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Effect of crude oil on the physicochemical properties of sandy loam soil amended with cocoa pod husk and plantain peels

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ABSTRACT

The effect of crude oil on the physicochemical properties of sandy loam soil amended with cocoa pod husk and plantain peels was carried out in the Department of Genetics and Biotechnology, University of Calabar, Calabar. Top soil (0-15cm depth) was randomly collected from four points, bulked to form composite sample, sieved and two kilogrammes each were weighed into thirty six plastic buckets, which were then polluted with 250ml of crude oil. The plastic buckets were labeled in single form (COC_1, 400CPH, 500CPH, COC_2, 400PP, 500PP), and in combined forms (COC_3, 200CPH + 200PP, 250CPH + 250PP), with the control as PC_1, PC_2, PC_3 (0g) without crude oil. The amendments were applied and soil samples taken at baseline (before and after pollution) and 90 days after treatment. The result shows that the organic carbon before and after pollution of the soil were 1.29±0.02 and 6.42±0.03 respectively and the pH of the soil before and after pollution were 5.20±0.10 and 5.90±0.10 respectively. The result of this study shows that the pH values of the treated soil was 7.90±0.06 and 8.10±0.06 for 400CPH, 500CPH respectively, 7.40±0.06 and 7.80±0.06 and 7.40±0.06 for 400PP, 500PP respectively and 7.2±0.01 and 7.40±0.06 for 200CPH+200PP, 250CPH+250PP respectively as compared with the crude oil controls (COC) 5.89±0.03. The result of percentage organic carbon content of the soil after treatment were 2.80±0.06 and 2.45±0.01 for 400CPH and 500CPH respectively, 3.26±0.01 and 2.99±0.02 for 400PP, 500PP respectively and 2.85±0.06 and 2.62±0.04 for 200CPH + 200PP, 250CPH + 250PP respectively, as compared with the crude oil control (COC1) 5.98±0.04. This result thus suggest that cocoa pod husk due to its buffering capacity is a good bioremediating agent that should be used in the degradation of petroleum hydrocarbons in regions where they is an oil spill.

Keyword: Crude oil, Cocoa pod husk, Plantain peels, Physicochemical, Degradation

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INTRODUCTION

Crude oil production and exploitation is a major source of income for the Nigerian economy. Petroleum provides about 90% of the export earnings and serves as primary raw materials for the chemical industries. The high demand for petroleum products in the form of cooking gas, aviation fuel, gas oil, engine lubricating oil, asphalt and coal tar means increase in production and this eventually results in oil spills and hydrocarbon contamination of the environment especially through oil well blow out, tanker accidents, accidental rupture of pipelines and routine clean up operations [1, 2]. The spill of petroleum and its products has led to profound terrestrial and aquatic environmental degradation, especially in oil producing communities. The impact on terrestrial environment ranges from aesthetic quality modification to death of sensitive biotic species.

One of the environmental challenges posed by oil pollution is the alteration in the physical and chemical nature of the soil which subsequently affects the growth of plants [3]. Petroleum hydrocarbon contamination may affect plants by retarding seed germination and reducing height, stem density, photosynthetic rate and biomass or resulting in complete mortality [4].

The environmental consequences of oil pollution on most agricultural lands have turned hitherto productive areas into wastelands, with increasing soil infertility due to the alteration of physicochemical properties of the soil, and dwindling agricultural productivity thus has led to redundancy of farming and fishing activities resulting in urban and rural migration, in oil producing area due to the attendant economic downturn [5]. The degree of oil impact also depends on various factors, such as the type and amount of oil, the extent of oil coverage, the plant species, the season of the spill, the soil composition, and the flushing rate. Oiled shoots of crops like pepper, okra, cocoyam, yams and tomatoes may wilt and die off due to blockage of stomata thereby inhibiting photosynthesis, transpiration and respiration. In fact, germination, growth performance and yield of these crop stifled by oil spillage [6]. This present study is aimed at utilizing cocoa pod husk, plantain peels and it combination in restoring the physicochemical properties of soil after intensive pollution with crude oil.

