Soil Remediation Test

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**D. M. Manlapig
W. Williams**

**PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY FOSSIL
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Abstract

Soils contaminated with petroleum by-products can now be effectively remediated using a variety of technologies. Among these are in-situ bioremediation, land farming, and landfill/replacing of soil. The range of efficiencies and cost effectiveness of these technologies has been well documented. Exsorbet Plus is showing promise as an in-situ bioremediation agent. It is made of naturally grown Spaghnum Peat Moss which has been activated for encapsulation and blended with nitrogen-rich fertilizer. In its initial field test in Caracas, Venezuela, it was able to remediate crude oil- contaminated soil in 90 days at less than half of the cost of competing technologies.

Waste Solutions, Corp. and the US Department of Energy signed a Cooperative Research and Development Agreement to test Exsorbet Plus at the Rocky Mountain Oilfield Testing Center near Casper, Wyoming. As part of the test, soil contaminated with crude oil was treated with Exsorbet Plus to aid the in-situ bioremediation process. Quantitative total petroleum hydrocarbon (TPH) measurements were acquired comparing the performance of Exsorbet Plus with an adjacent plot undergoing natural unaided in-situ bioremediation.

Introduction

The Rocky Mountain Oilfield Testing Center (RMOTC) is located at the US Department of Energy's (DOE) Naval Petroleum Reserve No. 3 (NPR 3) approximately 35 miles northeast of Casper, Wyoming. RMOTC was established, by the DOE, to partner with the petroleum industry to improve domestic production through the field testing of new production, drilling, and environmental technologies, and disseminating information to the petroleum industry. NPR-3 is a 10,000-acre producing oil field. The reserve produces from 500 wells ranging in depth from 250 ft. to 6000 ft., and all are available for field test.

During Fiscal Year (FY) 2000, tank battery B-1-20 was taken out of service and decommissioned. Hydrocarbon contaminated soils were gathered and placed in a land farm area permitted by Wyoming Oil and Gas Conservation Commission (WOGCC). The site measures approximately 200' x 300'. It contains 30,000 cubic feet of contaminated soil. RMOTC selected this site to conduct a field test using a commercial peat moss material to accelerate the natural hydrocarbon degradation process.

Test Description

RMOTC partnered with a private industry company to test a commercial peat moss material to aid the in-situ bioremediation process. Quantitative total petroleum hydrocarbon (TPH) measurements were acquired comparing the performance of the soil amendment with an adjacent plot undergoing natural unaided in-situ bioremediation.

The objective of this test was to promote a better and more cost-effective method of cleaning up crude oil spills and improving the environment.

Several measures of hydrocarbon are available. EPA measures hydrocarbons by a standardized analytical protocol called EPA-418.1, known as O&G. This test, when applied to soils, is time consuming and costly. The use of the analytical method known as EPA-418.1 was used to comply with Wyoming Oil and Gas Conservation Commission rules. Two variations of TPH are available: TPH-Infrared and TPH-Gas Chromatography with Flame Ionization Detection. Neither O&G nor TPH serve as an adequate index for tracking bioremediation treatment performance. Both methods demonstrate little or no decrease in hydrocarbon content as the result of bioremediation because the method reports biomass as TPH. The results demonstrated no reduction of TPH as the result of treatment.

Gas chromatographic analysis of total petroleum hydrocarbon standardized to peak area response is a better indicator of bioremediation performance. The EPA-8015 modified method, which is gas chromatographic and measures diesel and gasoline range organic compounds, was used in conjunction with EPA-418.1 modified method to determine the bioremediation performance of the land farm.

Experimental Design and Procedure

Testing Procedures

The land farm located at B-1-20 measured approximately 200' x 300'. The land farm was divided into two separate plots, a control and a treated both measuring 100' x 100'. A small tractor was used to disk the soil 6 inches deep. This technique distributes the soil amendments and aerated the system. Each month the land farm was disked to allow a greater surface area for soil contact with water and chemical amendments.

