soil through populated neighborhoods, is relatively quite, and does not pose explosion hazards. Typical contaminants which have been treated successfully include: diesel fuel, gasoline, jet fuel, oil derivatives, pesticides, sludges, and crude oil.

Methods

Over a period of three days, 3000 tons of contaminated soil was processed through the Bio-Raptor™ utilizing U.S. Microbics' proprietary blend of oil-degrading microbes using two front loaders (with 3.5 cubic yard buckets), and a bulldozer. The processed soil was then windrowed at heights between four feet and eight feet (as high as the front loaders could reach without soil compaction). A small, untreated pile was placed in separate location to serve as a control for the duration of the project. Pretreatment composite samples were obtained at ten-bucket load intervals to assess the hydrocarbon concentration range of the soil being processed. The total petroleum hydrocarbon range (C_4-C_{35}) was between 6700 ppm and 14,300 ppm with the average being 9478 ppm.

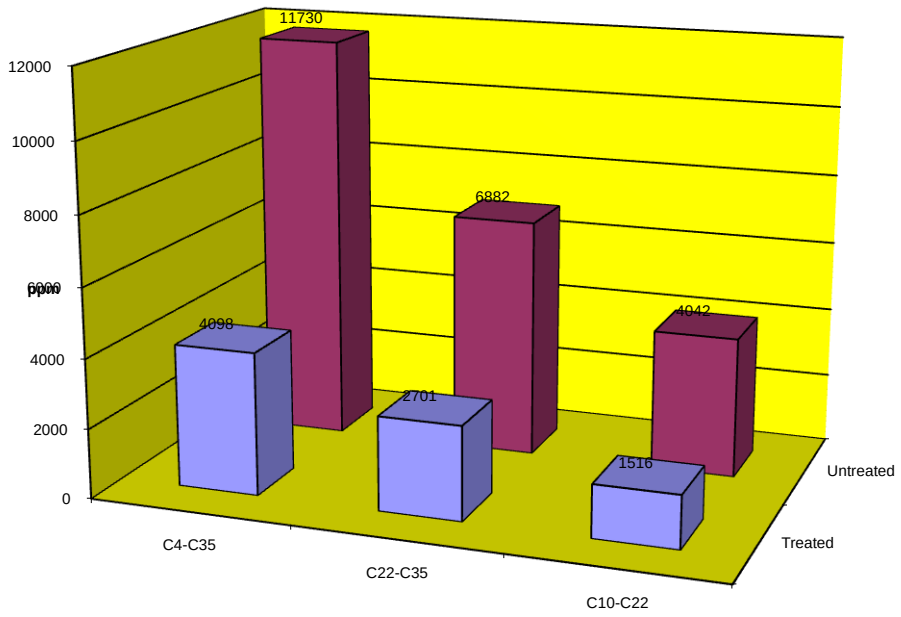
After the microbial application, the surface of the windrows was moistened every day for a short period to aid in moisture retention. Samples were obtained from six selected areas in the windrows and the control pile at one week, two weeks, four weeks, and six weeks after treatment and sent to a certified environmental laboratory for analysis. The control pile was accidentally bulldozed before the six week samples were obtained. However, control concentrations did not vary much during the remediation process and the four week results were used for comparative measurements at six weeks. For each of the selected areas, a composite sample was obtained from each of the top, middle and bottom of the respective piles. The analysis method used was EPA method 8015, which measures petroleum hydrocarbons. More specifically, four groups of petroleum hydrocarbons (by carbon containing number) were measured. The C_4-C_{10} range measures gasoline hydrocarbons, which include benzene, toluene, ethylbenzene, and xylenes. The C_8-C_{16} range measures kerosene compounds. The C_{10}-C_{22} range measures diesel fuel compounds, while the C_{22}-C_{35} range measures waste oil or larger crude oil compounds. The unit of measurement was mg/kg, which is equivalent to parts per million (ppm).

Results

The initial, pretreatment average sample results based on 50 samples are as follows: C_4-C_{10} range hydrocarbons measured 12.38 ppm, C_8-C_{16} hydrocarbons measured 0 ppm, C_{10}-C_{22} hydrocarbons measured 3261 ppm, the C_{22}-C_{35} hydrocarbons measured 6221 ppm. The average total hydrocarbon range (C_4-C_{35}) was 9478 ppm.

After two consecutive weeks of follow up sampling, the average concentrations based on two sampling events are summarized in Table 1 and Figure 1 (Page 4). Week four results are summarized on page 5. Week six results are

summarized in Table 3 and on Figures 2-3 (Pages 6-7).

