Corn Cob Compost Stimulated Bioremediation of Petroleum Hydrocarbon Polluted Soil

[1]Egbo Walamam Mansi and [2]Yaguo Eremasi Benjamin Ikele
[1]Research and Development Centre,
Bayelsa State Polytechnic, Aleibiri
[2]Directorate of Academic planning and Quality Assurance,
Bayelsa State Polytechnic, Aleibiri
egbomansi@yahoo.com; 08066677173
DOI: 10.56201/ijcsmt.v10.no4.2024.pg212.221

Abstract

Petroleum hydrocarbon pollution in soil and ground water has serious adverse effects on the environment and human health. Bioremediation is a viable and effective response to soil contamination with petroleum hydrocarbon and can be positively enhanced by the use of organic waste. The aim of this study is to investigate corn cob as possible supplement for the stimulation of bioremediation of hydrocarbon pollution in soil. Agricultural soil sample was collected from farm land and prepared for the study. Ikg of the prepared soil sample was measured in eight replicates into plastic bioreactors labeled CONTR, A, B, C, D,E, F and G). The soil sample in each bioreactor (bowl) was spiked with equal of quantity of engine oil dissolved in gasoline and allowed to stand for two weeks to acclimatize. The spiked soil samples in A, B, C,D, E, F and G bioreactors were then treated with different of amount (100g, 200g, 300g, 400g, 500g, 600g and700g) of matured corn cob compost respectively. While the control (CONTR) was not treated. Laboratory analysis indicates that each experimental set up had an initial Total Petroleum Hydrocarbon (TPH) Concentration of 60,163.09Ppm. Result of the regular monitoring of soil physicochemical parameters showed that at the end of three months (84 days) TPH concentration reduced to 53567.91Ppm in the control, 15428.48Ppm in A, 9616.15Ppm in B, 6710.31Ppm in C, 3894.33Ppm in D, 2805.28Ppm in E, 1694.80 in F and 978.51Ppm in G. A Further analysis of the biostimulation effectiveness showed the TPH biodegradation effectiveness of 10.96% was achieved in the control, 74.36% in A, 84.02% in B, 88.85% in C, 93.53% in D, 95.34 in E, 97.17% in F and 98.37% TPH removal effectiveness was achieved in set up G. From the results obtained, it is concluded that the corn cob compost significantly stimulated the bioremediation of petroleum hydrocarbon in the treated soil samples; however the quantity of the compost determines the rate of TPH removal.

Keywords: *Petroleum Hydrocarbon, bioremediation, corn cob, stimulation soil and pollution*

1.0 INTRODUCTION

1.1 Background of the study

crude oil pollution in many sites within the Niger Delta region of Nigeria is so high that it is beyond the intervention level stipulated by the Environmental Guideline and Standard for the oil industry (EGASPIN) for both soil and ground water. Intervention and risk reduction measures are therefore urgently needed for both soil and groundwater. The pollution is due to the high incidences of oil spillage in the region.

The Niger Delta region is an oil exploration and production hub in Nigeria. Crude oil production activities have being going on in the region since crude oil was first discovered in economically large quantity in 1956, at Oloibiri in Ogbia Local Government Area of the present Bayelsa State in the region. Crude oil spill happens because of willful and criminal actions, rusting oil pipelines as well as containers where crude oil is stored, human error or carelessness on the part of oil company workers when drilling and servicing oil wells or road/marine accident involving oil carrying vessels like tankers and barges.

Thousands of tons of oil have been released into the surrounding land and water in the Niger Delta region. In 2015, oil spill occurred in a community called Azuzuama in Southern-Ijaw Local Government Area of Bayelsa State where an Agip oil pipeline exploded and killed about twelve workers on oil pipeline maintenance (Arodiegwu, 2015). In the same year another oil spilled occurred in Ikarama in Yenagoa Local Government Area of Bayelsa State and a vast land was covered with crude oil with the attendant destruction of plants and animals resources (Daily post, 2015). In 2013, a newspaper report has it that about 420 to 630 million gallons of crude oil have been released in to the land and water bodies in the Niger Delta zone of Nigeria since the drilling of crude oil started in Oloibiri in 1958 (Chika, and Ejiofor, 2013). Most of the oil spills that occurred in the Niger Delta are not reported or are under reported (Oyinloye and Olamiju, 2013).

Petroleum hydrocarbon pollution in soil and ground water has serious adverse effects on the environment and human health. Uncontrolled released of crude oil into the environment such as in the case of oil well blowout, pipeline outburst or breakage of crude oil storage tank severely threatens the health of people and their wellbeing (Ntukakpo, 1996; Nwilo and Badejo, 2005).

