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BIOREMEDIATION OF A HOME HEATING OIL, KEROSENE, SPILL

USING NANOBITE PROACTIVE BIOREMEDIATION PRODUCTS

Report Date: June 2016

Louth County Council

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SUMMARY

In November 2015, Unirem Limited was requested to examine a domestic heating kerosene leak that had occurred in a semidetached house. A pipe or joint to the burner unit in the burner unit shed had cracked at an earlier time releasing heating oil, Kerosene, into the shed interior from where it pooled to the North and West of the shed, within the garden of the property.

Bore holes were sunk on a grid pattern into the concrete floor and wall of the shed and the soil surrounding the burner shed. Soil and concrete samples collected from these bore holes were sent for independent analysis to Bio Search (N.I.) Limited, 31 Dufferin Road, Belfast BT3 9AA for Total petroleum hydrocarbons (**TPH**) analysis.

A proactive bioremediation product Nanobite Liquid was used to bond with the fuel. Nanobite Liquid is a crystalline matrix that behaves like a liquid, that attaches to carbon atoms to form small perfect spheres wherein the contaminate is digested by naturally occurring microbes, turning the carbon based fuel into carbon dioxide (CO2) and Water (H2O). As Nanobite Liquid can be used on site, there is no need to dig and haul the contaminated soil away.

Results from Bio Search show that as of the 26th of May 2016 an average 98%of the contaminated was bio-remediated and continues to fall daily. Nanobite Liquid continues to work as long as TPH are present. When all the TPH is gone, the microbes within the matrix eat the matrix. There is no residue.

Bore Hole	Start	Finish	%
Location	mg/Kg	mg/Kg	Reduction
CONCRETE FLOOR CENTRE	31200	34.6	99.8891%
CONCRETE FLOOR CENTRE	51200	66.3	99.8705%
CONCRETE BACK WALL	698	44.1	93.6819%
SOIL MID FRONT	5870	87	98.5179%
SOIL MID SIDE	5200	110	97.8846%
Excavation Site	4180	110	97.3684%

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- Kerosene in soil and concrete eliminated
- Pungent odour of spilled fuel eradicated within 48 hours of application.
- Process is tidy and nonintrusive
- No harmful or toxic residue left
- No chemicals used
- No danger to the water table.
- No flora or fauna damaged or ever endangered.
- Soil returned and levelled.
- Soil micro-environment restored
  (Earth worms, Beatles and other microorganisms now active in treated soil)
- Plant life restores – grass and weeds now growing in spill area where they had been brown and dead foliage)
- Pictures, Test results on file: Unirem Limited
- No further action required

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The Process

Initial Contact

Details of the leak as reported to Unirem Limited were noted and a document was prepared on the 20th of October 2015.

The proposed actions to be undertaken were outlined in this document and they being acceptable to all parties, a meeting to inspect the contamination was organised.

Initial Meeting

An initial meeting took place at the premises on Friday the 23rd of October 2015 at 09.45. On entering the premises it was noticed that the odour of spilled kerosene seemed to be concentrated in the boiler house situated outside the house, in the rear garden

Burner Unit Shed:

On exiting the building a small shed, approximately 1 metre square was located outside and to the left the rear door of the house. The shed was in the corner betwixt the rear wall of the premises and the wall adjoining the neighbour's house to the left (South).

On the concrete floor of the shed the remains of an oil spill that had occurred sometime earlier was noted. The spill had occurred due to a leak from a pipe entering the burner unit. This pipe had been repaired and no sign of fresh or liquid oil was present on the concrete floor. The owner of the premises was not sure as to the amount of oil that may have been spilled.

The spilled oil having oxidised due to heat, the vapour omitted was noticeable. The odour was traceable in a radius of a metre from the shed.

Surrounding Ground
A new Oil tank was noted approximately four meters to the right of the Oil burner shed. No oil odour came from that units, and the grass growing in its surrounds showed that no oil had spilled from this unit. The singular source of the kerosene being the leak from the pipe within the oil burner shed.

Suggested Course of Action

A number of items need to be considered and steps undertaken in order to professionally eradicate this oil spill:

1. Eliminate the odour or spilled oil coming from the oil burner shed as quickly as possible for the health, safety and general comfort of anyone within the gaseous plume of the oxidised heating oil.
2. Establish the parameters of the spill, its width and depth.
3. Devise a plan to eradicate all the spilled hydrocarbon in-situ.
4. Provide testament that all the oil has been eradicated.

