Petroleum Contaminated Soil Remediation Using Poultry Feaces and Plantain Stem

M.J. Ayotamuno, O.M. Olatunji and S.T. Ikari

Department Of Agricultural and Environmental Engineering, Rivers State University Of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria

Abstract

The effect of poultry, dropping and plantain stem on the remediation of crude oil contamination soil was studied ex-situ at the same crude oil contamination levels but different ratio of treatment. The basic method employed in the research work is Biostimulation as one of the biomediation method. This research was experimentally designed in 10 replicates of soil samples including the control sample. The soil were contaminated and allowed to infiltrate for 3 days before treatment. The treatment were added to the contaminated soil at different quantities of 250g, 180g, and 100g except the control. The soil were in the same weight of 4000g, respectively, and 250/cm^3 (0.25/litres) of crude petroleum oil was used to pollute the soil, except the control. After three days the soil were tilled and watered for aeration of the micro-organism capable of degrading hydrocarbons. After pollution, the soil was sampled and analyzed in the laboratory together with the unpolluted soil so as to know their physiochemical properties before and after pollution. Thereafter, the treatment was applied to the contaminated soil to decompose and form micro-organism that degrades the hydrocarbons. The soil treatments were allowed for one to two months for proper remediation to take place. At the first month of remediation, the soil were sampled and analyzed to know the level of remediation. From the results obtained, it really certified that remediation has occurred in all the treatment reactors, from the overall performance, it really shown that treatment C which is chicken dung, was more effective than any other because of high reduction of Total Petroleum Hydrocarbon (TPH) value from 17, 284 mg/kg to 1,186 mg/kg at the second (2) months of remediation. The results of this research work suggest that the application of poultry dropping and plantain stem will be environmentally friendly since, it helps microbial utilization of hydro carbons content of the soil and degrade it to less toxic condition.

Introduction

Crude petroleum oil spill has been the most prevalent problem in the environment. The release of crude petroleum oil into the environment due to oil spill has recently drawn world wide attention.Oil spillage has dislocates many living within the oil producing areas as a result of their polluted waters, air, damaging of farmlands (Ekpu, 2008). In Niger Delta area of Nigeria, there has been over 500 reported cases of crude petroleum oil spillages since 1976, realizing about 2.5 million barrel of crude oil into the environment, (Odiete, 1999; Korie-Siakepere, 1998; et al.) Also an uncontrolled releases of the compounds into the soil and groundwater of the compounds into the soil and ground water are frequent as a result of leakages from an underground storage Tanks and piping containing diesel, heating oil, fuel and gasoline. This leakages is in droplet but in large quantity causing acute and long term damages to agricultural soil, and other works done on the soil which have greatly affected our environment and society as polluted soils are great threat to both plants, animals, human and micro-organism crude petroleum oil is physically, chemically and biologically harmful to soil due to high concentration of many toxic compounds e.g polycyclic aromatic ydrocarbons, benzene and its substitute cycloatkane rings (Franco et al, 2004). The presence of high molecular weight compounds

with very low solubility in water prevent natural bio-degradation process form working efficiently in hydrocarbon contaminated soils. These compounds also penetrate macro and micro pores in soil and thus limit water and air transport that would be necessary for organic matter conversion (Cavavaca and Roida, 2003). Soil remediation is a collective term for various methods that are used to purify and revitalize the soil. This process of clean-up is a part of a broader efforts to purify the air and otherwise repair damage done to the ecosystem. Example of countries that practiced soil remediation are Canada, United State and Australia (online/www. Soil remediationtech). The conventional techniques used for remediation has been to dig up contaminated soil and move it to a land fill, but these method simply moves the contaminated soil else where and may, cause significant risk in the excavation, handling and transport of hazardous materials. Additionally, it is very difficult and expenses to find new landfill site for the final disposal of the excavated material. The cap and contain method is only an interim solution since the contamination remains on the site requiring monitoring and maintenance of the isolation barriers for a long time will face all the associated cost and potential liability. A better approach than these traditional methods is to completely destroy the pollutant if possible or atleast to transform them to harmless substances. Some technologies that have been used are high temperature incineration and various types of chemical decomposition (e.g base catalyzes dechlorination, oxidation). They can be very effective at reducing several drawbacks, principally their technology complexity, the cost for both workers at site and near by residents (Odu; et al 1955). The pollution of the environments, draw the attention of pollution control regulation in the oil and gas operation industries governed by the principal legislation of petroleum Act. 1967. Regulatory bodies such as Federal Ministry of environment (FMENv) and Department of petroleum Resources (DPR) here in Nigeria required that operators should treat and control the discharged of these effluent to ensured that, the environment are friendly to man and other living things here on earth. The remediation of crude petroleum oil polluted soil using poultry dropping and plantain stem as a nutrient source offer an alternative measure over other conventional methods of remediation technologies, and it will not only be effective in remediation of the polluted site, but would be less expensive and as well environmentally friendly. Therefore the objectives of this work is to: Determined the effectiveness of remediating crude petroleum oil polluted soil with poultry dropping and plantain stem; determination of some physiochemical parameters of polluted and unpolluted soil; also determine the rate of remediation in the various samples, observing and comparing these changes with respect to the control samples (unpolluted soil) to ascertain if any remediation has taken place and make recommendations based on the findings.

