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Effect of palm bunch ash treatment on remediation and growth performance of *Zea mays* in crude oil polluted soil

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Abstract

The effect of polluted hydrocarbon (PHC) soil altering the fertility of the soil for effective plant growth yield is a major concern. This study examines the use of oil palm bunch ash as biostimulation technique for bioremediation of PHC soils. Under strict compliance of oil treatment of 10g, 20g, 30g, 40g, 50g, and 60g with oil palm bunch ash on soil samples of 2kg weighed surface soil of 0-20cm polluted and non-polluted sites were collected randomly into perforated planting bags. Various results of residual and cumulative effect on treated soil of oil palm bunch ash enhances the improvement of *Zea mays* growth performance at 7WAP (7 weeks after planting) after eight months post-treated soils. The residual result shows that optimum treatment favoured 40g/2kg soil with plant emergence (41.67%), plant height (22.77cm) and dry matter (0.7235g), while cumulative treatment revealed 30g/2kg treatment as optimum with plant emergence (91.67%), plant height (24.40 cm) and dry matter (0.8202g). No doubt, this study of treating PHC soil with oil palm bunch ash at the above mentioned treatment levels improved soil performance for plant growth by reducing the hydrophobic nature of soils which resulted to improvement in the availability of water, oxygen and mineralization of soils.

Key words: Biostimulation, Bioremediation, Residual, Cumulative, Plant Performance.

1. Introduction

One of the challenges of our time is the ability of applying the findings from science and technological studies in solving environmental problems.

Petroleum hydrocarbon and its products have contributed in no small measure the economic development of nations, especially Nigeria. However, it also impacts negatively on soil and agricultural productivity of oil bearing communities. Crude oil and its products enter the soil via crude oil pipe leakages, oil tank ruptures and indiscriminate disposal of refinery products (Schweb and Banks, 1999), leading to changes in soil properties (Mc Gill *et al*, 1981; Trofimov and Rozanova, 2003). Studies have shown that soils polluted with petroleum hydrocarborns (PHCS) has the characteristics of low water holding capacity, moisture content and hydraulic conductivity (Trofimov and Rozanova, 2003; Suleimano *et al*, 2005; Nwaoguikpe, 2011). Crops grow and perform well in soils having the right amount and proportion of nutrients, water, oxygen and organisms.

The presence of PHCS in soils alters the fertility status and hence reduces their ability to support proper crop growth and development (Abii and Wosu, 2009). Odugwu and Onianwa (1987) reported that PHC polluted soils hindered seed germination and attributed this condition to the hydrophobic nature of these soils which reduce or prevent the availability of water and oxygen that are essential to seed germination (Adam and Duncan, 2002).

Similar studies by Rahber et al (2012) indicated a reduction in leaf area and root length in sunflower (*Halianthus annus*) growing on a PHC polluted soil, and attributed this condition to water deficiency induced by the pressures of PHC in the soil. At low concentrations, PHC'S may have positive effects on crops, as they are known to stimulate crop growth (McGill et al; 1981).

In a bid to remediate the negative impact of hydrocarbon pollution in soil, several techniques including Remediation by Enhanced Natural Attenuation (RENA), which uses the principle of land farming by biostimulation or bio-augmentation of soil biota with commercially available micro flora has been adopted (Ebuechi *et al*; 2005).

Biostimulation works on the principle that micro organisms is responsible for degrading pollutants already exist in the soil and they have great potential for bioremediation, especially when conditions that promote their activities are provided.

Studies have shown that soils inundated with PHC shows an initial reduction in microbial population, especially in soils that has not experienced previous pollution. This reduction is followed by a rapid increase in number of micro organisms that are capable of degrading the contaminants (Gramss *et al*, 1998; Seghers *et al;* 2003).

Several studies have indicated biostimulation as an effective technique for remediation of PHC-polluted soils (Peressutti *et al;* 2003; Bento *et al*; 2004; Sarkar *et al;* 2005).