1. Eliminate the Odour:

There are two factors to consider here.
A. The vapour that is already in the air and
B. The vapour that might still be omitted from the oil burner shed.

A. Petroleum Hydrocarbon Air Vapour
The Application pf NanoBite Liquid sprayed in a fine mist will bond with any kerosene vapour that is in the air. The liquid bonds nearly instantaneously with petroleum hydrocarbon vapours and will within 48 hours turn all such vapour into harmless carbon dioxide and water.

The air in and around the oil burner shed in roughly a 1 metre circle radius would need to be sprayed. This would include and pipes, walls or other structures within this radius.

B. New Vapour Eradication
The area within the oil burner shed would be surface sprayed and scrubbed with NanoBite Liquid. This process would occur after ground samples have been taken from within the shed by means of a number of bore holes. The samples need to be taken first as the prior application of the NanoBite Liquid would interfere with the accuracy of the samples that are been taken.

2. Establish the parameters of the spill, its width and depth.

In order to establish the correct course of action, the width and depth of the oil plume needs to be established. Basically how wide the spill is and how deep it has gone. The only certifiable method of doing this is to take ground samples at different depths and widths in and around the outside of oil burner shed. This process is undertaken in a grid pattern.

The contents of these sample areas will be sent to an independent testing laboratory. The test that we would be carrying out would be to establish how much oil is located within the given sample and the results of this test usually are measured in parts per million.

TPH testing is not undertaken by labs in Ireland rather all samples are sent to England for analysis. Although Unirem Limited works with analytical laboratories within the island of Ireland, a time period of three weeks needs to be aside to allow the samples be sent to England and the results to return.

3. Devise a plan to eradicate all the spilled hydrocarbon in-situ.

Once the size and depth of the oil spill is known, exact plans can be drawn up to eradicate it. Having exact test results allows us to home in on the contaminated areas and apply the correct course of action. Depending on where oil is found we would provide specific services;

Oil in concrete
Drill holes would be placed into the concrete floor into which NanoBite Liquid would be injected. The NanoBite liquid would bond with and eradicate the spilled oil in situ.

Oil in Soil
Any oil discovered in the soil around the shed, will be excavated to a depth greater than that of the oil plume. The soil will be and spread out in 10 metre square lots, to a depth of 5cm onto which NanoBite liquid is applied. This course of action requires the turning of the soil, the number being directly dependent on the concentration of the oil found within the soil. At the end of the period, the oi will be eradicated, the concentration being brought down to background hydrocarbon levels.

4. **Provide testament that all the oil has been eradicated.**

At the end of the treatment period, additional tests would be conducted by means of sending soil samples off to an independent test laboratory to be tested for total petroleum hydrocarbons. This is known as a TPH test and is read in parts per million. The comparison between the original tests taken at the start of the work and the final tests taken at the end of the work, shows that the spilled oil has been eradicated.

Soil Sampling

The Unirem Limited initial field survey involved the boring of sampling holes into the concrete floor and walls of the burner shed and the digging of soil analysis pits in the soil adjacent to the burner shed

Information on the geology, hydrogeology and soils of the area from the Geological Survey of Ireland (GSI) was reviewed. The principal soil type in the area is gleys, which generally displays poor drainage characteristics. The gleys parent material consists mainly of Ordovician and Silurian shale and sandstone glacial till.

In addition, this gleys layer sits on a compact impervious layer of building debris. The property is a terraced house in an area of high urban density. Initial expectations based on the knowledge of the soil layout suggested that a kerosene leak of a minor nature, a leaking pipe (litres rather than hundreds or thousands) was most likely to remain near the soil surface.