MATERIALS AND METHODS

Experimental design

Top soil (0-15cm depth) was randomly collected from four points, using a dutch auger, bulked to form a composite sample and two kilogram each of the composite samples were weighed and transferred into thirty six labeled plastic buckets (PB) with drainage holes at the base, plugged with cotton wool to retain the soil [7]. The plastic buckets were arranged in triplicate in a completely randomized design. Crude oil (Bonny light) obtained from Nigeria Agip oil Company, Port-Harcourt, River State, Nigeria was applied as the pollutant. 250ml of crude oil was applied to each plastic bucket labeled in single form (COC_1, 400CPH, 500CPH, COC_2, 400PP, 500PP), and in combined forms (COC3, 200CPH + 200PP, 250CPH + 250PP), with the control as PC_1, PC_2, PC_3 (0g) without crude oil. The oil was thoroughly mixed with the soil in the plastic buckets and the set up were allowed to stand for one week for acclimatization between the soil and the oil. After one week post- contamination the amendments were applied and mixed thoroughly with the soil. 250mls of distill water was applied every one week in other to adjust the moisture content of each sample to 60% of the soil moisture holding capacity [8].

Laboratory analysis

Sampling was done on day Zero (before crude oil contamination), day 8 after contamination, 90 days after treatment regime. Soil sample were collected using dutch auger and taken to the laboratory for physicochemical.

Determination of physicochemical properties of soil

Estimation of physicochemical parameters was done using the method of [9]. The following parameters were analyzed: moisture, organic carbon, particle size, nitrogen, phosphorus, potassium, magnesium, sodium, aluminum, hydrogen, pH, exchangeable cation exchange capacity, base saturation and electrical conductivity.

Statistical analysis

Collected data was subjected to analysis of variance (ANOVA) test using 3-factor factorial in a Completely Randomized Design (CRD). Mean were separarated using Least significant difference LSD test

RESULTS

Baseline physicochemical properties of the soil.

The result of baseline physicochemical properties of soil before and after contamination with crude oil as presented in Table 1 shows that the pH of the unpolluted and polluted soil was 5.20 ± 0.10 and 5.90 ± 0.10 respectively. The organic carbon for unpolluted and polluted soil was 1.29 ± 0.02% and 6.42 ± 0.03% respectively. The total hydrocarbon carbon content for unpolluted and polluted was 28.00 ± 2.64mgkg^{-1} and 1056.44 ± 7.65mgkg^{-1} respectively and the soil was identified and classed as sandy loam.

Table 1 Baseline physiochemical properties of soil before and after contamination of crude oil

Parameters	Before contamination	After contamination
Moisture (%)	11.52 ± 0.10	10.27 ±0.06
Sand (%)	84.30 ± 0.76	83.6 ± 0.40
Silt (%)	9.70 ± 0.06	8.8 ± 0.32
Clay (%)	6.00 ± 0.58	7.6 ± 0.17
Ph	5.20 ± 0.10	5.90 ± 0.10
Org. C (%)	1.29 ± 0.02	6.42 ± 0.03
Total N (%)	0.11 ± 0.01	0.07 ± 0.01
Avail. P ($mgkg^{-1}$)	37.7 ± 0.26	2.03 ± 0.03
Ca ($Cmolkg^{-1}$)	2.00 ± 0.15	2.4 ± 0.10
Mg ($Cmolkg^{-1}$)	1.00 ± 0.10	0.8 ± 0.05
K ($Cmolkg^{-1}$)s	0.45 ± 0.01	0.76 ± 0.01
Na ($Cmolkg^{-1}$)	0.11 ± 0.01	0.13 ± 0.01
Al^{3+} ($Cmolkg^{-1}$)	0.95 ± 0.03	1.50 ± 0.06
H^{+} ($Cmolkg^{-1}$)	1.00 ± 0.06	1.80 ± 0.06
ECEC ($Cmolkg^{-1}$)	3.56 ± 0.05	4.09 ± 0.25
BS (%)	45.22 ± 0.75	19.32 ± 1.3
E C (ds/m)	0.62 ± 0.02	0.35 ± 0.05
THC ($mgkg^{-1}$)	28.0 ± 2.64	1056.44 ± 7.65
Texture	Sandy loam	Sandy loam

Table 2 Macronutrients in Cocoa pod husk and Plantain peels

Parameters	Cocoa pods husk	Plantain peels
pH	7.2	6.0
Organic carbon (%)	29.53	42.29
Nitrogen (%)	2.80	2.45
Phosphorus (%)	0.32	0.34
Potassium (%)	0.72	0.64
Calcium (%)	1.2	0.76
Magnesium (%)	0.80	0.64