Materials and Method

The experimental reactors (Baskets) were located at the University Teaching and Research farm in the Rivers State University of Science and Technology, Port Harcourt, Nigeria. Port Harcourt is an important city in the Niger Delta region, Nigeria. The Niger Delta region produces over 98% of Nigerian's economic main stay namely crude oil is derived. The region have a seasonal rainforest and it is characterized by sand and clay depositor. Port Harcourt falls within the tropical rain forest vegetation belt and receives an annual rainfall of about 2700mm, while the average temperature of the area is about 27^0C (Ayotamuno et al, 2006).

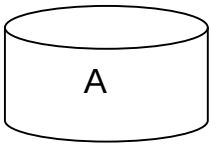
The top soil sample was dogged with shovel and put into 15 litres of reactors, the top soil is usually sandy loam and the vegetation cover is the tropical rainforests (Odokuma and Dickson, 2003), the depth of soil sample collected is between 0 – 30cm.

The plantain stem and the top soil used were obtained from one of the farm land at the Rivers State University of Science and Technology, Port Harcourt while the poultry waste was collected from a poultry farm at Nkpolu community near Rivers State University of Science and Technology, Port Harcourt.

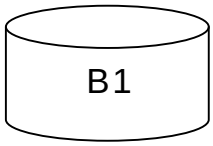
The crude petroleum oil was gotten from Nigerian National Petroleum Company (NNPC) and was analyzed for the followig parameters: pH, Total Organic Carbon, Total Nitrogen, Total Hydrocarbon content. The colour of the crude petroleum oil was black.

3.3 experimental design

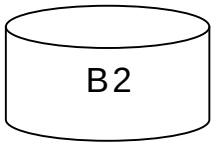
The remediation work was carried out for eight weeks between August and September, 2012. The soil samples dogged was divided into ten (10) treatment reactors as shown below:



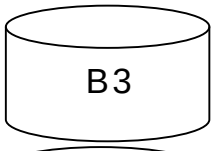
A = as the control soil sample with no treatment whatsoever?



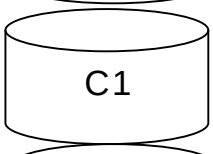
B1 = Polluted soil applied with 250g of plantain stem + 0.5 liter of water two times a week and tilling of the soil was done three (3) times a week.



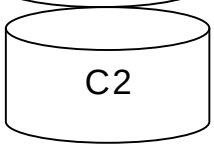
B2 = Polluted soil applied with 180g of plantain stem + 0.5 liters of water two times a week and tilling of the soil was done three (3) times a week.



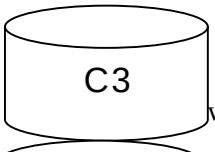
B3 = Polluted soil applied with 100g of plantain stem plus0.5 liter of water two times a week and tilling of the soil was done three (3) times a week.



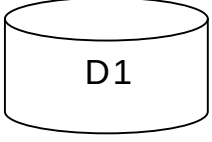
C1 = Polluted soil applied with 250g OF poultry dropping plus0.5 liter of water two time a week and tilling of the soil was done three (3) times a week.



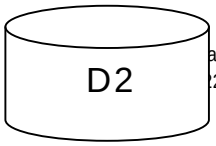
C2 = Polluted soil applied with 180g of poultry dropping plus 0.5 liter of water two (2) times a week and tilling of the soil was done three (3) times a week



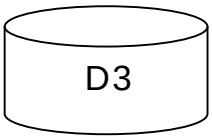
C3 = Polluted soil applied with 100g of poultry dropping, plus 0.5 liter of water two(2) times a week and tilling was done three(3) a week.