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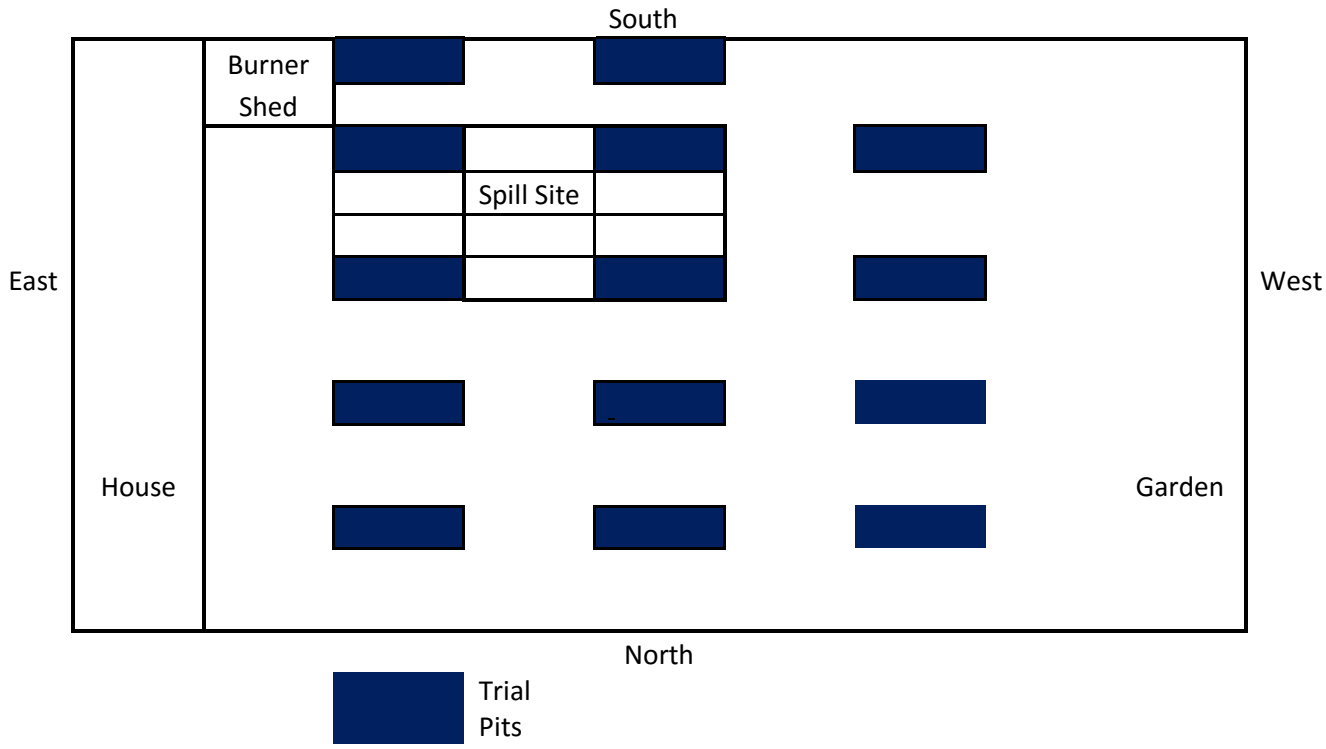
Pollutant Pathway

On investigation of the trial holes themselves, the poor quality drainage was a contributor to the spilled fuel largely pooling in an area to the north and west of the burner shed and to a depth no more than 40 cm. The initial identification of the spill area could be identified by the dead foliage, namely the black/ brown grass and weed stalks. Digging in this area confirmed the depth and width of the kerosene plume.

The digging of soil analysis pits is undertaken in a grid pattern. Sample pits are sunk to the deepest known depth the pollutant has sunk in a matrix one metre apart within the zone you are working in. The odour of spilled oil and the texture of it in the soil are easily recognizable.

Specific the spilled kerosene was found in an area to the north and west of the burner shed and that the kerosene plume was between 1 to 2 Metres square at this location at a depth of 40 cm.



Secondary pit Inspection
In order to certify that the correct width of the pollutant plume has been discovered, the pits are inspected after 48 hours to see if any kerosene has gathered within. No kerosene was found in any of the sample pits other than in the spill area already identified adjacent to the burner shed.