Physicochemical properties of crude oil amended soil

pH

The results obtained indicated that there were significant differences ($p < 0.05$) among the various agro-wastes used in the study. The addition of 400g and 500g cocoa pod husk showed that the pH values obtained were as follows: 7.9±0.06 and 8.10±0.06 respectively, as compared with 5.30±0.01 and 5.89±0.03 of the pristine control and crude oil polluted control respectively. The addition of 400g and 500g plantain peels to the polluted soil showed that the pH values were as follows: 7.4±0.06 and 7.8±0.06 respectively, as compared with 5.36±0.01 and 5.82±0.02 of the pristine control and crude oil polluted control respectively and the addition of 400g and 500g cocoa pod husk + plantain peels(1:1) to the polluted soil shows that the pH values were as follows: 7.2±0.10 and 7.4±0.06 respectively, as compared with the pristine controls and crude oil polluted controls having the following values: 5.31±0.01 and 5.80 ±0.03 respectively. The result indicates that 400g and 500g of cocoa pod husk significantly increases ($p < 0.05$) the pH of the soil than the concentrations of plantain peels and cocoa pod husk + plantain peels (1:1) treated soil (Table 3).

Organic carbon

The organic carbon content of the treated soil polluted with crude oil shows that when 400g and 500g cocoa pod husk were added to the soil the following mean value were obtained: 2.80±0.06 and 2.45±0.01 respectively, as compared with 1.29±0.01 and 5.92±0.04 of the pristine control and crude oil polluted control. The addition of 400g and 500g plantain peels to the polluted soil showed that the means values of organic carbon were as follows: 3.26±0.01 and 2.99±0.02 respectively, as compared with 1.30±0.01 and 5.98±0.03 of the pristine control and crude oil polluted. When 400g and 500g cocoa pod husk + plantain peels (1:1) were added to the polluted soil the mean values of organic carbon were as follows: 2.85±0.06 and 2.62±0.04 respectively, as compared with the pristine control and crude oil polluted control values which were 1.31±0.02 and 5.98±0.04 respectively. This result shows that 500g of cocoa pod husk significantly reduces ($p < 0.05$) the organic carbon content of the soil than plantain peels and cocoa pod husk + plantain peels (1:1) (Table 3).

Table 3 Physicochemical parameters of crude oil polluted soil amended with cocoa pod husk, plantain peels and cocoa pod husk and plantain peels