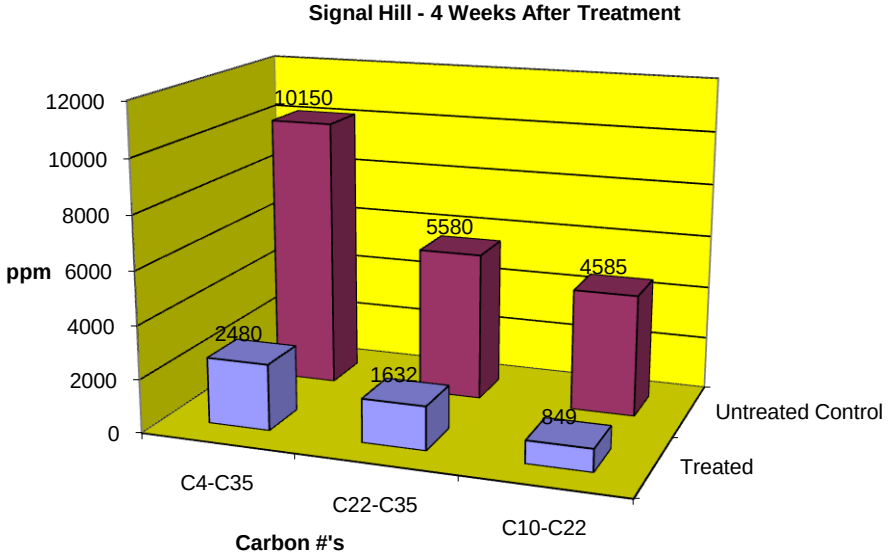


	C4-C35	C22-C35	C10-C22
Treated	4098	2701	1516
Untreated	11730	6882	4042

Petroleum Hydrocarbon Degradation Two Weeks After Treatment

	Total Range C4-C35 ppm	Crude Oil Range C22-C35 ppm	Diesel Range C10-C22 ppm	Gasoline Range C4-C10 ppm
Control	11,730	6882	4042	0
Treated	4098	2701	1516	0
% Reduction	65%	61%	63%	not applicable

Figure 1: This graph represents the reduction average based on the combined sampling results from week one and week two. C4-C35 represents the total petroleum hydrocarbon range spectrum of the analytes. C22-C35 represents the carbon range of waste oil and crude oil. C10-C22 represents the carbon range of diesel fuel hydrocarbons.

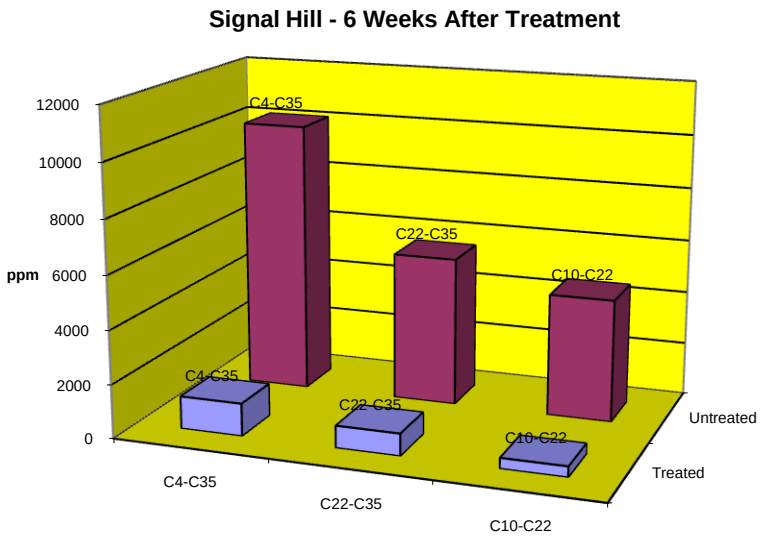


	C4-C35	C22-C35	C10-C22
Treated	2480	1632	849
Untreated Control	10150	5580	4585

(Table 2) Petroleum Hydrocarbon Degradation Four Weeks After Treatment

	Total Range C4-C35 ppm	Crude Oil Range C22-C35 ppm	Diesel Range C10-C22 ppm	Gasoline Range C4-C10 ppm
Control	10150	5580	4585	0
Treated	2480	1632	849	0
% Reduction	76%	71%	81.50%	not applicable

Analytical results and lab samples were compiled and collected by Signal Hill Petroleum and Sub-Surface Waste Management personnel.



	C4-C35	C22-C35	C10-C22
Treated	1217	825	392
Untreated	10150	5580	4585

Figure 3: This graph represents the reduction average based on sampling results from week six. C4-C35 represents the total petroleum hydrocarbon range spectrum of the analytes. C22-C35 represents the carbon range of waste oil and crude oil. C10-C22 represents the carbon range of diesel fuel hydrocarbons.

