Journal of Research in Biology

An International Scientific Research Journal

Original Research

Remediation of crude oil polluted soil in Otuogidi town in Bayelsa State of Nigeria using poultry manure.

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ABSTRACT:

Remediation by poultry manure (RPM) is a farming treatment technology, which relies on biological processes to cleanup pollution in soil. In this study, remediation by poultry manure was employed on oil contaminated site in Otuogidi town at Bayelsa State of Nigeria. 200g of the polluted soil samples were distributed in four sterile containers labeled A, B, C, and D. 100g, 200g, 300g and 0g of manure were added to the soil samples respectively. Then the total heterotrophic bacteria and fungi, hydrocarbon utilizing bacteria and fungi, total petroleum hydrocarbon, moisture content, sulphate content, nitrate content, phosphate content, soil pH and temperature were determined. The total heterotrophic bacteria counts ranged from 5.00 X 10^2 to 3.91 X 10^5cfug^{-1} and fungi ranged from 2.40 X 10^2 to 2.00 X 10^3cfug^{-1}. The hydrocarbon utilizing bacteria counts ranged from 3.20 X 10^2 to 3.02 X 10^4cfug^{-1} and fungi which ranged from 5.00 X 10^1 to 3.60 X 10^2cfug^{-1}. In the crude oil contaminated samples, the values of total petroleum hydrocarbon, pH and temperature were greatly influenced by high rate of microbial activities including high humidity which has a great impact in any given sample. This made the microbial and physicochemical properties of the soil samples to vary with the different concentrations of nutrient supplement and at different periods of remediation. Therefore, poultry manure is an effective method of remediating crude oil polluted soil.

Keywords:
Remediation, Contamination, Heterotrophic, Physicochemical, Microbial.

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Article Citation:
Ebe TE, Mgbemena IC, Njoku JD, Ihejirika CE, Emeribe E, Edward KC.
Remediation of crude oil polluted soil in Otuogidi town in Bayelsa state of Nigeria using poultry manure.
Journal of Research in Biology (2012) 2(6): 544-548

Dates:
Received: 06 Jun 2012 **Accepted:** 28 Jun 2012 **Published:** 31 Jul 2012

INTRODUCTION

The discharge of crude oil into the environment constitutes a serious pollution problem. This can threaten human health and of beneficial organisms in the environment (Aboribo, 2001). Increasing petroleum exploration, refining and operation petroleum companies in the Niger Delta region of Nigeria have led to the wide scale contamination of most of its soils, creeks, swamps, rivers and streams.

The main causes of oil spill in Nigeria include criminal damage, equipment failure example wellhead blowout, valve and flanges failures etc; corrosion: either through chemical or biological agent, human error and technical failure.

Consequently, there is a need for remediation which will depend on the degree of actual or potential environmental threat. Many substances (Hydrocarbons, halogenated organic solvents halogenated organic compounds, non- chlorinated pesticides and herbicides, nitrogen compounds etc.) known to have toxic properties have been introduced into the degree of toxicity and danger to human health. Many of these substances come in contact with and are sequestered by soil (Nester *et al.,* 2001).

Crude oil spills may cause damage to the environment in many ways. Oil spill on land may lead to soil compaction, disruption of land surfaces, introduction of heavy metals into the soil, infertility for a long period of time until natural processes re-establish stability. Bioremediation is a destructive technique directed towards stimulating microorganisms to grow and use the contaminants as food and energy source. Bioremediation is also the use of living organisms to reduce or eliminate environmental hazards resulting from accumulation of toxic chemicals or other hazardous wastes (Nester *et al.,* 2001). It is the enhancement of live soil organisms such as fungi, bacteria etc to breakdown hydrocarbon and organic contaminants (Adenipekun, 2008).

Metabolic processes of these organisms are capable of chemical contaminants as an energy source, rendering the contaminants harmless or less toxic products in most cases (Nester *et al.,* 2001). A mixed culture of acclimated bacteria added to contaminated oil to reduce the lag period and increase the rate and extent of bioremediation. Organic manure is considered to be a good amendment agent for bioremediation of polluted soil. The presence of residual crude oil in the polluted soil boost the carbon supply in the soil, hence favored the growth of the hydrocarbon utilizing bacteria as compared with crude oil free soil (Ijah *et al.,* 2003).

The main purpose of this work is to determine the effectiveness of poultry farm manure in crude oil polluted soil.