Third pit inspection
In order to certify that the sample pits have been dug to the correct depth, the sample pits are excavated to a depth 50% in addition to the deepest depth of any contamination found. The deepest depth being 40cm, 50% being an addition of 20 cm, the sample pits were then dug to a depth of 60cm. These samples pits were then observed for an additional 48 hours. No kerosene was found in the sample pits even after heavy rainfall (the sample pits held clear water)

Bioremediation Procedure

Burner Shed:

It was clear that the primary objective would be to eradicate the hydrocarbon within the concrete of the burner shed. The leak had occurred from a pipe or joint to the burner unit at the North West edge of the shed. The kerosene had pooled on the concrete within the shed and had saturated the soil to the North West of the burner unit.

Concrete being a mixture of cement, sand and water is vulnerable to the penetration and pooling within of petroleum hydrocarbons. Specific to this case the kerosene has soaked into the floor where the spill had occurred and then spread through the concrete.

The burner shed consisted of a concrete floor, concrete block walls and a tin roof. The shed acted like an oven when the sun shone, turning the kerosene liquid within into petroleum vapour. A gap between the tin roof and the block walls allowing this vapour to escape.

Boreholes were drilled into the concrete floor and walls in a grid formation. These bore holes were between 20 and 30 cm apart. Nanobite liquid was sprayed under pressure into these bore holes. This allowed the Nanobite liquid to bond with and eliminate any fuel that had impregnated the concrete. Anywhere where the kerosene went, the Nanobite liquid was capable of following. Nanobite Liquid locks onto the hydrocarbon chain and digests the kerosene one molecule at a time. As such it will follow the hydrocarbon chain (the spilled fuel) up walls and through the floor.

Soil Remediation

The kerosene plume to the North and West of the burner shed. The depth of the plume had been found to be 40cm. As explained earlier in this document; the soil here was excavated to a depth of 60cm.

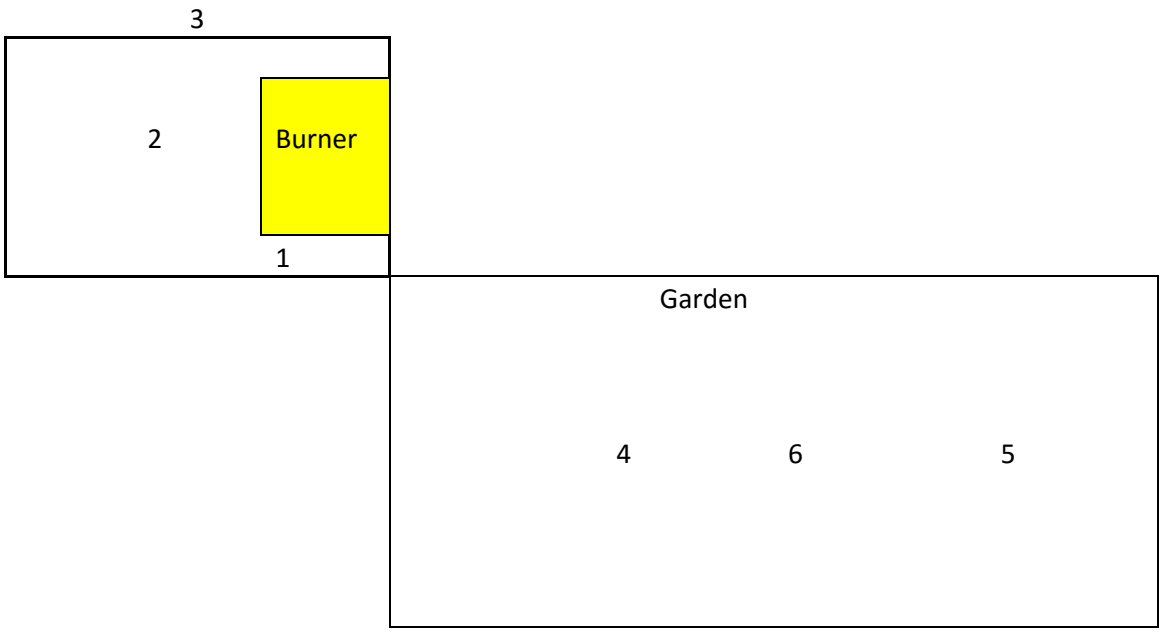
This soil was laid out to a depth of 5cm to the north and west of the excavation area. In all two and a half metric tons of soil were excavated.This soil and the excavation area were sprayed with Nanobite Liquid.

