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POTENTIAL OF OIL PALM EMPTY FRUIT BUNCH ASH FOR REMEDIATION OF CRUDE OIL POLLUTED SOIL

E. Albert and F. B. G. Tanee

Department of Plant Science and Biotechnology
University of Port Harcourt, Port Harcourt, Nigeria

ejikemealbert@yahoo.com, tanee_3030@yahoo.com

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ABSTRACT

The potential of oil palm empty fruit bunch ash for remediation of crude oil polluted soil was investigated. Three levels (100 g, 200 g and 300 g) of ash treatments in 2 kg of soil were set up alongside a control (nil ash) after pollution with100 ml of crude oil. Composite soil samples were collected and analyzed at intervals of 30 days. Results showedthat total hydrocarbon content was significantly reduced by 1.13 % in 100 g; 2.20 % in 200 g; 2.08 % in 300 g ash treatments respectively and 0.71 % in the control, nitrogen content increased slightly by 0.011 mg/kg, 0.009 mg/kg and 0.015 mg/kg in 100 g, 200 g and 300 g ash treatments respectively while total organic carbon increased by 7.72 % in 200 g ash treatment and phosphorus content by 0.05 mg/kg, 0.17 mg/kg and 0.34 mg/kg in the order of ash treatments. Soil pH increased in alkalinity, soil electrical conductivity and cation exchange capacity also increased with increase in ash treatment. Oil palm empty fruit bunch ash treatment of crude oil polluted soil reduced total hydrocarbon content, increased soil nitrogen and phosphorus contents. It was concluded that, oil palm fruit bunch ash can be used for restoration of crude oil polluted soil.

Key words: Soil; Crude Oil; Pollution; Oil Palm Bunch; Remediation

INTRODUCTION

Nigeria is one of the world's major crude oil producing countries. However, the exploration, exploitation, transportation, processing and use of this mineral and its many derivatives have left harmful effects on the environment (Ifeadi & Nwankwo, 1987).

In Nigeria, a large amount of crude oil is spilled annually into the environment especially in the Niger Delta area. Kontagora (1991) reported that between 1976 and 1990, oil companies in Nigeria reported a total of 2,796 oil spills and an estimated 2,105,393 barrels of crude oil were spilled into Nigeria's environment. From the '90s till present day, the spate of oil spill has continued unabated or even doubled as justified by UNEP (2011) on the assessment of extent of crude oil environmental pollution in Ogoniland. The situation became worsened by increased agitation for oil mineral rights by various rural communities and ethnic nationalities in Nigeria which led to militancy and violence

against oil facilities, crude oil theft and artisanal refining which is still ongoing in the Niger Delta. Crude oil environmental pollution therefore has become widespread and has left large expanse of farmlands, creeks, swamps and groundwater destroyed (Okpokwasili and Odokuma, 1990; Odokuma and Ibor, 2002; UNEP, 2011).
Crude oil being a complex mixture when released into the environment presents different challenges (Vandermuelen and Lee, 1986). Ogboghodo *et al*. (2004) and Kayode *et al*. (2009) reported that crude oil pollution alters soil physical and chemical properties, is phytooxic on plants (Omosun *et al*., 2008) and reduced dry matter accumulation (Ekpo and Ebeagwu, 2009; Agbogidi, 2011).

Bioremediation has become an increasingly important remedial option for environmental pollution. Bioremediation has a great potential for destroying environmental pollutants (Song *et al*., 1990). It is inexpensive, environmentally friendly and use of simple processes is some of advantages over other remedial methods such as physical and chemical treatments etc. Biostimulation, a method of bioremediation involves the addition of microbial nutrients to stimulate the degradation of a pollutant has been explored in some studies which tested substances such as NPK, dungs and some organic materials. In line with similar scientific trials, ash derived from oil palm empty fruit bunch, a commonly available agrowaste was reported by Udoetok, 2012; Kala et al. (2009) to be rich in phosphate and nitrate etc was tested for application in chemical reduction process such ashydrocarbon degradation.

This study was carried out to evaluate the potential of oil palm empty fruit bunch (OPEFB) ash to stimulate microbial degradation of petroleum hydrocarbon by indigenous soil microorganisms. A positive result will provide a simple and low technology approach of remediating petroleum hydrocarbon pollution. It will also provide a way to use oil palm empty fruit bunch which is readily available and constitute nuisance in palm oil mills in Niger delta area. Furthermore, successful stimulation of hydrocarbon degradation will help recover farmlands which have been rendered unfarmable due to crude oil pollution.

