WASTEWATER TREATMENT - INDUSTRIAL

14200 PETROLEUM REFINERIES & SOIL REMEDIATON CASE STUDIES AND TESTIMONIALS

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The case study results listed above were achieved with MICROBE-LIFT® Technology and products, formulated and manufactured by Ecological Laboratories Inc., with technical support for administering the products provided by Ecological Laboratories Inc., in support of their worldwide representatives.

For more information on MICROBE-LIFT® Technology contact

Ecological Laboratories Inc.
www.EcologicalLabs.com

CS14200

Made in the USA

A Major Oil Company in Hong Kong Remediates Subsurface Hydrocarbon Contamination with MICROBE-LIFT® Technology

Location: **Oil Transportation & Transfer Site, Hong Kong**

Background: **Ecological Laboratories** has addressed wastewater technology internationally for over ten years. In that time they have remediated a variety of petroleum contaminated sites including oil production ponds in Venezuela for GEBetz, containment ponds in Israel, and sites in the Dominican Republic and throughout Asia. In this case, a major oil company, who chooses to remain anonymous, had detected contaminated soil under a concrete slab at an oil transportation and transfer site. The oil had seeped into the ground to a depth of two meters.

Objective: To avoid further mobilization, it was imperative to remove the oil by the most cost effective, least disruptive technology available. Working with their local agent, Ecological Laboratories developed a remediation plan using MICROBE-LIFT® technology.

Because in-situ treatment generally requires support engineering, it is important to first confirm that the hydrocarbon can be degraded by the inoculant and that the site does not contain additional toxicity that would inhibit biological activity. Therefore, a benchtop remediation trial was run using a soil bio-slurry inoculated with a MICROBE-LIFT® formulation.

This MICROBE-LIFT® formulation was applied to a slurry containing contaminated soil in a tank. Dry weight of material was 10-15%, pH 7-9, TPH content at 3-5%. The TPH was not diesel based, but made up of linear hydrocarbon chains between C12 and C20. The boiling point is between 200° and 250° C in the gas chromatographic analysis (C10-C40) giving the following splitting in mg/kg dm:

Hydrocarbon Fraction C10-C40 mg/kg Ds 43,400
Hydrocarbon Fraction C10-C12 mg/kg Ds 875
Hydrocarbon Fraction C12-C16 mg/kg Ds 21,375
Hydrocarbon Fraction C16-C20 mg/kg Ds 6,750
Hydrocarbon Fraction C20-C24 mg/kg Ds 2,475
Hydrocarbon Fraction C24-C28 mg/kg Ds 800
Hydrocarbon Fraction C28-C32 mg/kg Ds 400
Hydrocarbon Fraction C32-C36 mg/kg Ds 460
Hydrocarbon Fraction C36-C40 mg/kg Ds 300

The test tank contained +/- 600 liters in a slurry (+/- 75 kg waste+ 525 kg water). Nitrate was added to assure that proper C:N:P ratio for biological degradation was present. The slurry was re-circulated in order to provide adequate mixing. The initial test was run for 28 days. Each 7 days the slurry was sampled in order to follow the TPH content and the biodegradation.

A Major Oil Company in Hong Kong Remediates Subsurface Hydrocarbon Contamination with MICROBE-LIFT® Technology

Solution:

After three weeks the MICROBE-LIFT® formulation had reduced the petroleum by 71%.

MICROBE-LIFT® had readily degraded the contaminating TPH and there was no toxicity present that would prevent a successful remediation. The results of the study are shown below:

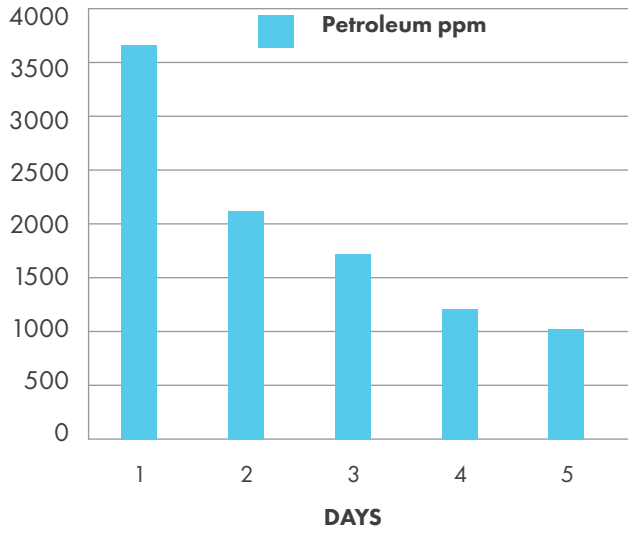

Fig. 1: *This graph shows the result of the bench top remediation with an initial concentration of 35-40,000 ppm of hydrocarbons C10 to C40 being reduced by 71% in one week*

Results Achieved:

The in–situ treatment was initiated. After drilling a test hole of two to three meters, a gradient-flow analysis was conducted. Diluted MICROBE-LIFT® was applied through injection holes and recycled through extraction holes downgrade to get the same results in the field. The site was successfully remediated. In our experience, all applications for in-situ remediation tend to be site specific depending on other contaminants present and engineering required providing adequate contact, but in general most land treatment plans require the following:

- Inoculation with capable consortium of microbes (pretesting recommended)
- Provision of the necessary nutrients (adjust C:N:P ratio)
- pH and moisture adjustment as necessary
- Assurance of contact between microbes and pollutants:
  1. Land farm surface pollution - work remediation ingredients into soil or
  2. Subsurface soils - provision of an engineered system, often pump and treat, to assure contact
- In some cases, a solubilizing agent such as a lipophilic surfactant may be recommended to increase surface contact.

Effective bioremediation is always the most cost effective solution for elimination of hydrocarbon contamination and it is widely used by industry globally. Ecological Laboratories' MICROBE-LIFT® technology, is a highly effective solution to hydrocarbon pollution when used with proper, site-specific application.

For more information on MICROBE-LIFT® Technology contact

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Successful In Situ Remediation of Hydrocarbon Contaminated Soils in South Africa

Location: PepsiCo Frito-Lay Simba Isando, Gauteng, South Africa

Background: Use of the vehicle workshop area at the Frito-Lay Simba Isando plant was discontinued due to outsourcing of the distribution chain. An area in front of the wash bay borderedby the workshop and boundary walls had been heavily contaminated by hydrocarbon.This contamination was a mix of petroleum (PRO) and diesel (DRO) range organics and covered a surface area of approximately 300 square metres. The contamination occurred in three main areas, these being DRO in approximately 30 square metres under the removed diesel tank, a mix of DRO and PRO in approximately 120 square metres in front of the wash bay and an area of approximately 90 square metres of tar macadam covered soil. The wash bay area was contaminated with a mixture of petroleum, diesel,oils, alkanes and kerosenes. During initial sampling the average depth of contamination was found to be 150 mm below the surface, a target depth of remediation was set at 250 mm below the surface. In order to re-use this ground the company requested they 2000 mg/kg. This value was chosen based on the fact that the site was industrial and would not readily be used for agriculture or human occupation in the foreseeable future. Another factor affecting this target is that the Department of Water Affairs and Forestry (DWAF) had in the past recommended the use of a similar target for hydrocarbons in an industrial area (Snyman 1996). The area was completely enclosed by concrete walls on three sides and a brick workshop on the remaining side. Thus, in-situ bioremediation was the preferred method providing the following benefits:

- No expensive removal and replacement of the walls was needed,
- No removal and transfer of the contaminated soil would be required.
- No addi tional treatment system was required.
- No suitable dumping site with associated transfer and fees would have to be utilized.