D1 = Polluted soil applied with 150g of plantain stem plus 150g of poultry dropping, plus 0.5 litres of water two (2) a week and tilling of the soil was done three (3) times a week.



D2 = Polluted soil applied with 100g of plantain stem plus 100g of poultry dropping plus0.5 liter of water two times a week and tilling was done three(3) times a week.



D3 = Polluted soil applied with 50g of plantain stem plus 50g of poultry dropping plus 0.5 liter of water two times a week and tilling was done three (3) times a week.

Method Of Remediation

4000g of soil was measured into 10 treatment reactors respectively. And out of the 10 treatment reactors, only 9 treatment reactors were polluted with 5 liters of crude petroleum oil, except sample A, which is the control. This samples were allowed for three consecutive days for proper infiltration. After the three days, the soil was collected from each of the treatment reactor as composite sample with the aid of a hand trowel including the unpolluted soil. And this were in line of the work of (Odokuma and Dickson, 2005 and Ayotanmuno et al, 2006).

Nutrient Application and Tilling

Plantain stem and poultry dropping was applied using the broad method to each reactor option for comparison. This application was done in all the treatment cells except the control and work into 13cm depth at each cell. 250g, 180g, 100g of plantain stem, poultry dropping and mixture of both organic manure were added to the polluted soil respectively, and each quantity of the organic were replicated 2 times.

The relevant reactor options were tilled at the same rates previously stated with a trowel to provide maximum aeration, adequate mixing of nutrients, microbes and water that was applied.

Tilling was done in line with the work of Odokuma and Dickson (2003), and it (tilling) was done three (3) times a week to provide proper aeration that will decrease the contamination level due to the oxidation of easily degradable petroleum components.

Water was applied to each treatment cells with the exception of the control cell (reactor A), the specified quantity of 0.5 liters of water was added twice in a week. During the eight(8) weeks remediation period with the use of perforate cans.

Laboratory Analysis And Procedure

The following parameters were analyzed using methods derived from relevant literatures (Ayotamuno *et al*, 2007). pH, Moisture Content + (MC), Total Petroleum Hydro Carbon (TPH), Total Organic Carbon (TOC), Total Nitrogen (TN), Electrical Conductivity (EC) and Bacteria Counts of the soil.

These were used to defined the level of the remediation achieved in the research work. Sample were collected and analyzed three (3) days after pollution was done, four (4) weeks and eight (8) weeks of the course of the remediation.

Results and Discussion

Tables 1 and 2 below show the physiochemical parameters obtained before, during and after remediation.

Table 1: Physiochemical Characteristics Of The Soil Before Crude Oil Contamination.

PH	EC %	MC %	TN g/kg	TPH Mg/kg	TOC %	Salinity Mg/kg	Bacteria count (C fu/g
6.92	5901	12.4	2.11	28.4	1.27	26 91	$8.32x10^6$

Table 2: Physiochemical Characteristics 3 Days After Contamination

Parameters	**Polluted soil**
PH	4.65
Electric conductivity (U_S/CM	4244
Moisture content (%)	13.1
Total Nitrogen (g/kg)	1.00
TPH (mg/kg)	17.284
TOC (mg/kg)	7.30
Salinity (mg/kg)	3,539
Bacteria count (cfu/y)	$2.70x10^6$

Table 3: Concentration Of Soil Physiochemical Parameters After One Month Of Remediation

Sample ID	**PARAMETERS ANALYSED**							
	PH	**MC (%)**	**EC (U_S/CM)**	**Salinity (mg/kg**	**TPH (mg/kg**	**TOC (%)**	**TN (g/kg**	**Bacteria Count (cfu/g)**
A (control)	4.60	11.8	5, 170	2,714	20.2	1.22	1.08	$3.38*10^6$
B1	5.40	14.5	4, 460	1,5 73	6,914	4.87	2.62	$4.32*10^6$
B2	5.28	13.9	4, 875	1,761	8,230	5.52	1.39	$3.78*10^6$
B3	5.30	13.5	4,312	1,915	11,523	6.35	1.28	$3.24*10^6$
C1	5.10	14.3	7,750	3,523	4,938	2.81	2.09	$5.40*10^6$
C2	5.42	13.7	6,782	3,083	5,761	3.04	1.86	$4.59*10^6$
C3	5.55	13.4	5,813	2,642	6,648	3.32	1.65	$4.05*10^6$
D1	5.64	14.4	5,328	2,422	5,576	3.56	1.87	$4.86*10^6$
D2	5.61	14.1	5,086	2,312	6,648	3.95	1.64	$4.19*10^6$
D3	5.74	13.6	4,989	2,268	8,230	4.35	1.46	$3.65*10^6$

Table 4: Concentration Of Soil Physiochemical Parameters After 2 Months of Remediation.