MATERIALS AND METHODS

This study was carried out at the screened house of Department of Plant Science and Biotechnology, University of Port Harcourt, Nigeria. Raw crude oil was obtained from Shell Petroleum Development Company (SPDC) Limited, Nigeria while oil palm empty fruit bunches were obtained from a palm oil mill at Aluu, Port Harcourt. The oil palm empty fruit-bunches obtained from the mill were sun-dried to a constant weight, placed in a metal bowl and then burnt in air to derive its ash.

Top-soil was collected from within 5 m × 5 m area located in a fallow land behind Department of Gas Engineering, University of Port Harcourt. The soil was bulked together and thoroughly mixed to avoid spot differences. The bulked soil was air-dried and sieved using 2 mm soil sieve to remove plant materials and boulders.

Two kilogramme (2 kg) each of the processed soil was placed in twenty (5 L capacity) vessels randomly separateed into batches A, B, C and D. The set ups were

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irrigated with 500 ml of water to prevent dryness of soil, treated with 100 ml of crude oil eachand allowed for seven (7) days for the pollutant to infiltrate into the soil. Thereafter, 100 g, 200 g and 300 g of oil palm empty fruit bunch (OPEFB) ash were incorporated into batches B, C and D respectively while batch A received no ash treatment and therefore served as the control. The experiment was watered at 14 days interval to prevent the soil from drying up and maintain conducive soil condition for bioremediation processes.

Composite sampling technique was used to obtain soil samples on the thirtieth (30) and sixtieth (60) days after treatment for analysis. Samples collected were analysed for total hydrocarbon content, nitrogen content, phosphorus content, total organic carbon, soil pH, soil electrical conductivity and cation exchange capacity.

Total hydrocarbon content was determined by gas chromatographic method using GC machine (HP 5890 II) through flame ionization detection (GC-FID) after extraction with toluene. Nitrogen content was determined using Kjedahl method, phosphate content by Bray No.1 method and total organic carbon was determined according to Walkley-Black (1934). Soil pH and electrical conductivity were determined through meter methods by means of pH meter (Hanna HI 8314 model) and conductivity meter (HACH Ectestr microprocessor model) while cation exchange capacity by spectrophotometric method by means of atomic absorption spectrophometer (AAS). Data obtained were analyzed using paired t-test statistical analysis according to Ogbeibu (2005) and presented in bar graphs using Excel package of Microsoft Office 2007.

RESULTS

Table 1 is natural (baseline) chemical characteristics of soil and its chemical characteristics seven (7) days after pollution with crude oil. Some soil assessment characteristics were altered after treatment with the pollutant as shown in the Table. Total hydrocarbon content, THC increased from 0.191 mg/kg (baseline) to 3469 mg/kg 7 days after pollution (7 DAP). Soil phosphate content was also increased (from 0.004 – 2.18 ppm) while nitrogen, total organic carbon, pH, conductivity and cation exchange capacity were reduced 7 DAP compared with the baseline (Table 1).

Table 1: Baseline and Soil Characteristics Seven (7) Days after Treatment with Crude Oil

Parameter	**Baseline**	**7 days after pollution (DAP)**
Total hydrocarbon content, THC (mg/kg)	0.191	3469.0
Nitrogen (mg/kg)	0.297	0.113
Phosphate (mg/kg)	0.004	2.18
Total organic carbon (%)	3.437	1.28
pH	8.42	5.13
Conductivity (µS/cm)	325	122.0
Cation exchange capacity (meq/100g)	13.465	12.432

Fig. 1 showed the effect of the remediation treatment material (OPEFB) on total hydrocarbon content. There was a significant reduction in THC of the treatments compared with the control over the interval of study. THC reduced by 0.71 %, 1.13 %, 2.20 % and 2.08 % in the control, 100 g, 200 g and 300 g ash treatments respectively. This showed proportional reduction in THC with the amount of ash applied. The result suggests that OPEFB is capable of stimulating biodegradation of petroleum hydrocarbon polluted soil by fostering microbial metabolism due to its high essential nutrients content (Ubochi *et al*., 2006; Ijah *et al*., 2008 and Onyelucha *et al.*,2013).