Adedokun and Ataga (2007) reported a significant improvement in the growth of *Vigna unguiculata* (cowpea) when polluted with crude oil, automotive gasoline oil and spent engine oil and were biostimulated with sawdust

and cotton, and bioaugmented with *Pleurotus pulmonarium.* Their finding shows a reduction in time for germination from 3 to 8 days, increased seed germination from 60% to 96%, plant height from 10.3cm to 22cm, leaf number from 3 to 5 and biomas from 0.5g to 1.5g dry weight.
This study relies on biostimulation technique to study the growth performance of *Zea mays* in PHC polluted the soil, using oil palm bunch ash inorganic nutrient supplement.

2. Materials and Methods

Soil samples for this study were obtained from oil spill site at well 31 (PPMC Asset) in Bomu oil field of the Shell Petroleum Development Company, Nigeria Limited in Ogoni land, Rivers State, Nigeria. Surface soil (0 – 2cm depth) of polluted and non-polluted sites was collected randomly and bulked to form a representative samples respectively.

The composite samples were labeled and transported to the green house of the Biological Science Department of the Rivers State University of Science and Technology, Port Harcourt for ex-situ experimentation.

The experiment was conducted in a completely Randomized Block Design (CRD), with six replications of crude oil polluted soils treated with 10g, 20g, 30g, 40g, 50g and 60g of oil palm bunch ash per 2kg soils weighed into perforated planting bags. Six replications of non-polluted, untreated 2kg soils were set up as control experiment.

Oil palm bunch ash was applied by incorporating appropriate quantities into the soils and properly mixed to ensure even distribution within the soil. All treatments were transferred into evenly perforated planting bags and incubated.

All treatments were watered at three days intervals with 40ml of tap water, which was properly worked into the soil.

Treatments were aerated monthly by spreading on polyethylene, with continuous mixing and watering for a duration of three days before re-transferring them into their respective planting bags.

2.1 Cumulative Treatment

At three months post treatment, the CRD design was transformed into split block design, with three replications serving as residual treatment while the other half (3 replication) were subjected to additional treatments with 10g, 20g, 30g, 40g, 50g and 60g oil palm bunch ash. The experiment was further monitored for three months.

2.1 Soil Preparation for Planting

Post-treated soils were uniformly spread in thin layers on polyethylene and watered at three days interval for three weeks with 100mls of tap water, properly worked into the soils and daily aerated by continuous turning. After three weeks, 2kg soils were transferred into planting bags, well labeled and allowed to settle for two days before planting.

2.3 Planting and Watering

Planting was done at six months post treatment for plant performance studies. Treated soils and control were planted to viable seeds of *Zea mays* at eight seeds per stand with three replications. Uniform watering was done at three days intervals with 50ml of tap water.

2.4 Germination Studies

Daily emergence count was recorded for all treatment and control for seven days after planting (7 DAP) Percentage emergence of *Zea mays* was determined by the formula:

$$\text{Emergence count (\%)} = \frac{\text{No. of seeds that emerged}}{\text{No. of seeds planted}} \times \frac{100}{1}$$

At the end of germination studies, the number of plant per stand was thinned down to five plants.

2.5 Plant Heights at 2, 3 and 4 weeks after planting (2, 3 and 4 WAP)

The height of *Zea mays* per stand was measured using measuring tape from the base of the plant to the collar of the last leaf in the plant and recorded at two, three and four weeks after crop emergence.

2.6 Biomass yield at 4 weeks after planting (4 WAP)

The entire plants per stand of treatment and control were harvested at the end of four weeks after planting (4 WAP), washed and oven dried to constant weight at 80^{o}c. The total dry weight of treatment and control was weighed and recorded.

Data were analyzed using statistical procedure for descriptive statistic, SPSS 19, Chi-square, t-test and Excel were used to compare the mean and to analyze the least significant different (LSD).