A report by (Gill and Sandota, 1976; Ekundayo *et al.* 2000) indicates that crude oil pollution reduced crop productivity by 95 percent when compared with control soil. A study by Daniel and Pepple *(*2006) also revealed that crude oil pollution had impact on plant height, leave size and plant dry weight. Oil Pollution, whether chronic or acute, is reported to have some negative and unpleasant effects on health of human beings, soil fertility and plant productivity (Agbogid and Ejemete (2005).

Oil spill causes injuries to animals, loss of habitat, closure of beaches, parks, water ways, recreational and commercial fisheries (National Ocean and Atmospheric Administration, 2024). Oil pollution can also cause mental problems such as depression, anxiety, posttraumatic stress, liver, lungs and heart problems in humans and animals (Shishira, 2023. Oil spill also causes long term damage to environmental species, their habitats or their breeding grounds, (Treehugger, 2024). Benzene, a volatile organic compound present in crude oil and gasoline is known to cause leukemia in humans (Hussein. *et al.* 2016).

The risk pose by oil pollution has warranted that the development of various oil pollution remediation methods or technology. Among which bioremediation has been recognized globally as an ecofriendly, economical and effective environmental restoration technology for hydrocarbon pollution remediation. Bioremediation is a technology that utilizes the metabolic potentials of micro-organisms such as bacteria, fungi to degrade liquid petroleum into harmless compounds (Watanabe, 2001). Odokuma and Dickson (2003) described bioremediation as the application of microorganism's metabolic processes such as (biodegradation, bioaccumulation, biofermentation, bioabsorption, bioadsorption etc.) to clean contaminants in water, sediments and soil.

Bioremediation by stimulation is the most effective technic. It involves the addition of microbial nutrient supplement to the polluted medium and aeration in order to stimulate the growth and metabolic activities of indigenous microorganisms such as bacteria and fungi that feast on hydrocarbon as a source of carbon and energy for their growth and production. Bioremediation can be a viable and effective response to soil contamination with petroleum hydrocarbon and can be positively enhanced by the use of organic waste (Vincenzo, 2016; Egbo and Ambrose, 2023).

Various organic materials have been studied as possible source of nutrient supplement for biostimulation. These include rice husk, saw dust, wood charcoal, poultry droppings, cow dung, hay straw etc. However corn cob has not been studied as possible supplement for bioremediation. The aim of this study is to investigate corn cob as possible supplement for the stimulation of bioremediation of hydrocarbon pollution in soil.

2.0 MATERIALS AND METHODS

2.2 Area of the study

The study was conducted in Bayelsa State Polytechnic temporary site in Yenagoa. Yenagoa is the capital of Bayelsa situated in the Niger Delta region of Nigeria. Yenagoa town is situated between Longitude 60 15l East of the Greenwich meridian and Latitude 40 55l North of the Equator. This location put Yenagoa firmly on the Equatorial climatic belt which is characterized by high temperature, humidity and heavy rainfall (Egbo and Eremasi, 2022)

2.2 Method

Corn cob wastes were collected, dried and crushed into small size and composted for three months. Chemical analysis of total nitrogen, total phosphorus, total potassium and pH of the corn cob was conducted.. A bulk quantity of agricultural soil was collected from fallow farm land then sun dried. The dried soil was then grinded into fine powder form and sieved with 2.5 pore size sieve. The sieved soil was spiked with engine oil dissolved in gasoline. 1kg of the spiked soil was collected in eight replicates into plastic bioreactors. The bioreactors were labeled A, B, C, D, E, F and G while the control was labeled CONTR and therefore was not treated with the compost.. The spiked soil samples which are prototype of polluted soil were treated with different amount of mature (100g, 200g, 300g, 400g, 500g, 600g and 700g) corn cob biomass compost respectively. Analytical samples were collected from the spiked soil samples for laboratory analysis of day zero concentration of total petroleum hydrocarbon and polycyclic aromatic hydrocarbon. Hydrocarbon degrading bacteria and fungi in the polluted soil were screened and identified by morphological and biochemical methods.

The treated soils samples were sprinkled with water and thoroughly mixed every four days to moisturized and aerate the soil for optimum performance of hydrocarbon degrading microbes in the soil. During the study, soil samples were collected from each experimental set up for analysis of total organic carbon, residual TPH and PAHs. Soil electrical conductivity and pH were also monitored every two weeks for a period of three months.