The excavation site was sprayed, even though at the time of excavation there was no kerosene present for the following reason. Oil in soil in an area beside a hole will flow into that hole due to rainfall. Thus if you prepare the ground beforehand no remedial action is needed latter.

During the remediation process the soil was turned three times and sprayed with Nanobite liquid.

Analytical Samples

Samples were taken from several areas within the burner shed and the contaminated soil. These were sent for analysis to an independent analytical laboratory Bio Search (N.I.) Limited, 31 Dufferin Road, Belfast BT3 9AA for parts per million presences of kerosene in the concrete / soil. This process is known as TPH analysis (Total Petroleum Hydrocarbons).



In all six sample sites were determined, three in the burner unit shed and three in the garden soil.

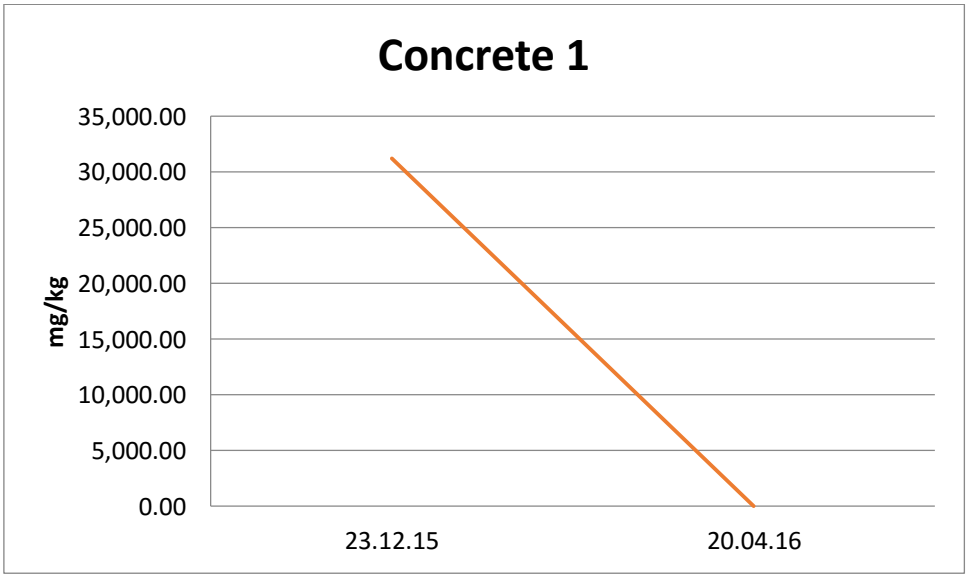
The first set of samples were taken from these areas on the 14th of December 2015 and sent by courier to Bio Search Ltd. for analysis. The laboratory section of Bio Search concluded its analysis on the 23rd December 2015. The lab results were then printed off and verified by Bio Search management and dispatched to Unirem Limited, which received the signed documentation in January 2016.

The second set of samples was taken on the 20th of April, 2016 and sent to Bio Search Ltd for analysis, the results being available on the 28th of that month.

The third set of samples was taken on the 27th of May, 2016 and sent to Bio Search Ltd for analysis the results being available on the 8th of June, 2016.

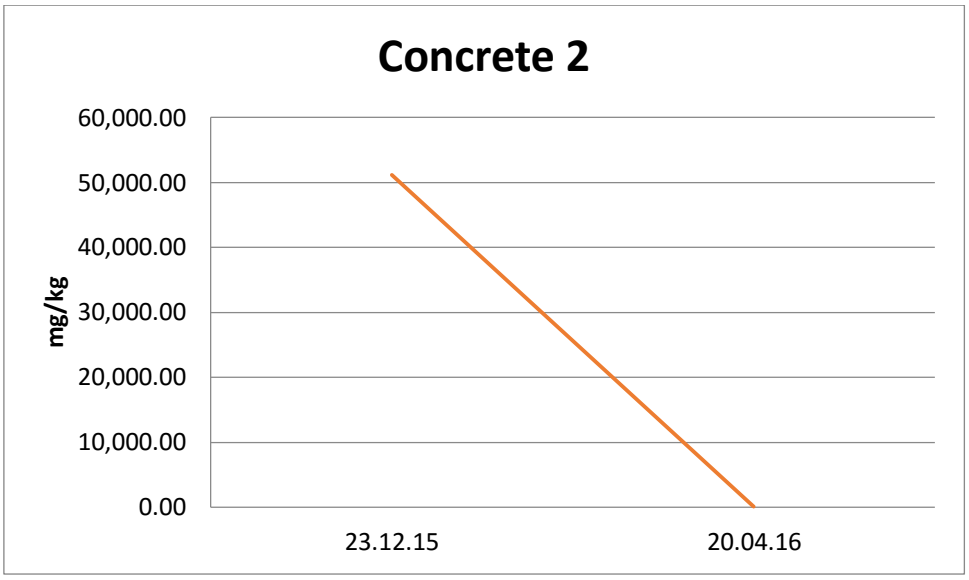
The result for each specific test area is listed in the following pages.