A composite sample from five distinct sections from the control and five from the treated plot were collected using a shovel to dig a one-foot deep profile. At each of the five sections a soil scoop was used to measure four scoops per section. The representative samples for the control and for the treated plots were mixed in a five-gallon bucket separately to obtain a composite for each section. The soil sifter was used to homogenize the sediments. From these sediments three soil samples from the treated and three soil samples from control testing plots are stored in six 250 ml sample jars. Four of the samples were taken to Energy Labs for analysis using the standard methods EPA-418.1 modified and EPA-8015 modified. The two remaining soil samples were analyzed using the Hach NPK-1 soil test kit to measure nitrogen, phosphorus, potassium, and pH in soil. To prevent cross contamination from each plot the shovel, sifter, soil scoop, and five-gallon bucket were cleaned with distilled water.

Discussion

Organic amendments in the form of peat moss or low salt manure improve soil structure. Also, organic materials serve as a sink for salts by exchange mechanisms and dilute salts in soil solution by increasing moisture-holding capacity. Fertility adjustments in the form of fertilizer amendments, aeration, and moisture are necessary for bioremediation program. Fertilizer amendments include nitrogen, phosphorus, and potassium. Ammonium nitrate, ammonium sulfate, and urea are good nitrogen sources. Split application coupled with tillage operations increase fertilizer use efficiency, and lessen the potential for eutrophic stagnation. Research shows the optimum carbon, nitrogen (C:N) ratio for field degradation of petroleum hydrocarbon is 150:1. A lower C:N ratio theoretically will improve degradation rates. Phosphorus and potassium are elements that may be limiting in the soil matrix and cause a positive response when added to the system. A nitrogen, phosphorus, and potassium (N:P:K) ratio of 4:1:1 provides good balance of these elements. They should be applied in split application to increase efficiency. Fertilizer applications should be tilled into the soil to distribute the amendment through the treatment zone. Tilling also infuses oxygen into the soil. Generally some other variable, such as water use efficiency or free air exchange limits the utility of adding more nutrients.

Analysis from the Hach soil kit shows that the soil on both the treated and control plots range from a pH of 6 to 7 indicating the soil is fairly neutral in hydrogen ions. High levels of phosphorus and low levels of nitrogen were also indicated by the Hach soil test kit. These results indicate that the N:P:K ration is not balanced.

According to the analytical results from Energy Laboratories analysis report, TPH measured by EPA 418.1 and EPA 8015 modified from dates 5/25/00 to 7/13/00 has decreased on the treated plot. TPH decreased by 2,170 mg/Kg according to the EPA 418.1 test results. (Figure 1) Analytical results from laboratory analysis indicate that diesel range organics (EPA 8015 modified) decreased in concentration by a factor of 2,860 mg/Kg. Both analytical results indicate positive reductions of hydrocarbons. EPA-418.1 measures total hydrocarbon biomass, while EPA-8015 modified measures specific DRO compounds. However, variation in TPH and diesel range organics has been observed from the analytical test analysis. This can be caused by a number of variables such as: soil moisture content, soil sampling techniques, diskng procedures, fertilizer amendments, and soil temperature. All of these factors can affect the rate of hydrocarbon degradation and also influence analytical test results.

Conclusion

Remediation entails biodegradation of crude oil using native soils' microflora. Biosimulation involves the modification of the site to enhance the growth of indigenous microbes already present. Parameters having a profound effect on rates of hydrocarbon degradation include: initial oil level, moisture content, aeration, Carbon:Nitrogen ratio, and other fertilizer amendments. Through observation and research the bioremediation of the contaminated site indicates a reduction of hydrocarbon levels. For optimal remediation of the site, the following recommendations could have been enacted:

- Add more of the commercial peat moss product to the land farm and test to ensure the proper balance of the N:P:K ratio.
- Closely monitor soil moisture content to ensure that moisture levels range between 50 and 80 percent of the soil water-holding capacity.
- Disk the site twice a month to a depth of 10 inches to ensure aeration of the system and to distribute the soil amendments.
- Change to cross section sampling technique to ensure a good representative composite of the entire plot.

Due to lack of response from the client none of the recommendations were enacted and the project ended prematurely.

Appendix A-References

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Appendix B-Figure

Figure-1