2.2 Analysis of the effectiveness of TPH biodegradation in each experimental set up

Following the observed progressive decrease in residual TPH Concentration in the experimental set ups during the study, the effectiveness of bioremediation of Total petroleum Hydrocarbon in the experimental set ups was be evaluated using the equation of Samuel *et al.* (2015).

$$\text{Percentage TPH degradation (Pd)} = \frac{TPHi - TPHt}{TPHi} x\ 100 \qquad (3.4)$$

Where TPH_i is the initial Total petroleum hydrocarbon concentration in soil samples

TPH_t is the residual Total petroleum hydrocarbon concentration in soil samples at time t

3.0 RESULTS AND DISCUSSIONS

3.1 Results

After composting the corn cob for three months some chemical characteristics of the corn cob compost were analyzed. The results of the chemical analysis are presented in Table 3.1

Table.3.1: **chemical characterization of the corn cob compost**

Parameters	sample (corn cob compost)
pH	8..20
TOC	8.76
TN (%)	0.84
Phosphate (mg/kg)	149.05
Potassium (mg/kg)	325.17

After spiking the soil with the engine dissolved in petrol baseline microbial and physicochemical characteristic of the treated soil was undertaken and the results are presented in Table 3.2.

Table 3.2: **chemical characterization of the soil**

Parameters	sample (soil)
pH	5.86
EC	415.71 µs/cm
TPH	60163.09ppm
PAHs	43,818.57ppm
HUB cfu/g	$1.37X10^2$
HUF **(sfu/g)**	81

In order to achieve the main aim of this research, regular monitoring of the physicochemical properties of the treated soil samples such pH and electrical conductivity of the soil samples in each experimental set up is very vital. The results of the analysis of the pH is presented in Fig. 3.1 while the result of electrical conductivity (EC) is presented in Fig.3.2

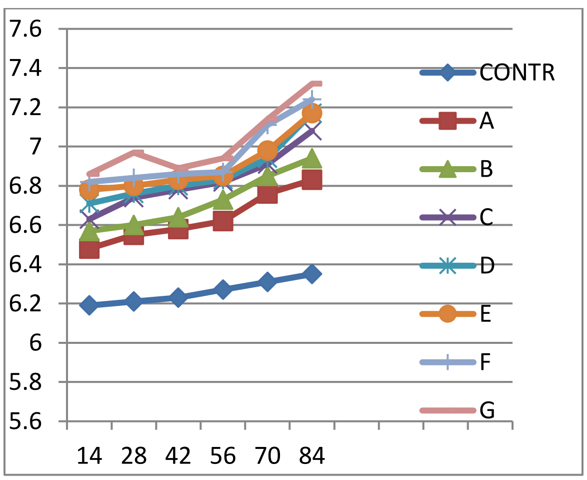


Fig 3.1: time series graph of PH of the soil Samples.

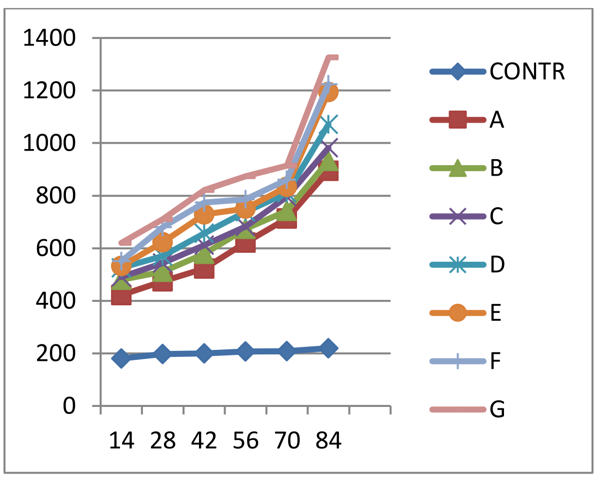
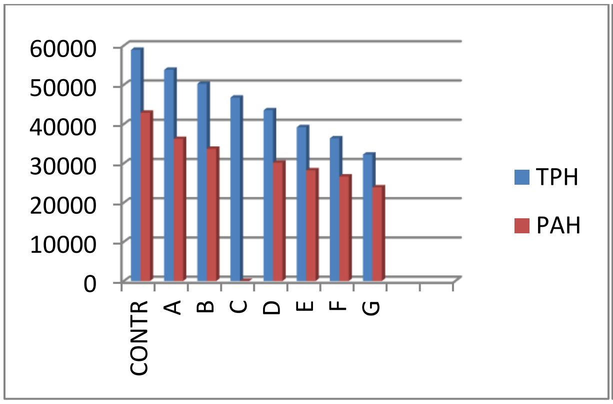


Fig 3.1: time series graph of EC of the soil Samples.