Sample ID	PARAMETERS ANALYSED							
	PH	**MC (%)**	**EC (U_S/CM)**	**Salinity (mg/kg**	**TPH (mg/kg**	**TOC (%)**	**TN (g/kg**	**Bacteria Count (cfu/g)**
Control A	5.83	11.20	5,040	2,518	16.7	1.15	1.03	$3.57*10^6$
BI	6.40	14.1	2,068	940	1,536	2.44	2.94	$1.08*10^7$
B2	6.15	13.4	2,906	1,321	2,351	3.07	2.02	$7.56*10^6$
B3	5.96	13.0	3,580	1,627	3,841	3.97	1.978	$5.83*10^6$
C1	6.75	13.8	4,650	2,114	1,186	1.12	2.84	$2.89*10^7$
C2	6.66	13.2	4,069	1,850	3,280	1.52	1.35	$2.38*10^7$
C3	7.27	12.9	3,488	1,585	3,662	2.21	1.20	$2.13*10^7$
D1	6.57	14.0	3,197	1,453	1,186	1.62	1.29	$1.06*10^7$
D2	6.31	13.7	2,797	1,271	1,797	2.19	1.06	$6.29*10^6$
D3	6.17	13.1	2,744	1,247	3,048	2.72	0.989	$4.75*10^6$

Discussion

From tables 1 and 2, it was observed that the polluted soil has changed in its physiochemical behaviour. The pH of unpolluted soil and polluted soils before remediation were 6.92 and 4.65 respectively. After 2 month of remediation the pH of polluted soil has changed to 6.75. This shows that, the polluted soil is more acidic in nature due to the presence of hydrocarbon. This is in agreement with the findings of Atuanya, (1987).

It was also observed that, the moisture content increases in all the reactors after remediation has taken place. This is due to the reduction in total petroleum hydrocarbon prior to the treatment used since remediation has occurred, the infiltration rate of the soil have been cleaned-up from hydrocarbons.This is in agreement with the findings of Baker, (1970).

From the results obtained, there was a decrease in the electrical conductivity value before contamination and after remediation has taken place.

From the results obtained in table 3 and 4, the salinity concentration is at minima with respect to the ASTMD 5000 standard limit of 600 mg/kg. Also The reduction of TPH as obtained from the result shows that the application of poultry dropping and plantain stem which are organic nutrients, and as well tillage could improve positively on biodegradation of crude petroleum oil polluted soil. The

reduction in TPH values from 17,284 mg /kg to 1,186 Mg /kg really shows effective utilization of nutrients and support the claim that nitrogenous nutrient supplied, provides a suitable environment for decontamination. This is in line with the findings of Lielani (2004).

The result in table 4.3 and 4.4 showed that, organic carbon degradation took place after remediation and more effectively on treatment B_3, B_2 and D_3. The application of nutrient enhances greater degradation of organic carbon.

Also the total Nitrogen of the soil increases from 1.00 g/kg to 2.84g/kg after remediation have occurred. This also tells us that, the contaminated soil have started regaining its nutrient in respect to the organic nutrient added to the soil, and this is in agreement with the work of Bitzer, and Sims (1988).

Based on the results obtained, the microbial activities increased during remediation. The hydrocarbon utilizing bacteria (HUB) were favoured for the mineralization of the contaminants through the application of plantain stem and poultry dropping (Table 3 & 4). it was realized that plantain stem had more bacteria prolification as against poultry droppings. It's total heterotrophic bacteria count first decreased from $8.32x10^6$ cfu/g to 2.70×10^6 cfu/g and later increased to 7.56×10^6 cfu/g as the remediation period continued. This is in line with the work of Odu (1982).

Conclusion

From the performance of individual treatment organic nutrients, treatment B_1, B_2, B_3 (application of plantain stem) and treatment C_1, C_2, and c3 (application of poultry dropping) degrade the hydrocarbons at a lower concentration than the mixture of both. But the treatment C1, C2 and C3 performed more effective than any other treatment in degrading the hydrocarbons during the period of remediation; thereby calculated the highest hydrocarbons loss due to high formation of hydrocarbon utilizing bacteria. Also the application of plantain stem (B1) records high hydrocarbons loss but with a slight difference to the mixture of both treatment as seen in reactor D_1.

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