Addition of OPEFB ash was found to significantly increase the nutrient content of the polluted soil compared with the control as nitrogen and phosphorus contents increased with increase in ash treatment (Figs 2 and 3). The increase in nitrogen and phosphorus content is understandable since the treatment material is of organic origin and has been reported to have high concentration of mineral nutrient contents (Udoetok, 2012).

Fig. 4 shows total organic carbon (TOC) result. This wasfound to increase with ash treatment and time. The highest TOC value was obtained in 300 g ash treatment while the least was obtained in the control. It can be explained that the increase TOC was due to the pollutant applied.

Soil pH showed a reduction in acidity from 5.48 (of the control) to its minimum (6.00) in treatment (Fig. 5). Conductivity increased from 200 μS/cm to 236 μS/cm and to 400 μS/cm in 100 g, 200 g and 300 g ash treatments respectively compared with 127 μS/cm of the control (Fig. 6), while cation exchange capacity (CEC) increased significantly in treatment compared with its control (Fig. 7). The changes pH, conductivity and CEC results may be due to high concentrations of cations from the ash as reported by Udoetok (2011). The high concentrations of the cations could have adjusted the pH of the medium to alkaline which resulted in increased soil electrical conductivity and cation exchange capacity.

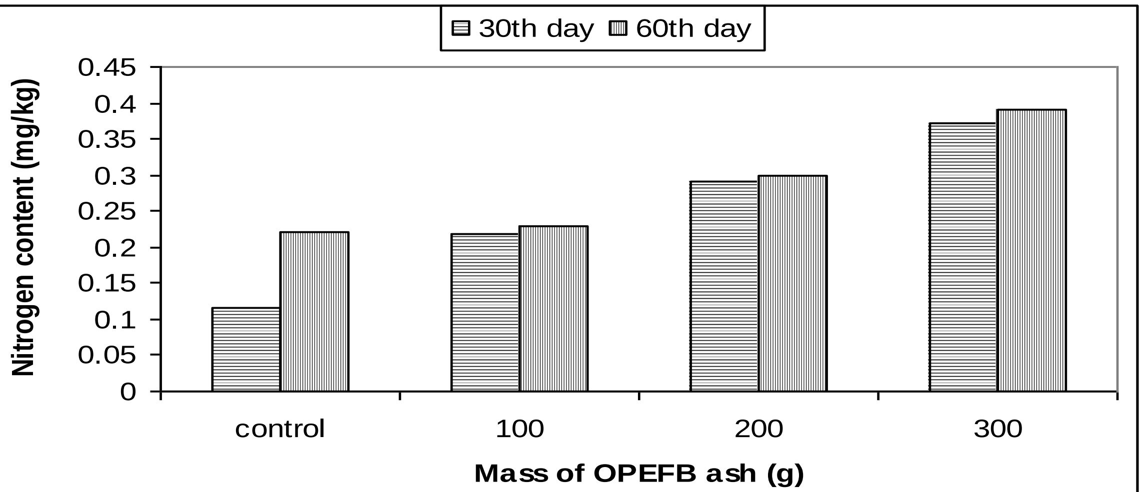

Fig. 2: effect of OPEFB ash on nitrogen content of crude oil polluted soil

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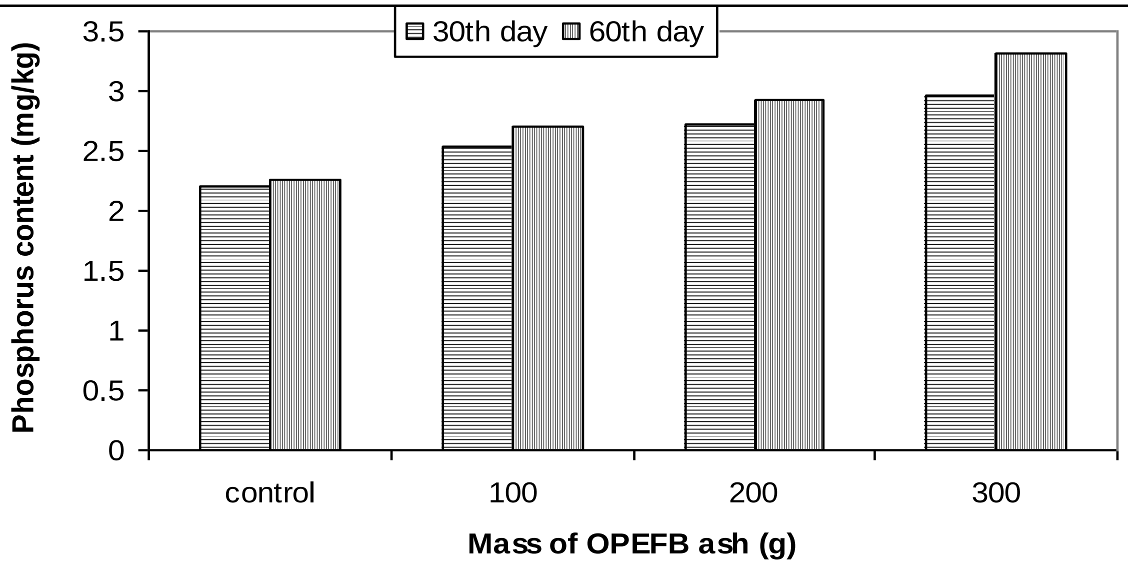