TPH and PAHs concentrations in each experimental set up during the study at days 14 and 28 are presented in Fig 3.3 and Fig 3.4



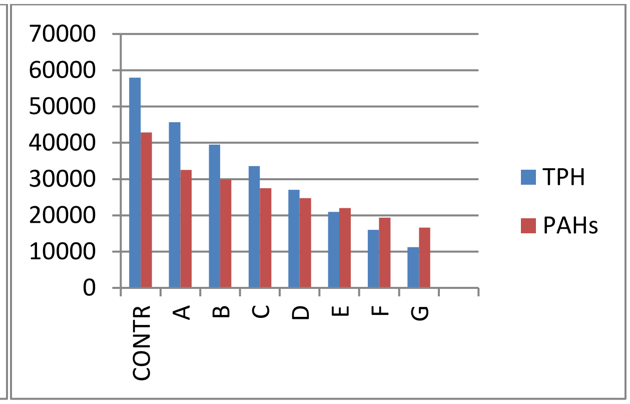
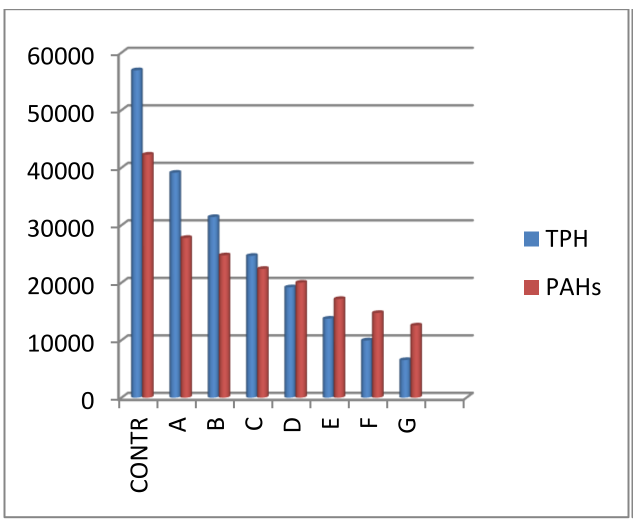


Fig3.3: Hydrocarbon concentrations in the experimental set ups at day 14

Fig3.4: Hydrocarbon concentrations in the experimental set ups at day 28

TPH and PAHs concentrations in each experimental set ups during the study at days 42 and 56 are presented in Fig 3.5 and Fig 3.6



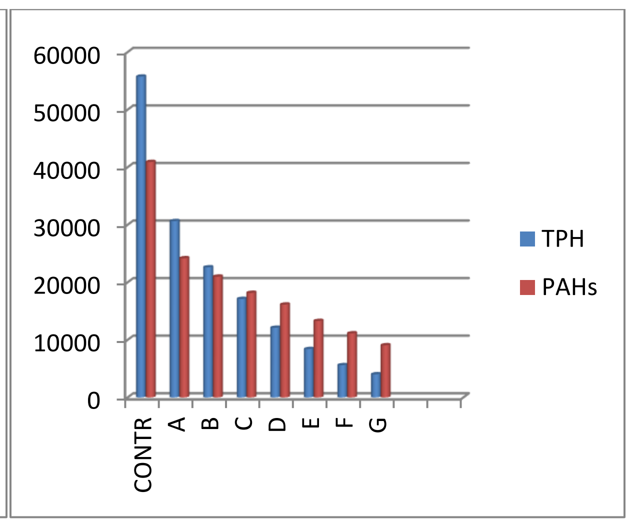
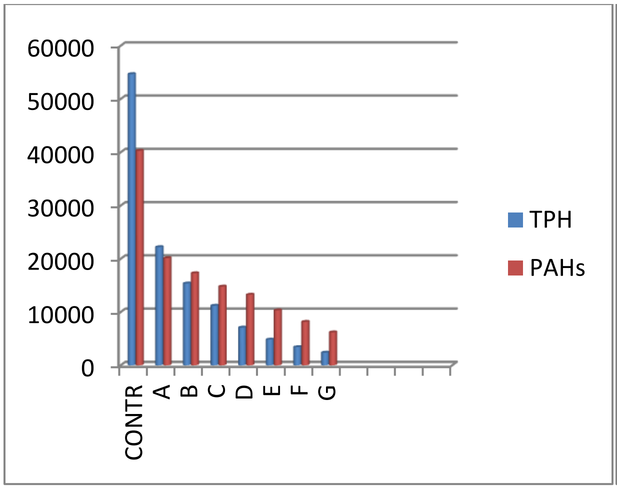