Analytical Results
Burner Shed/Concrete/Floor
Bio Search Ref: Sample Area 1



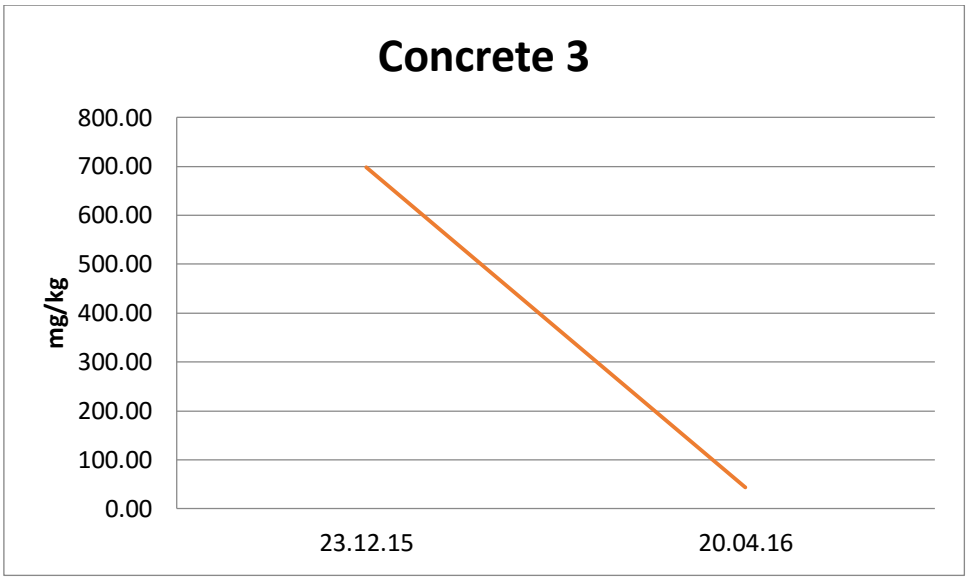
Date	Mg/Kg
23.12.15	31,200.00
20.04.16	34.60
Reduction	99.89%

Analytical Results
Burner Shed/Concrete/Floor
Bio Search Ref: Sample Area 2



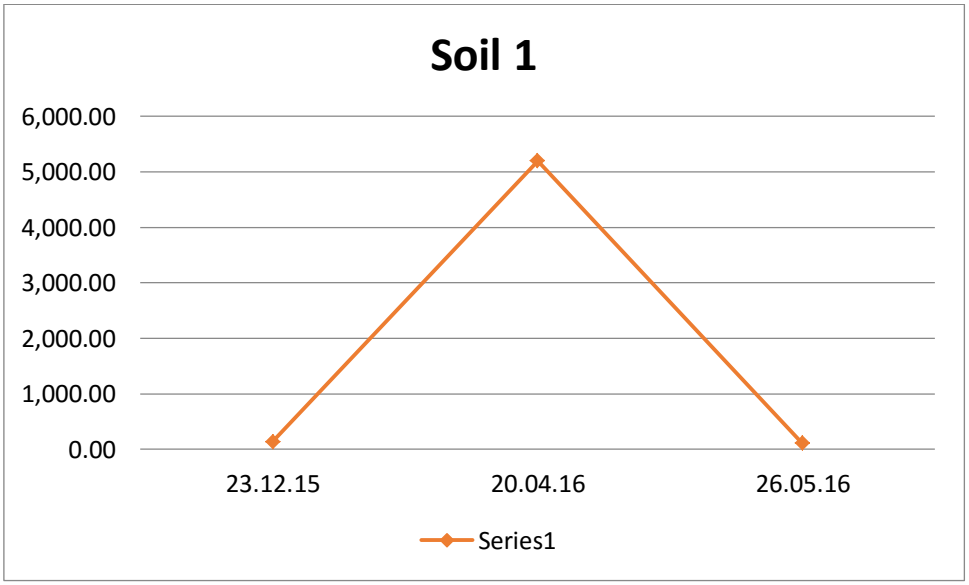
Date	Mg/Kg
23.12.15	51,200.00
20.04.16	66.30
Reduction	99.87%