Objective:

Due to environmental audits there was a need to bioremediate the soil in as short a time span as possible with a 12-week time span allocated. To create the most favorable conditions for a successful bioremediation of hydrocarbons in soil, a number of factors needed to be considered:

1. Product specifically manufactured for the bioremediation of hydrocarbons would be needed. MICROBE-LIFT® technology in the USA were selected based on proven efficacy and exceptional technical backup available from the producers of the product, **Ecological Laboratories**, based in Florida USA.

2. The soil needed to be regularly tilled to the depth of the contamination in order to aerate the soil providing the most suitable conditions for the growth of the bacterial colonies.

3. The Carbon:Nitrogen:Phosphate (C:N:P) ratio of the soil was tested and modified as necessary to provide optimal nutrient conditions for growth of the amended bacteria.

4. The soil was kept damp, but not saturated, to provide the most suitable environment for bacterial growth. Due to the limited time and budget available this was achieved with a manually set flow rate of water as opposed to control via measured moisture content.

5. The bioremediation products were dosed in a regular regime to provide a continuous replenishment of the bacterial consortium to the area being treated thus building the most effective bacterial population for the oxidation of the hydrocarbon compounds.

The above conditions were satisfied using the following method. Prior to the delivery of hardware and product, initial soil samples were taken as a baseline for the bioremediation and to ascertain the C:N:P ratio. An independent laboratory was used to analyse the soil samples. Two sampling areas were determined to provide an average value of contaminated soil and a control sample of uncontaminated soil. The soil samples were taken by extracting a plug of soil which was then placed in a sample jar, inverted and kept at constant temperature in a polystyrene container until delivered to the laboratory.

The soil was then tilled to a depth of 250 mm.

The initial values for the C:N:P ratio were given as 100:4:1 rounding to the nearest whole number. This value was deemed to be close enough to the required values of 100:5:1; therefore no fertilizer was added.

An irrigation system comprising 25 mm irrigation pipe was laid. This consisted of a delivery trunk main pipe running along the west wall for 0.10 metres. This trunk main was fed via a 1 kW water pump fed by a 60-litre drum. The drum was replenished from the water main using a regulator valve to maintain a constant volume of water in the drum. Five branch pipes were laid 2 metres apart, running at right angles from the trunk main eastwards across the contaminated area. Each 30 metre branch pipe was connected to the trunk via a tee piece and regulating valve. 360-degree irrigation spinners were fixed at 2 metre intervals along each branch pipe. This layout created an effective grid system of 2 metre squares fed from each irrigation spinner. The required flow rate of water was then manually set using the regulator valves.

Once the required flow rate was confirmed by monitoring the soil moisture content for two days, ½ kg of MICROBE-LIFT® formulation was spread evenly over the soil. This dosage of MICROBE-LIFT® formulation was repeated every 2 days from the inoculation date.

In order to dose the MICROBE-LIFT® formulation,12 litres of MICROBE-LIFT® formulation as an inoculation dose was poured into the 60 litre drum feeding the pump. The mains water inflow to the drum created sufficient turbulence to mix the product with the water. This mixed product was then pumped into the irrigation system and evenly distributed via the 360 degree spinners. A quantity of spare spinners was kept available for replacement of blocked spinners. These were replaced as and when required. A MICROBE-LIFT® formulation dosage of 4 litres was then repeated every 2 days from the inoculation date.

This dosing schedule ran for 44 days from 15 May 2010 to 28 July 2010. The total product utilized was 47kg of MICROBE-LIFT® formulation.

The soil was then tilled to 250 mm once every two weeks.