MATERIALS AND METHODS

Collection of Samples

Soil samples used in this research were collected from an oil spilled area in Otuogidi Town in Bayelsa State, Nigeria in January, 2012.

The samples were collected using soil Auger at the depth of 10cm, stored in sterile aluminum foils and transported to the laboratory within 48hours of collection.

The soil reclamation material was poultry dropping collected from the poultry house in the School of Agriculture Agricultural Technology [SAAT], Federal University of Technology Owerri [FUTO] and was preserved in the laboratory at room temperature.

Sample Preparation

The soil samples were weighed and distribution into sterile containers in 200g portions. These were mixed with different concentrations of poultry manure as follows:

200g of polluted soil + 100g of poultry manure [Sample A]
200g of polluted soil + 200g of poultry manure [Sample B]
200g of polluted soil + 300g of poultry manure [Sample C]
Polluted soil without nutrient supplement [Sample D]

The above samples were stored at room

temperature, moderate moisture and oxygen for 12 weeks. In addition, Total Heterotrophic Bacteria and Fungi (THB and THF) counts in the soil samples were enumerated by adding 1g of each sample to 9ml of distilled water and serially diluted. Hydrocarbon Utilizing Bacteria and Fungi (HUB and HUF) were also enumerated.

The following were also determined: Total Petroleum Hydrocarbon (TPH), Moisture, Sulphate, Nitrate, Phosphate, Soil pH and Temperature.

RESULTS

The following results were obtained based on laboratory analysis conducted on bioremediation of crude oil polluted soil using poultry manure as the nutrient supplement.

DISCUSSION

The variation in counts of Total Heterotrophic Bacteria (THB) over the period of 12 weeks may be due to changes in the physicochemical properties of both the soil and the poultry manure. However, the difference in counts of Total Heterotrophic Bacterial (THB) and Total Heterotrophic fungi (THF) between the biodegraded crude oil polluted soil and the control was significant, probably due to rapid biodegradation of the crude oil in the soil. Hydrocarbon Utilizing Bacteria (HUB) in biodegraded crude oil polluted soil were higher than those of the control.

The bacterial counts in polluted soil remedied with nutrient supplement were higher than the fungal counts in the biodegraded crude oil polluted soil. The higher counts of bacteria compared with fungi may be as a result of the nutrient status of the soil (Jobson *et al.,* 1974) and the presence of some toxic components which do not favor fungal growth.

The decrease in pH value may be due to increased degradation of crude oil by microorganisms in the soil, resulting in accumulation of acidic metabolites. However, as the week progressed the Total petroleum hydrocarbon (TPH) content in the samples decreased (shown in Tables I-IV). The reduction in TPH content may be due to the utilization of petroleum hydrocarbon as food and energy by microorganisms. Reduction of nutrients and increase in THB, THF, HUB,HUF counts as the week progressed as shown in Tables I-IV indicated the absorption of nutrients by the microorganisms for energy and proliferation.

The moisture content of the remedied crude oil polluted soil was lower than that of the control (shown in Table IV). It may be due to the fact that that the dried nutrient supplement in the samples absorbed some amount of the moisture leading to low moisture content. Moreover, high humidity equally can contribute to low moisture content in the samples. Both nitrogen and phosphorus levels were higher in the supplemented crude oil polluted soil than non-supplemented polluted soil. This agrees with the findings of Odu (1972) who reported increase in nitrogen and phosphorus contents of a supplemented crude oil polluted soil. The reason could be due to higher organic matter content of the poultry manure (nutrient supplement) and as well the polluted soil.

Further more, the temperature value was higher in the remedied crude oil polluted soil than in control (shown in Table). This may be as a result of the activities of microorganisms which could generate much heat in the process of hydrocarbon degradation thereby increasing the temperature value. Additionally, high humidity may affect the temperature value of the samples. The rate of crude oil biodegradation in the soil was rapid. This may be due to the fact that the indigenous microorganisms in the soil and those introduced through nutrient supplement have efficient ability in utilizing the residual crude oil as a source of carbon and energy (ljah et al., 2003). Crude oil contains hydrocarbon and does not resist attack by microorganisms (Atlas 1995).