Fig3.5: Hydrocarbon concentrations in the Experimental set ups at day 42

Fig3.6: Hydrocarbon concentrations in the experimental set ups at day 56

TPH and PAHs concentrations in each experimental set ups during the study at days 70 and 84 are presented in Fig 3.7 and Fig 3.8



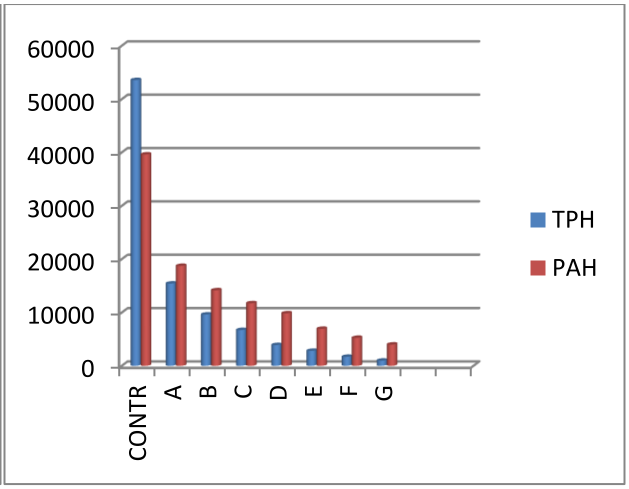


Fig3.7 Hydrocarbon concentrations in the Experimental set ups at day 70

Fig3.8 Hydrocarbon concentrations in the experimental set ups at day 84

Result of the analysis of the effectiveness of corn cob enhancement of the bioremediation of petroleum hydrocarbon in polluted soil is presented in Table 3.3,

Table 3.3:Result of the analysis of bioremediation effectiveness

S/NO	EXPERIMENTAL SET UP	BIOREMEDIATION EFFECTIVENESS (%)
1	CONTR	10.96
2	A	74.36
3	B	84.02
4	C	88.85
5	D	93.53
6	E	95.34
7	F	97.18
8	G	98.37

3.2 Discussions

Biosimulation is the most effective approach to petroleum hydrocarbon remediation. It requires the addition of microbial nutrient to the polluted soil followed by aeration and moisturization to enhance microbial degradation of the petroleum hydrocarbon in the soil or polluted medium. In this study, bioremediation of petroleum hydrocarbon using corn cob as biostimulant was conducted in a laboratory scale.

The results of pH and electrical conductivity (EC) of the treated polluted soil during the study are presented in Fig. 3.1 and Fig. 3.2. The results showed that pH and EC of the spiked soil were 5.86 and 415.71 µs/cm respectively. pH and EC increase in the soil samples as the TPH concentration reduces. This showed that the soil was acidic and saline. Ejairu and Okiotor (2022) also reported soil pH range of 4.80-5.60 from a polluted site in Delta State and EC of 185µs/cm from same soil. This is an indication that petroleum hydrocarbon pollution increases soil acidity

The experimental set ups had initial Total Petroleum Hydrocarbon (TPH) Concentration of 60,163.09Ppm. Result of the regular monitoring of soil physicochemical parameters showed that at the end of three months (84 days) TPH concentration reduced to 53567.91Ppm in the control, 15428.48Ppm in A l, 9616.15Ppm in B, 6710.31Ppm in C, 3894.33Ppm in D, 2805.28Ppm in E, 1694.80 in F and 978.51Ppm in G. A Further analysis of the biostimulation effectiveness showed the TPH biodegradation effectiveness of 10.96% was achieved in the control, 74.36% in A, 84.02% in B, 88.85% in C, 93.53% in D, 95.34 in E, 97.17% in F and 98.37% TPH removal effectiveness was achieved in set up G. (Ogochukwu et al., 2023) conducted a study on biostmulation of Petroleum contaminated soil using organic and inorganic amendments and reported that water Hyacinth compost achieved 93%, combination of spent mushroom and water Hyacinth compost recorded 89% while inorganic (N.P.K) achieved 86% TPH removal after 56 days. This result obtained in this study has shown that corn cob can be a good organic amendment for the biostimulation of petroleum hydrocarbon degradation in polluted soil.