Results achieved: The table below gives the results of the laboratory analysis:

Date	TPH mg/kg Series 1	TPH mg/kg Series 2	% Reduction In contaminated soil
13th May 2010	17630	151	
8th June 2010	16012	701	9.2
9th July 2010	1684	402	89.5
28th July 2010	1681	1433	89.5

Fig. 1: *Series one is the contaminated soil while series 2 refers to soil not considered contaminated.*

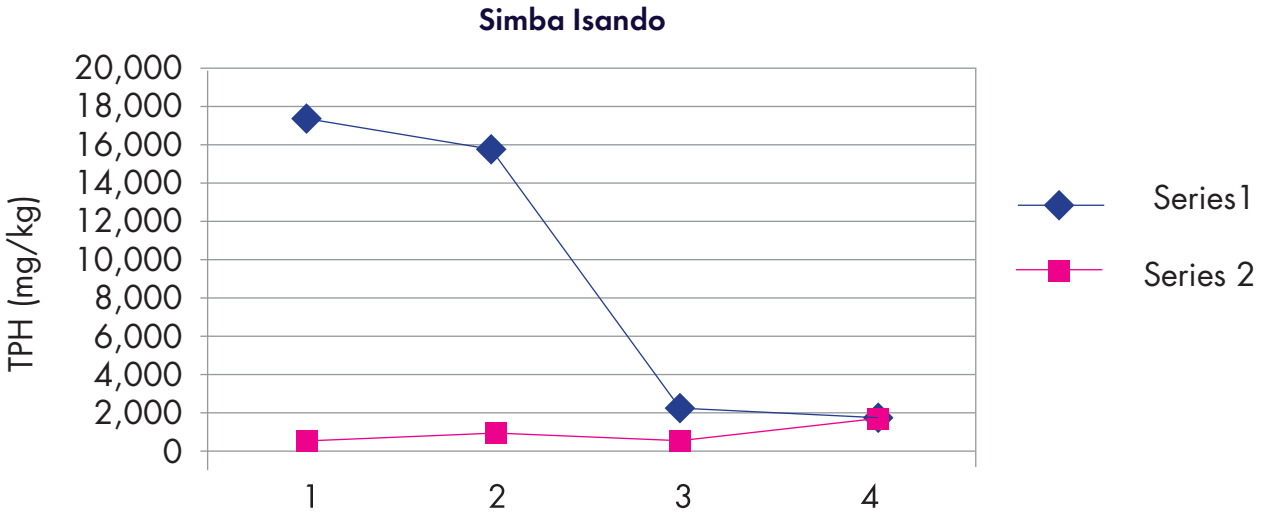

Fig. 2: *Shows the data represented graphically.*

Series 1 indicates that the contamination was reduced from an initial TPH value of 17630 mg/kg to 16012 mg/kg. This reduction occurred in the initial 3 weeks after inoculation indicating that the bacterial consortium from the MICROBE-LIFT® formulation has begun to take hold and multiply in the soil. The growth of the consortium reaches a peak in this period and begins to stabilize to a point where the bacterial colony has grown to a level where the colony/nutrient source is balanced and maximum oxidation of the hydrocarbons is in progress.

This oxidation process continues at this level for a period of 4 weeks until the nutrient content supplied by the hydrocarbons has been depleted to the point where the bacterial colony begins to die off in relation to the nutrient source.

During the final 3 weeks of the remediation the bacterial colony has once again reached equilibrium with the nutrient source, however at a much lower level. This is the expected outcome of the natural bell curve growth of organisms in the presence of a finite nutrient source.

Series 2 shows a small upward trend in the TPH value reaching approximately the same level of TPH value given by series 2. This upward trend is due to the action of the water/product mix creating an osmotic effect in the soil where some of the hydrocarbon contamination is spread throughout the treatment area. It is shown in the results that the target TPH value of 2000 mg/kg was reached and exceeded in 10 weeks with the final value being 1681 mg/kg. This is seen to be a reduction of 89.5%.

Conclusions: Despite the short time frame given for the bioremediation, the MICROBE-LIFT® formulation succeeded in remediating the hydrocarbon contamination. The required result of reducing the contamination to an acceptable level of 2000 mg/kg TPH was reached in 10 weeks, being 2 weeks shorter than the requested duration.

In short, **Ecological Laboratories** achieved a successful bioremediation using the method as proposed. MICROBE-LIFT® technology has proven its ability to degrade hydrocarbons in the DRO and PRO range.