Table I. Trend of Change in Zero Week

Parameters	A	B	C	D
THB (cfug^{-1})	5.00X10^{2}	7.40X10^{3}	1.02X10^{5}	1.20X10^{2}
HUB (cfug^{-1})	3.20X10^{2}	4.1X10^{3}	7.90X10^{3}	2.20X10^{2}
THF (cfug^{-1})	2.40X10^{2}	2.80X10^{2}	4.10X10^{2}	1.10X10^{2}
HUF (cfug^{-1})	5.00X10^{1}	7.00X10^{1}	8.00X10^{1}	3.00X10^{1}
TPH	387.00	384.00	382.00	390.00
P^{H}	5.21	5.24	5.28	4.11
Temp. (°C)	25.00	25.00	26.00	25.00
Nitrate (%)	12.40	12.80	12.80	2.40
Phosphate(%)	0.72	0.76	0.78	0.17
Sulphate (%)	67.00	70.00	75.00	20.00
Moisture	22.00	17.90	12.90	28.20

Table II. Trend of Change in the fourth week

Parameters	A	B	C	D
THB (cfug^{-1})	1.46x10^{3}	1.67x10^{4}	2.21x10^{5}	1.30x10^{2}
HUB (cfug^{-1})	8.30x10^{2}	1.24x10^{4}	1.46x10^{4}	2.40x10^{2}
THF (cfug^{-1})	7.70x10^{2}	9.30x10^{2}	1.25x10^{3}	1.30x10^{2}
HUF (cfug^{-1})	1.10x10^{2}	1.50x10^{2}	2.00x10^{2}	2.00x10^{1}
TPH	370.00	366.00	361.00	388.00
P^{H}	5.13	5.17	4.22	4.10
Temp (°C)	26.00	26.00	27.00	25.00
Nitrate(%)	11.70	12.10	12.40	2.40
Phosphate(%)	0.51	0.60	0.69	0.16
Sulphate(%)	58.00	65.00	72.00	18.00
Moisture	4.10	19.30	13.60	31.20

Table III. Trend of Change in the Eight week

Parameters	A	B	C	D
THB (cfug^{-1})	2.01x10^{3}	2.66x10^{4}	3.17x10^{5}	1.30x10^{2}
HUB (cfug^{-1})	1.33x10^{3}	1.75x10^{4}	2.05x10^{4}	2.50x10^{2}
THF (cfug^{-1})	1.22x10^{3}	1.36x10^{3}	1.66x10^{3}	1.40x10^{2}
HUF (cfug^{-1})	1.70x10^{2}	2.10x10^{2}	2.70x10^{2}	4.00x10^{1}
TPH	352.00	339.00	320.00	386.00
P^{H}	4.98	4.94	5.10	4.12
Temp (°C)	27.00	28.00	29.00	25.00
Nitrate(%)	9.50	10.90	11.70	2.30
Phosphate(%)	0.41	0.49	0.57	0.16
Sulphate(%)	52.00	60.00	65.00	17.00
Moisture	21.70	17.60	11.60	29.20

Table IV. Trend of Change in the 12th week

Parameters	A	B	C	D
THB (cfug^{-1})	2.89x10^{3}	3.43x10^{4}	3.91x10^{5}	1.50x10^{2}
HUB (cfug^{-1})	1.91x10^{3}	2.48x10^{4}	3.02x10^{4}	2.30x10^{2}
THF (cfug^{-1})	1.67x10^{3}	1.88x10^{3}	2.00x10^{3}	1.40x10^{2}
HUF (cfug^{-1})	2.20x10^{2}	2.80x10^{2}	3.60x10^{2}	5.00x10^{1}
TPH	325.00	311.00	284.00	385.00
P^{H}	4.84	4.83	4.94	4.11
Temp(°C)	30.00	30.00	32.00	26.00
Nitrate (%)	8.30	9.20	10.50	2.20
Phosphate (%)	0.32	0.40	0.49	0.14
Sulphate(%)	37.00	48.00	53.00	15.00
Moisture	21.40	16.80	10.10	29.90

There is a decrease in pH, TPH in the supplemented contaminated soil while temperature, THB,THF, HUB and HUF increased. Also, the moisture content in the supplemented soil was lower than the control.

Finally, the biodegradation that proceeded in the unsupplemented soil also indicated that degradation can also be carried out without supplementation of organic nutrient, although much slowly.

CONCLUSION

This study showed that nutrient supplement is effective in detoxifying and as well remedying the soil polluted with crude oil or its associated components. Therefore, based on the findings of this research project it is necessary to employ the use of nutrient supplement (poultry manure) when there is need to remedy spilled sites.

The study also showed that there is residual crude oil in the soil after 12 weeks of investigation and that the physicochemical properties of the soil were significantly affected. Conclusively, the study has show that

remediation by poultry manure is effective in the cleanup of polluted sites.

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