Analytical Results
Burner Shed/Concrete/Back Wall
Bio Search Ref: Sample Area 3



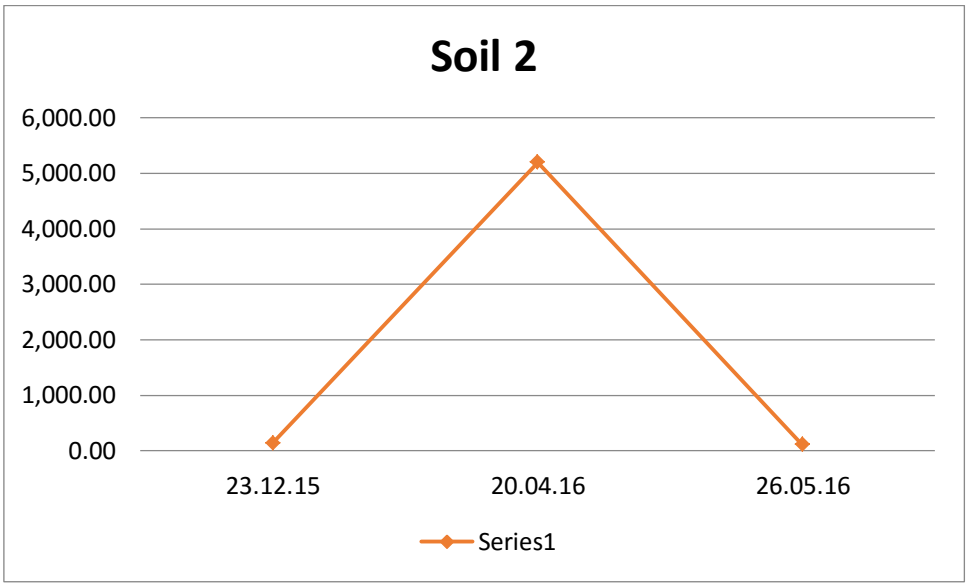
Date	Mg/Kg
23.12.15	698.00
20.04.16	43.10
Reduction	94%

Analytical Results
Soil 1
Bio Search Ref: Sample Area 4



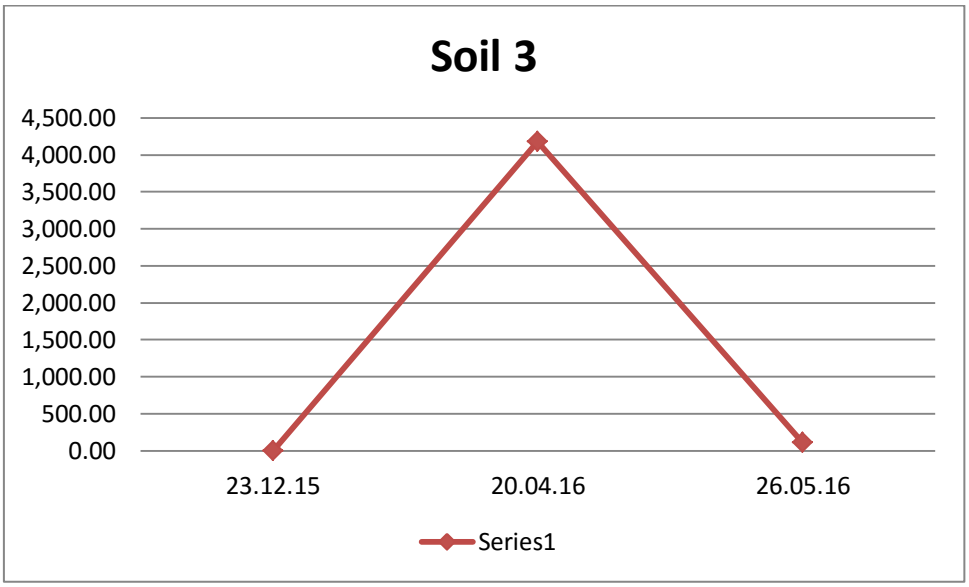
Date	Mg/Kg
23.12.15	157.00
20.04.16	5,870.00
26.05.16	96.90
Reduction	98%