Fig. 3: effect of OPEFB ash on phosphorus content of crude oil polluted soil

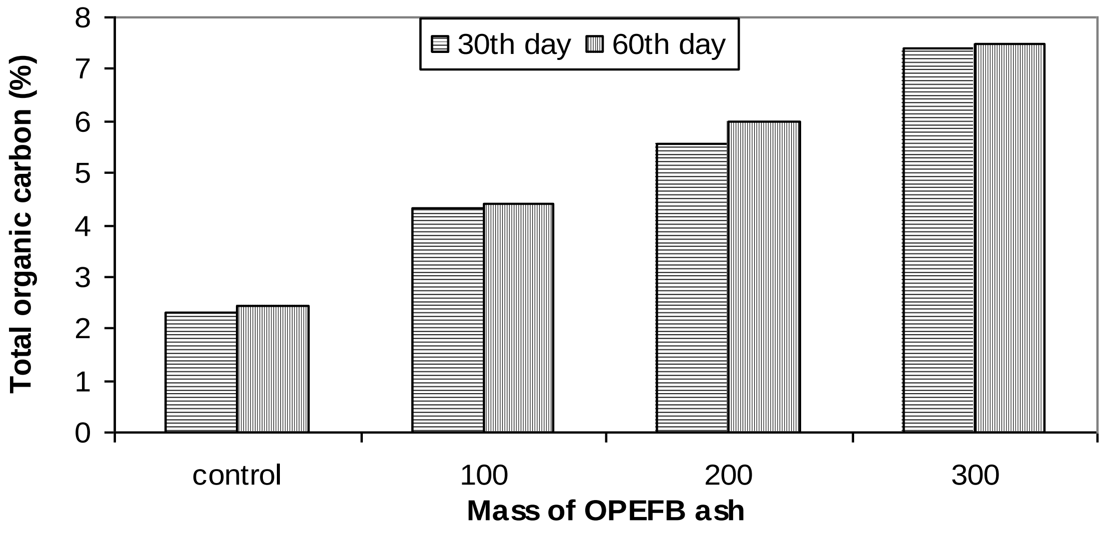

Fig. 4: effect of OPEFB ash on total organic carbon of crude oil polluted soil