4.0. Conclusion and Recommendations

4.1 Conclusion.

Bioremediation is one the major methods developed for the remediation of organic pollution in soil, sediment and ground water. It has been recognized globally as an effective, environmentally friendly and cheaper method of hydrocarbon pollution remediation. Bioremediation has two basic approaches. Bioremediation by augmentation and bioremediation by stimulation. Among the two, biostimulation is the most effective approach. It involves the addition of organic or inorganic nutrient to the polluted medium to enhance the growth and activity of indigenous microbes that can biodegrade the pollutant. The results obtained in the study show that corn cob is a potential organic material for biostimulation of petroleum hydrocarbon biodegradation.

4.2 Recommendations

Based on the results obtained in this study, recommendations are made as follows.

I. Application of locally sourced materials for the remediation of the severely polluted Niger Delta environment should encouraged and supported.
II. Further field study to evaluate the effectiveness of corn cob for biostimulation should be undertaken

REFERENCES

Agbogidi, O.M and Ejemete, O.R (2005). An assessment of the effectof crude oil pollution on soil properties, germination and growth of *Gambaya albidach, (L*). uniswa Research *Journal of Agriculture, Science and Technology*, 8(2), 148 – 155

Arodiegwu, E (2015). Oil pipeline explosion kill 12 in Bayelsa State. *Premium Times 5 Febrary, 2015*

Egbo Walamam Manis and Ambrose Inivie Francis (2023). Efficiency of Municipal Drainage Biosludge Enhanced Bioremediation of Crude Oil Polluted Soil. *World Journal of Innovation and Modern Technology*.7(1): 87-97

Egbo Walamam Manis and Eremasi Yaguo Benjamin Ikele(2022). Hydrochemical Assessment and Characterization of Selected Boreoles Water in Onopa, Azikoro and Agbura Axis of Atissa in Yenagoa Metropolis of Bayelsa State, Nigeria. *International Journal of Engineering and Modern Technology* (IJEMT) 8.(5):23 - 30

Ekundayo, E.P, Emede, T.O. and Osayinde, D. (2000) Plant foods for human nutrition, University of Benin, Nigeria.

Gill, L.S and Sandota,R.M.A (1976). Effect of foliarly applied ccc on the growth of Phaseolu Saureus Roxb. (mung or green gram). *Bangladesh journal of Biological Science*: 15; 35 – 40.

Ogochukwu A. Udume., Gideon Abu., Herbert O. Stanley., Ijeoma F. Vincent-Akpu., Yusuf Momoh and Michael O. Eze (2023). Biostimualtion of Petroleum Contaminated Soil Using Organic and Inorganic Amendments. *Journal of Plants* 12(3):431

Oyinloye, M. A, and Olamiju, O.I (2013) An Assessment of the physical Impact of Oil Spillage Using GIS and Remote Sensing Technologies: Empirical Evidence from Jesse Town, Delta State, Nigeria. *British Journal of Arts and Sciences*, 12 (2): 212 – 220.

Hussein, I., Abdel-Shafy, Mon, S.M and Mansur (2016). A review on poly cyclic aromatic hydrocarbon; source, environmental impact, effect on human health and remediation. *Egyptian Journal of Petroleum*. 25(1): 103 – 123.

National Ocean and Atmospheric administration (NOAA, 2024). How can a Oil Spill Affect Your Community. NOAAs, Dammage Assessment, Remediadion and Restoration program. Retrieved on 7th August, 2024 from www.darrp.noaa.gov/oi

Ntukakpo, D.S (1996). Spillage : Bane of petroleum, Ultimate water technology and Environment.

Nwilo, P.C, Peters, K.O and Badejo (2005). Oil spill problems and management in the Niger Delta International oil spill conference proceedings.2005 (1): Pp. 567 -570.

Odokumo, L.O and Dickson (2003).Bioremediation of crude oil polluted tropical rain Forest soil. *Global journal of Environmental Science.* 2 (1): 29 – 40.

Shishira Streenivas (2023). Health Effects of Oil Spills. Retrieved on 7th August, 2024 from www.webmd.com/cang

Treehugger, (2024) Environmental Consequences of Oil Spills. Retrieved on 7th August, 2024 from www.treehugger.com/env

Vincenzo Piemonte (2016). Bioremediation of hydrocarbon contaminated soil using selected organic wasyes. Oil and gas portal. Available at www.oil.gasportal.com/bio

Watanabe, K (2001). Microorganisms relevant to bioremediation current option in biotechnology. *Biotechnology journal*. 12(3): 237 – 241