Analytical Results
Soil 2
Bio Search Ref: Sample Area 5



Date	Mg/Kg
23.12.15	137.00
20.04.16	5,200.00
26.05.16	110.00
Reduction	98%

Analytical Results
Soil 3
Bio Search Ref: Sample Area 6



Date	Mg/Kg
23.12.15	0.00
20.04.16	4,180.00
26.05.16	110.00
Reduction	97%

Explanation of results

Unirem Limited utilizing Nanobite technology has reduced the contamination levels by on average 98% to date and falling daily. Nanobite liquid is an inert, fully biodegradable crystal matrix that locks onto the hydrocarbon chain pulling it into its matrix where naturally occurring microbes eat the oil.

Hydrocarbons behave differently in various material backgrounds. In concrete it tends to soak in, but stay put so is usually quicker to eradicate. In soil you will see a peak in readings after a number of weeks. The time period of this peak soil reading is dependent on the soil type, temperature, oil type and concentration. This process in Bio-Remediation is known as Encapsulation. Encapsulation is the result of the Nanobite crystal locking onto the hydrocarbon chain and pulling it into its matrix.

Please note a TPH test only tells you that hydrocarbons are present, not the state of decay they are in. In this spill the kerosene encapsulation peaked on the 20th April 2016 and having captured every chain of Hydrocarbon in the area, the naturally occurring microbes within the Nanobite crystal matrix eradicated it.

This also explains why there was a reading of 4000 mg/kg in May in the excavation hole. The reason for this is actually quite simple. Rain water carried the Nanobite crystals with oil trapped within them into the excavation hole from the surrounding area. The crystals are highly buoyant and will not sink thus no oil can enter the water table. The oil at this stage is non-toxic and has no odour as it is trapped within the matrix and bioremediating.

Although there are no Irish regulations or European guidelines for TPH clean-up levels in general, best practice recommends as per advice received from the Irish Environmental Protection Agency that a conceptual site model be developed and the use of Detailed Quantitative Risk Assessment (DQRA) techniques to assess the risks posed by individual contaminants. In this case the contaminant was known, namely home heating oil, namely Kerosene in the C9 –C16 carbon range and the extent of its exposure was limited to one specific area to the north west of the burner unit shed.

As there are no Dutch Guidelines or other limits set for TPH at present, limits set for mineral oil are sometimes used for comparison. The results determined were well within the Dutch 2009 Quality Safety Guidelines for Polyciclic Aromatic Hydrocarbons oil target levels (50 mg/kg) and way below the recommended intervention levels (5000mg/kg).

The output from DQRA normally provides Site Specific Target Levels (SSTLs) for remediation. These SSTLs are essentially clean up targets for any future remediation works and represent contaminant concentrations below which risks are deemed to be acceptable.

Best practice shows that clean-up levels in excess of 85% are deemed to be successful. Again a consideration given in setting SSTLs is the possible future corrective actions that the site involved may necessitate.

In this case no further action is envisaged or needed as the clean-up rate on site has reached **98%** efficiency.

Conclusion

- 98% success clean up rate
- Analytical testing undertaken by Bio Search Ltd.
- Contaminate in soil and concrete eliminated
- Pungent odour of spilled fuel eradicated within 48 hours of application.
- Process was tidy and nonintrusive
- No harmful or toxic residue left
- No chemicals used
- No danger to the water table.
- Grass to be restored
- Soil quality actually enhanced as microbial activity within the soil increases with the use of Nanobite liquid, whereas chemically cleaned soil has its naturally occurring microbial activity damaged.
- No flora or fauna damaged or ever endangered.
- No further action required

APPENDIX 1

BIO SEARCH ANALYTICAL RESULTS