For more information on MICROBE-LIFT® Technology contact
Ecological Laboratories Inc.
www.EcologicalLabs.com
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MICROBE-LIFT® Technology Cleans Up Petroleum Lagoon in Israel

Location: **Oil Company, Jordon Valley, Israel**

Background: Crude petroleum that had been collected from a transport spill was collected and deposited in a 100,000-gallon containment lagoon in the Jordan Valley, with the expectation that the petroleum would biodegrade over time.

Objective: After several months with little or no degradation observed, alternatives were evaluated to accelerate the petroleum breakdown. A recommendation was made to use bioremediation. After evaluating different microbial additives, **Ecological Laboratories** was contacted. **Ecological Laboratories** had utilized MICROBE-LIFT® technology very successfully in numerous petroleum clean-up applications.

Since the lagoon also contained municipal sewage there was adequate nitrogen and phosphorous present to provide the required nutrients for the petroleum degradation. In addition to the MICROBE-LIFT® formulation, FDG, a lipophilic surfactant, was applied to help solubilize the petroleum to make it more readily available to the microbes.

Fig. 1: *The lagoon was not a pretty sight with oil scum over the entire surface.*

Fig. 2: *A close-up picture shows the extent of the oil and scum in the lagoon.*

After inspection and evaluation of the lagoon, **Ecological Laboratories** developed a treatment plan as follows:

Day 1:	Add 300 mls. FDG (lipophilic surfactant) Plus 600 mls. MICROBE-LIFT® formulation
Every three days thereafter:	Add 70 ml FDG & 150 mls. MICROBE-LIFT® formulation

Fig.3*: Treatments were mixed with water and sprayed over the surface of the lagoon to provide maximum contact with the surface oil.*

Results:

After treatment, the water was dramatically cleaner with no visible oil scum on the surface.

The primary parameter for monitoring the crude petroleum breakdown was Total Petroleum Hydrocarbons (TPH). Other parameters tracked were Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Soluble COD, and Total Suspended Solids (TSS). Results from the outside lab testing of these parameters are shown below:

Initial, Pre-trial data (mg/l)				
BOD	COD	Soluble COD	TSS/TPH	TPH
1,900	12,900	268	55,427	25,000
After three weeks of treatment (mg/l)				
BOD	COD	Soluble COD	TSS/TPH	TPH
568	4,900	268	1,750	2,915
Percent removal in 3 weeks				
70%	62%		97%	88%

After three weeks of treatment, a reduction of almost 90% of the TPH was observed. While 60-70% reductions in BOD and COD were observed. The BOD numbers were likely artificially low due to the lack of the seed's acclimation to petroleum, which is known to inhibit microbial activity. Soluble COD did not change, due to that fact that as soluble COD is broken down more is solubilized by a combination of the added surfactant as well as biosurfactants produced by the bacteria. Generally, after all of the non-solubilized petroleum is solubilized and broken down, the soluble COD will drop to non-detectable levels.

Based on the three-week analytical data and physical observations, no further analytical testing was performed to save added cost as no more petroleum was observed in the lagoon. The initiation of the degradation had been confirmed.

This was another highly successful application for the degradation of petroleum oil.

For more information on MICROBE-LIFT® Technology contact
Ecological Laboratories Inc.
www.EcologicalLabs.com
CS14204

Effectiveness of Microbe-Lift® Bacteria Mixture in Bioremediation of Petroleum Contaminated Soils at Mostardi-Platt Plant

January 4, 1993

Ecological Laboratories, Inc.
P.O. Box 132
Freeport, New York 11520

Attention: Mr. Barry Richter, President

Gentlemen:

Effectiveness of Microbe-Lift Bacteria Mixture in Bioremediation of Petroleum Contaminated Soils

MOSTARDI-PLATT ASSOCIATES, INC. (MPA) has prepared this letter to inform you of the preliminary results of a controlled experiment involving the full-scale field application of Microbe-Lift for remediation of petroleum contaminated soils. In this experiment, four relatively uniform soil cells, with volumes of approximately 30,000 cubic feet each, were to be remediated by bioremediation. The contamination involved was a heavy fraction of petroleum.