	Cocoa pods husks				Plantain peels				Cocoa pods husks + plantain peels			
Parameter	PC_1	COC_1	400g	500g	PC_2	COC_2	400g	500g	PC_3	COC_3	400g	500g
Moisture (%)	$19.64^{h}\pm0.10$	$21.89^{g}\pm0.06$	$28.45^{d}\pm0.55$	$27.85^{e}\pm0.65$	$20.64^{h}\pm0.1$	$22.12^{g}\pm0.06$	$24.65^{f}\pm0.25$	$29.58^{c}\pm0.17$	$18.99^{h}\pm0.10$	$21.55^{g}\pm0.06$	$30.21^{b}\pm0.07$	$34.89^{a}\pm0.32$
Sand (%)	$83.90^{a}\pm0.31$	$84^{a}\pm0.76$	$83.9^{a}\pm0.40$	$82.50^{a}\pm0.26$	$82.96^{a}\pm0.31$	$83.56^{a}\pm0.76$	$79.1^{b}\pm0.25$	$78.9^{b}\pm0.35$	$83.58^{a}\pm0.31$	$81.55^{a}\pm076$	$81.9^{a}\pm0.72$	$82.2^{a}\pm0.21$
Silt (%)	$8.70^{e}\pm0.06$	$9.20^{d}\pm0.10$	$8.6^{e}\pm0.10$	$11.70^{c}\pm0.57$	$8.78^{e}\pm0.06$	$9.10^{d}\pm0.10$	$12.4^{a}\pm0.23$	$11.7^{b}\pm0.31$	$8.99^{e}\pm0.06$	$9.29^{d}\pm0.10$	$11.7^{b}\pm0.42$	$10.8^{c}\pm0.30$
Clay (%)	$7.40^{d}\pm0.06$	$7.70^{c}\pm0.06$	$7.3^{d}\pm0.06$	$5.40^{g}\pm0.06$	$8.26^{d}\pm0.06$	$7.34^{c}\pm0.06$	$8.50^{b}\pm0.10$	$9.4^{a}\pm0.15$	$7.43^{d}\pm0.06$	$9.16^{c}\pm0.06$	$6.4^{f}\pm0.06$	$7.0^{e}\pm0.25$
pH	$5.30^{f}\pm0.01$	$5.89^{e}\pm0.03$	$7.9^{b}\pm0.06$	$8.10^{a}\pm0.06$	$5.36^{f}\pm0.01$	$5.82^{e}\pm0.02$	$7.4^{c}\pm0.06$	$7.8^{b}\pm0.06$	$5.31^{f}\pm0.01$	$5.80^{e}\pm0.03$	$7.2^{d}\pm0.10$	$7.4^{c}\pm0.06$
Org. C (%)	$1.29^{g}\pm0.01$	$5.92^{a}\pm0.04$	$2.80^{e}\pm0.06$	$2.45^{f}\pm0.01$	$1.30^{g}\pm0.01$	$5.98^{a}\pm0.03$	$3.26^{b}\pm0.01$	$2.99^{d}\pm0.02$	$1.31^{g}\pm0.02$	$5.89^{a}\pm0.04$	$2.85^{b}\pm0.06$	$2.62^{c}\pm0.04$
Total N (%)	$0.16^{d}\pm0.01$	$0.09^{d}\pm0.01$	$0.30^{b}\pm0.01$	$0.33^{b}\pm0.01$	$0.15^{d}\pm0.01$	$0.07^{d}\pm0.01$	$0.24^{c}\pm0.01$	$0.29^{b}\pm0.01$	$0.16^{d}\pm0.01$	$0.08^{d}\pm0.01$	$0.32^{b}\pm0.01$	$0.45^{a}\pm0.05$
Avail. P ($mgkg^{-1}$)	$39.8^{b}\pm0.06$	$7.66^{h}\pm0.04$	$60.50^{a}\pm0.51$	$63.42^{a}\pm0.19$	$40.9^{b}\pm0.06$	$7.78^{h}\pm0.04$	$18.28^{e}\pm0.27$	$14.25^{g}\pm0.11$	$38.7^{b}\pm0.06$	$7.44^{h}\pm0.04$	$28.5^{d}\pm0.25$	$32.30^{c}\pm0.69$
Ca ($Cmolkg^{-1}$)	$2.11^{e}\pm0.06$	$2.23^{e}\pm0.06$	$12.60^{b}\pm0.15$	$17.40^{a}\pm0.31$	$2.10^{e}\pm0.06$	$2.20^{e}\pm0.06$	$6.30^{d}\pm0.06$	$7.0^{c}\pm0.26$	$2.12^{e}\pm0.06$	$2.24^{e}\pm0.06$	$6.2^{d}\pm0.15$	$6.5^{d}\pm0.10$