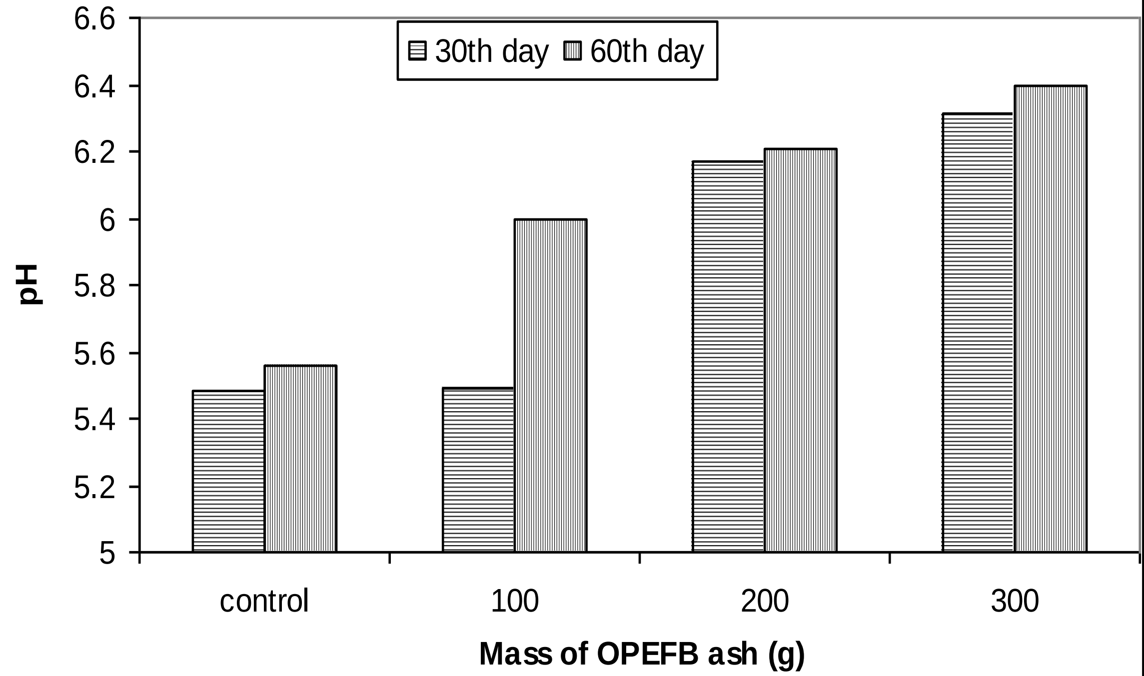

Fig. 5: effect of OPEFB ash on pH of crude oil polluted soil

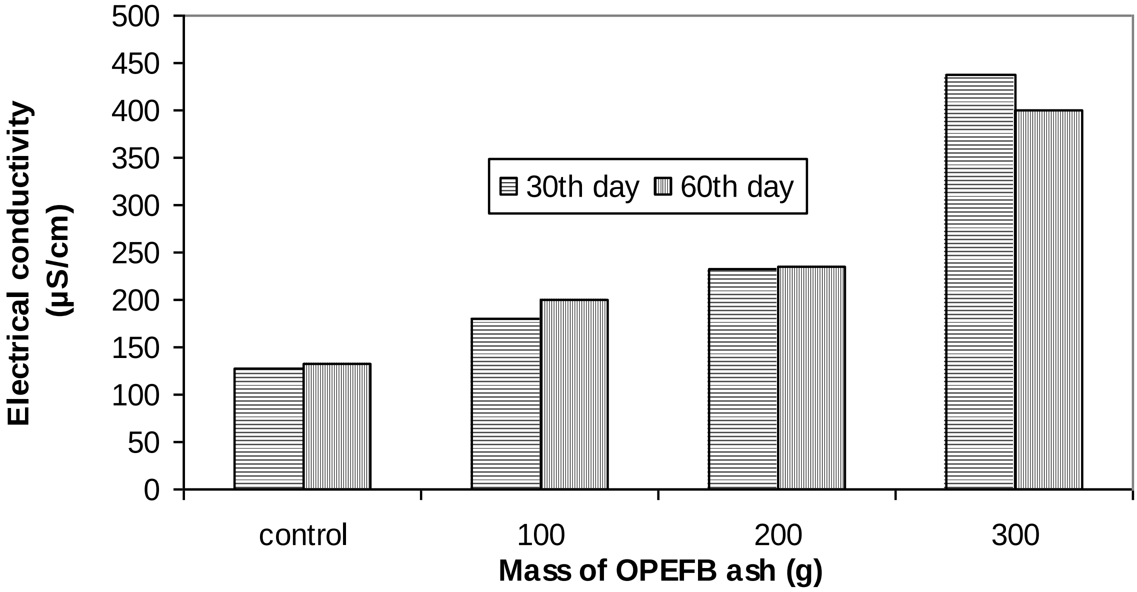

Fig. 6: effect of OPEFB ash on electrical conductivity of crude oil polluted soil