(Table 3) Petroleum Hydrocarbon Degradation Six Weeks After Treatment

	Total Range C4-C35 ppm	Crude Oil Range C22-C35 ppm	Diesel Range C10-C22 ppm	Gasoline Range C4-C10 ppm
Control	10150	5580	4585	0
Treated	1217	825	392	0
% Reduction	88%	85%	91.5%	not applicable

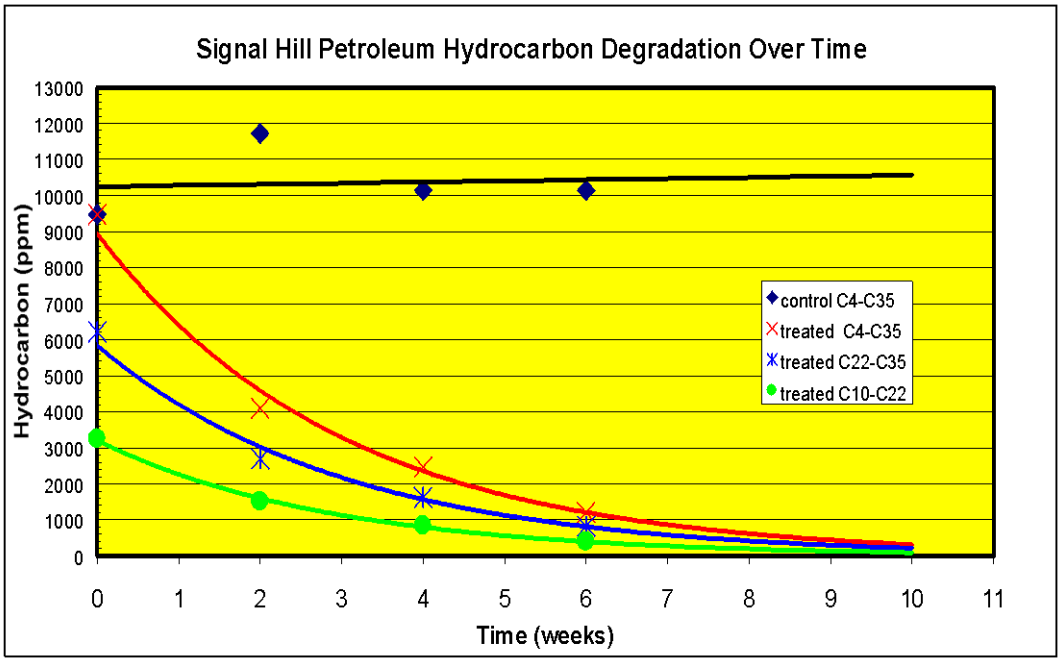
Figure 4: Comparative graph of showing the degradation curves of the various chain hydrocarbons over time as compared to the total average petroleum hydrocarbon (C4-C35) untreated control over time. (7 to 10 week results extrapolated based upon exponential smoothing).

Conclusion

The purpose of this field demonstration was to monitor petroleum hydrocarbon degradation under conditions that would minimize space requirements needed for traditional landfarming. To do this, two windrows were laid out in various stack heights. Another consideration was to measure degradation without any additional aeration. The objective of this field demonstration (C22-C35 degradation to below 1000 ppm) was reached within 6 weeks.

Results showed that six weeks into the program, petroleum hydrocarbon reductions approached 90%. In fact, fifteen of the eighteen samples obtained for the 6th sampling event revealed no detection of any petroleum hydrocarbon. It is interesting to calculate, based on average sampling results, and the total amount of soil treated, the amount (in pounds) of petroleum hydrocarbon present in the 3,000 tons originally treated and the amount of hydrocarbon (in pounds) digested six weeks after treatment. The average pretreatment sampling results of 9,478 ppm would contain **56,868 pounds** of hydrocarbon in 3,000 tons of soil. The amount of hydrocarbon present in the soil after six weeks of treatment based on 1,217 ppm is **7,302 pounds**. That means, that on average, **49,566 pounds** of petroleum hydrocarbon has been digested by the microbes in six weeks! This is roughly equivalent to 147 barrels of crude oil (one barrel = 42 gallons).

As a footnote, the bioremediation process used approximately 1,000 # of microbial blends which consumed 49,566 pounds of petroleum hydrocarbon. **This result means that each pound of bugs consumed 50 times its weight in 6 weeks!**



This field demonstration has shown, so far, that petroleum hydrocarbon remediation has occurred at a very good rate under the parameters mentioned above. If the windrows had been turned and aerated on a regular basis, the likely result would have been hydrocarbon digestion at a much greater rate.