Mg ($Cmolkg^{-1}$)	$1.00^{d}\pm0.15$	$0.90^{e}\pm0.06$	$1.40^{d}\pm0.01$	$3.20^{a}\pm0.10$	$1.10^{d}\pm0.15$	$0.80^{e}\pm0.06$	$1.20^{d}\pm0.10$	$1.40^{d}\pm0.10$	$1.00^{d}\pm0.15$	$0.90^{e}\pm0.06$	$1.8^{c}\pm0.15$	$2.5^{b}\pm0.10$
K ($Cmolkg^{-1}$)	$0.43^{a}\pm0.02$	$0.29^{a}\pm0.02$	$0.22^{b}\pm0.01$	$0.21^{b}\pm0.01$	$0.42^{a}\pm0.02$	$0.28^{a}\pm0.02$	$0.19^{b}\pm0.01$	$0.20^{b}\pm0.01$	$0.4^{a}\pm0.02$	$0.30^{a}\pm0.02$	$0.18^{b}\pm0.01$	$0.20^{b}\pm0.01$
Na ($Cmolkg^{-1}$)	$0.09^{a}\pm0.01$	$0.12^{a}\pm0.02$	$0.11^{a}\pm0.01$	$0.13^{a}\pm0.01$	$0.10^{a}\pm0.01$	$0.11^{a}\pm0.02$	$0.11^{a}\pm0.01$	$0.11^{a}\pm0.01$	$0.09^{a}\pm0.01$	$0.13^{a}\pm0.02$	$0.10^{a}\pm0.01$	$0.12^{a}\pm0.01$
Al^{3+} ($Cmolkg^{-1}$)	$0.99^{a}\pm0.01$	$1.00^{a}\pm0.15$	$0.02^{b}\pm0.01$	$0.01^{b}\pm0.00$	$0.98^{a}\pm0.01$	$0.07^{a}\pm0.15$	$0.08^{b}\pm0.01$	$0.02^{b}\pm0.01$	$0.98^{a}\pm0.01$	$1.00^{a}\pm0.15$	$0.11^{b}\pm0.01$	$0.07^{b}\pm0.01$
H^{+} ($Cmolkg^{-1}$)	$1.21^{a}\pm0.06$	$1.58^{a}\pm0.12$	$0.12^{b}\pm0.01$	$0.09^{b}\pm0.02$	$1.20^{a}\pm0.06$	$1.60^{a}\pm0.12$	$0.14^{b}\pm0.01$	$0.11^{b}\pm0.01$	$1.19^{a}\pm0.06$	$1.50^{a}\pm0.12$	$0.21^{b}\pm0.01$	$0.19^{b}\pm0.01$
ECEC ($Cmolkg^{-1}$)	$3.61^{f}\pm0.02$	$3.50^{f}\pm0.01$	$14.33^{b}\pm0.04$	$20.94^{a}\pm0.67$	$3.63^{f}\pm0.02$	$3.51^{f}\pm0.01$	$8.23^{e}\pm0.06$	$8.71^{d}\pm0.04$	$3.62^{f}\pm0.02$	$3.53^{f}\pm0.01$	$8.28^{e}\pm0.06$	$9.32^{c}\pm0.05$
EC (ds/m)	$0.69^{a}\pm0.01$	$0.34^{a}\pm0.01$	$1.31^{a}\pm0.01$	$1.26^{a}\pm0.01$	$0.68^{a}\pm0.01$	$0.33^{a}\pm0.01$	$1.27^{a}\pm0.00$	$1.57^{a}\pm0.00$	$0.67^{a}\pm 0.01$	$0.32^{a}\pm0.01$	$1.22^{a}\pm0.01$	$1.67^{a}\pm0.01$
BS (%)	$39.66^{e}\pm0.04$	$25.69^{f}\pm0.15$	$99.09^{b}\pm0.06$	$99.67^{a}\pm0.15$	$39.61^{e}\pm0.04$	$25.71^{f}\pm0.15$	$97.18^{d}\pm0.05$	$98.51^{c}\pm0.03$	$39.60^{e}\pm0.04$	$25.70^{f}\pm0.15$	$97.10^{d}\pm0.04$	$97.21^{d}\pm0.04$
Texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Mean followed with the same superscript along each horizontal array indicate no significant difference ($p > 0.05$)

