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 bordered by 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 meters. The contamination occurred in three main areas, these being DRO in approximately 30 square meters under the removed diesel tank, a mix of DRO and PRO in approximately 120 square meters in front of the wash bay and an area of approximately 90 square meters 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 bioremediate the soil to a value below a total petroleum hydrocarbon (TPH) value of 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 additional 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 analyze 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 meters. 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 meters apart, running at right angles from the trunk main eastwards across the contaminated area. Each 30 meter branch pipe was connected to the trunk via a tee piece and regulating valve. 360-degree irrigation spinners were fixed at 2 meter intervals along each branch pipe. This layout created an effective grid system of 2 meter 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.*

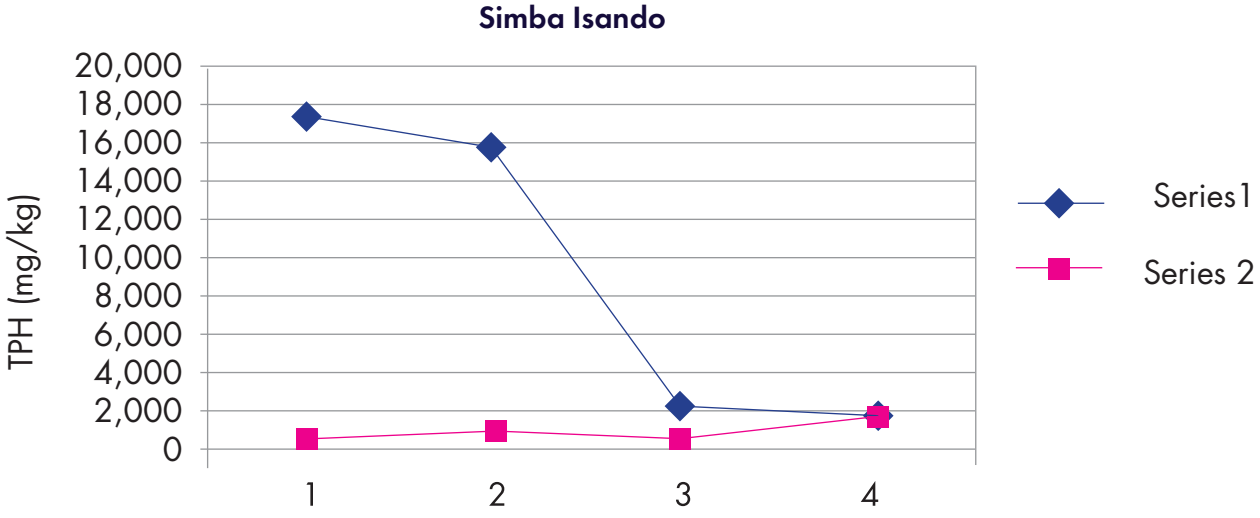

Fig. 2: *Shows the data represented graphically.*

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 1. 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
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