Three of the four cells have been treated using an application technique developed by MPA that incorporates the Microbe-Lift bacteria mixture, and the remaining cell was left in its natural state as an experimental control. No nutrients or enzymes were introduced to any of the four cells. The systems have since been closely monitored for indications of microbial decomposition of the petroleum product present in the soils. Data collected during the first two months of activity indicate a 78% increase in biodegradation of petroleum in the cells treated with Microbe-Lift, over the untreated cell. MPA will continue this experiment and inform you of the progress achieved using your product.

Sincerely,
MOSTARDI-PLATT ASSOCIATES, INC.

Douglas M. Waring

Douglas M. Waring
Environmental Engineer

DMW/bit

Compliance Environmental Confirms PCB Transformer Oil Degradation in Bioremediation Test

COMPLIANCE ENVIRONMENTAL, INC.
45. N. Fairfiled Drive, Dover, Delaware, 19901 Phone.fax: 302-697-0681

May 5, 1995

Mr. Barry Richter
Ecological Laboratories, Inc.
P.O. Box 132
Freeport, New York 11520-0132

Re: Transformer Oil Test Project

Dear Mr. Richter:

We would like to thank you for allowing us to include your product, Microbe-Lift, in our bioremediation test project. Microbe-Lift was used along with several other products to investigate the oil degradation process of non PCB transformer oil.

We found that Microbe-Lift could be an effective alternative for transformer oil clean-up projects. Our tests of Microbe-Lift indicated that it possibly contributed to the reduced amount of Total Petroleum Hydrocarbons (TPH) present in our samples.

Thank you for your interest in the project. Please feel free to contact me if you have any questions or concerns.

Sincerely,

COMPLIANCE ENVIRONMENTAL, INC.

Valentino, P. DeRocili, CHMM
Senior Environmental Manager

MICROBE-LIFT® Technology Helps Remediate TPH Contaminated Soils in Georgia and Tennessee

Location: **PCS Nitrogen, Georgia & Tennessee Sites**

Background: PCS Nitrogen, a business unit of Potash Corporation of Saskatchewan, is one of the largest producers of nitrogen worldwide. It produces nitrogen fertilizers and feed ingredients from three manufacturing facilities in the US and one in Trinidad. When they experienced heavy contamination of soils with hydrocarbon and TPH compounds at two of their facilities, they utilized Ecological Laboratories' MICROBE-LIFT® technology to remediate these sites.

Objective: During 2005, 2006, and 2007, **Ecological Laboratories** supplied PCS MICROBE-LIFT®, MICROBE-LIFT® /IND, and MICROBE-LIFT®/SA to be used with nutrient management to enhance and speed the remediation process targeting the removal of the petroleum compounds.

The bioremediation at two sites, in Georgia and Tennessee, included land farming with monthly bioaugmentation application, followed up by wet lay up over colder winter months with the application of microbial treatment.

Results Achieved: These bioremediation programs resulted in site recoveries with dramatic reductions in priority pollutants and TPH. At one site the wet lay up period for three months over the colder period resulted in the reduction of 17 inches of contaminated soil and a corresponding reduction in pollutants, a surprising efficacy considering the low temperature of treatment. It is postulated that the photosynthetic strains in MICROBE-LIFT® provide a substantial advantage in soil remediations.

The following pictures show the dramatic improvement at the Tennessee site:

Fig. 1: *These pictures show the site before the beginning of treatment*

Fig 3: *Excavation to ready the site for land farming shows the extent of contamination.*

Fig. 4: *This picture shows the site after successful remediation.*

The dramatic "after treatment" picture above confirms the efficacy of MICROBE-LIFT®'s photosynthetic consortium in remediating petroleum contaminated soil, and in this case, efficacy in spite of low temperatures.

For more information on MICROBE-LIFT® Technology contact
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