Total nitrogen

The result showed that the mean values of total nitrogen from 400 and 500g cocoa pod husk amended soil polluted with crude oil were as follows: 0.30±0.01 and 0.33±0.01 respectively, as compared with 0.16±0.01 and 0.09±0.01 of the pristine control and crude oil polluted. The addition of 400 and 500g of plantain peels in the polluted soil showed that the mean values of total nitrogen were as follows: 0.24±0.01 and 0.29±0.01 respectively, as compared with 0.15±0.01 and 0.07±0.01 of the pristine control and crude oil polluted control. When 400 and 500g of cocoa pod husk + plantain peels (1:1) were added to the polluted soil the mean values of total nitrogen obtained were as follows: 0.32±0.01 and 0.45±0.05 respectively, as compared with the pristine control and crude oil polluted controls: 0.16±0.01 and 0.09±0.01 respectively. This result indicate that 500g of CPH+PP (1:1) significantly increases ($p < 0.05$) the nitrogen content of the soil as compared with other amendment used for these study (Table 3).

Available phosphorus

The result obtained from this study showed that the mean value for the addition of 400 and 500g cocoa pod husk to the polluted were as follows: 60.50±0.51 and 63.42±0.19 respectively, as compared with 39.8±0.06 and 7.66±0.04 of the pristine control and crude oil polluted control. The addition of 400 and 500g plantain peels to the polluted soil showed that the mean values of the available phosphorus obtained were as follows: 18.28±0.27 and 14.25±0.11 respectively, as compared with 40.9±0.06 and 7.78±0.04 of the pristine and crude oil polluted control and the addition of 400 and 500g cocoa pod husk + plantain peels(1:1) to the polluted soil showed that the mean values for available phosphorus were as follows: 28.5±0.25 and 32.30±0.69 respectively as compared with the pristine control and crude oil polluted control which were as follows: 38.7±0.06 and 7.44±0.04 respectively. This result indicate that 400g and 500g of cocoa pod husk significantly increases ($p < 0.05$) the phosphorus content of the soil than plantain peels and cocoa pod husk + plantain peels treated soil (Table 3).

Potassium

The result obtained showed that the mean values for the addition of 400 and 500g cocoa pod husk to the polluted soil were as follows: 0.22±0.01 and 0.21±0.01 respectively, as compared with 0.43±0.02 and 0.29±0.02 of the pristine control and crude oil polluted control respectively. The addition of 400g and 500g plantain peels showed that the mean values of the potassium content were as follows: 0.19±0.01 and 0.20±0.01 respectively, as compared with 0.42±0.02 and 0.28±0.02 of the pristine control and crude oil polluted control respectively. The addition of 400 and 500g cocoa pod husk + plantain peels (1:1) showed that the potassium content of the treated soil were as follows: 0.18±0.01 and 0.20±0.02 respectively as compared with the pristine controls and crude oil polluted controls: 0.41±0.02 and 0.30±0.02 respectively. These results indicate that they were significant reduction ($p < 0.05$) in the potassium content of the treated soil as compared with their controls (Table 3).

DISCUSSION

Stimulated biodegradation of crude oil is at present being encourage because it ensures rapid remediation of oil-polluted ecosystem [1]. [10] Stated that pH is a predominant factor in estimating the rate of crude oil biodegradation in polluted soil. The result of this study as presented in table 2 shows that the pH values for pristine and crude oil polluted but unamended soil samples were generally within the acidic range (5.20-5.90). The application of the amendments changes the pH of the soil to alkaline with a range of 7.2-8.1. Alkalization of the soil was observed in all the amended soil used during this experiment. This result implies that the amendments have strong buffering effect, since strong acidic soil is a limitation to bioremediation. [11] reported a pH range of 6.5-8.0 for optimum mineralization of hydrocarbons. Thus the pH values recorded during this study are suitable for bioremediation.

However, it was also observed that the exchangeable acidity of the soil reduces in the amended soil, while the exchangeable cations such as magnesium, calcium, potassium and sodium increases with a base saturation range of 97-99% against the pristine and crude oil polluted soil with a base saturation range of 19-61%. Biodegradation of petroleum hydrocarbons occur rapidly in all the amended soil with a progressive decreased in organic carbon content. High reduction in the organic carbon was observed in soil amended with 500gram of cocoa pod husk and 500grams combination of cocoa pod husk + Plantain peels. It was observed that the organic carbon of cocoa pod husk was significantly reduced compared to other amendment. It can thus be said that cocoa pod husk possess the remediating potentials in degrading crude oil polluted soil. [12] reported that cocoa shells are particularly efficient in the removal of lead from acidic solutions; they also demonstrated that the removal of metals caused a decline in solution proton concentration (pH increase) and release of calcium, magnesium, potassium and sodium from the cocoa shell. [7] observed that poultry droppings and cassava peels possess strong bioremediation potentials in the reduction of organic carbon in the soil. The degradation of crude oil polluted soil was highly enhanced through the amendment having high nitrogen and phosphorus which are essentially needed for stimulating petroleum hydrocarbon degraders to degrade the hydrocarbons. This study also has it that the amended soil increases the total nitrogen and phosphorus level in the soil. Thus it can be said that this waste are good remediating agent with the ability of stimulating the fertility of the soil for growing of crops. The success of bioremediation would not be effectively achieved if the remediating agent is unable to restore the contaminated ecosystem for proper growing of crops. Cocoa pod husk have proven through this work to be one of the best option in remediating crude oil contaminated environment and thus should be used in the cleanup of oil spill in oil producing area.

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