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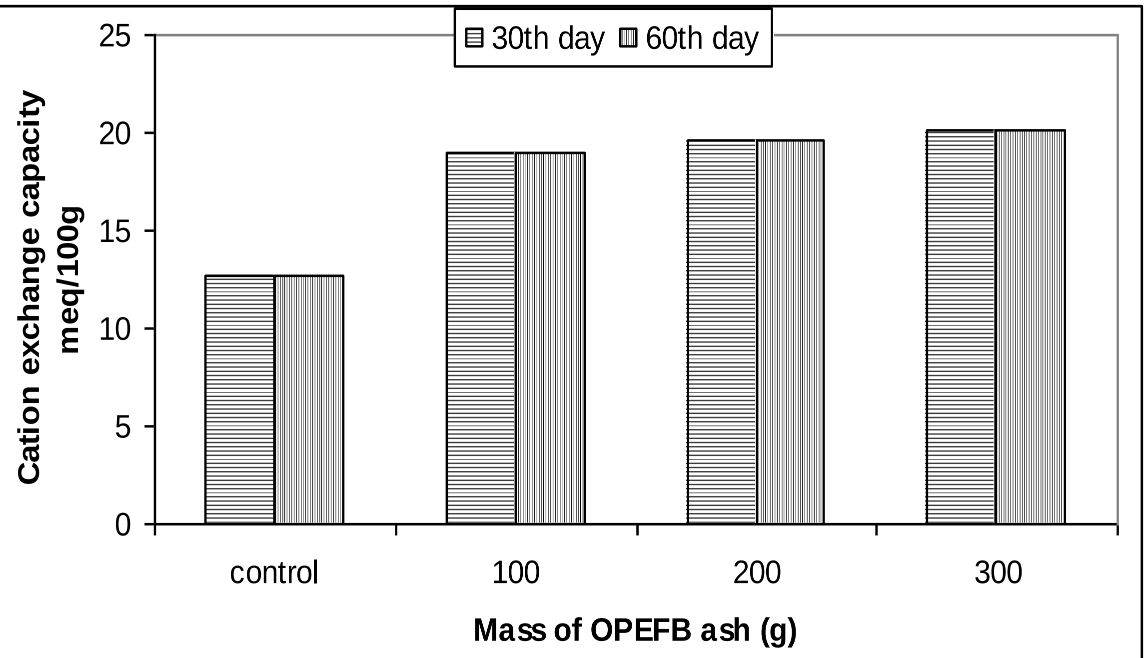

Fig. 7: effect of OPEFB ash on cation exchange capacity of crude oil polluted soil

DISCUSSION

The observed increase in THC 7 DAP pollution is in line with Osuji and Nwoye (2007). This observation can been explained by the fact that crude oil is composed of over 80% hydrocarbons and therefore its addition to the soil accounts for the tremendous increase of the variable in the polluted soil. However, reduction in THC after remediation is also in line with Udoetok (2012) suggestion that OPEFB ash is suitable for application in bioremediation hydrocarbon polluted soil. It also agrees with Onuh *etal*. (2008) who reported increase in soil phosphorus content using poultry manure to stimulate crude oil pollution of garden soil.

Increase in nitrogen content also agrees with Akpoveta *et al*. (2011) in a study on petroleum hydrocarbon polluted Niger Delta soil remediated with pig dung. Increase in TOC agrees with Ebere *et al*. (2011) which studied enhanced remediation of crude oil polluted soil using NPK fertilizer. The reduction in soil pH agrees with Abu and Atu (2008); Akpoveta *et al.* (2011) who obtained similar result in separate studies in which pH changes in biodegradation of hydrocarbons and oxygen limitations in bioremediation experiments were monitored.

Based on the results obtained, addition of oil palm empty fruit bunch ash to crude oil polluted soil stimulated biodegradation of petroleum hydrocarbon. This is evidenced by the higher percentage decrease in concentration of THC and increase in nutrient contents (nitrogen and phosphorus) in the treatments compared with the control. It is recommended that further investigation into effective use of this local and commonly available agrowaste material for remediation of petroleum hydrocarbon soil pollution be carried out as it might provide a low cost, environment- friendly and low technology material for mitigating crude oil soil pollution which destroys the environment, anti-conservation and reduces available farmland for food production in Niger Delta of Nigeria.

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