3. Result and Discussion

3.1 Effect of oil palm bunch ash on remediation and emergence of *Zea mays* seven (7) days after planting (7 DAP)

The result of the effect of oil palm bunch ash on remediation and emergence of *Zea mays* at seven (7) days after planting (7 DAP) is presented in tables 1,2 and figures 1,2.

Table 1: Percent emergence of *Zea mays* seven days after planting (7 DAP) on 8 months post treated soil with oil palm bunch ash (Residual treatment).

TREATMENT	% EMERGENCE
Unpolluted control	100
10g	0.00
20g	29.17
30g	25.00
40g	41.67
50g	33.33
60g	0.00

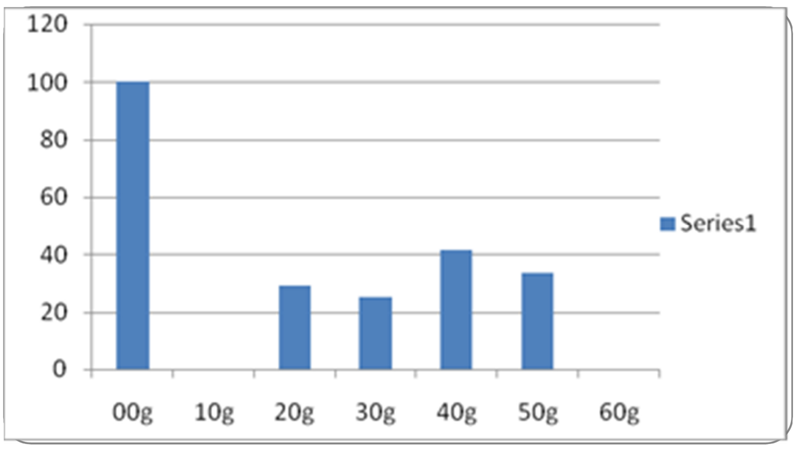

Fig. 1: Residual treatment percent emergence

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Table 2: Percent emergence of *Zea mays* seven days after planting (7 DAP) on 8 – months post treated soil with oil palm bunch ash (Cumulative treatment)

TREATMENT	% EMERGENCE
Unpolluted Control	100
10g	43.67
20g	54.17
30g	91.67
40g	37.5
50g	41.67
60g	0.00

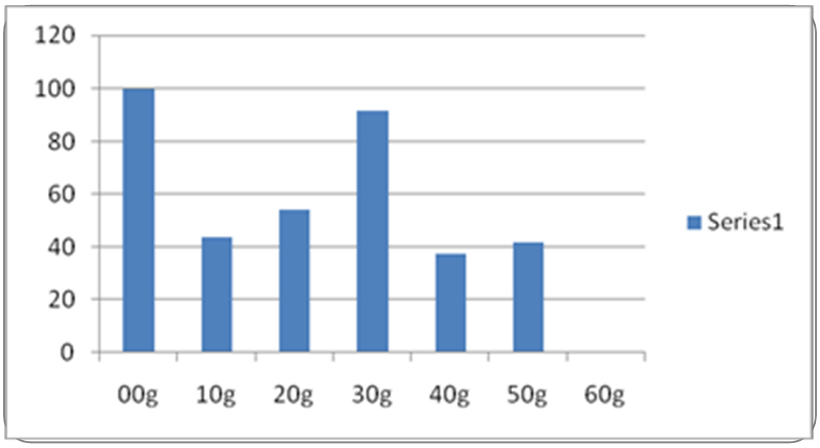

Fig. 2: Cumulative treatment percent emergence

The percent emergence of *Zea mays* for residual and cumulative treatment at 7 DAP are presented in table 1, 2 and fig. 1, 2. Soil treated with oil palm bunch ash at 40g and 50g rates had the highest percent emergence of 41.67% and 33.33% of *Zea mays*. 10g and 60g treatment had no germination for residual treatment. However cumulative soil treatment showed increase in percent emergence with treatment rate for 10g, 20g and 30g (43.67%, 54.17% and 91.67% respectively), with 30g treatment as optimum emergence. Result shows that cumulative treatment of crude oil polluted with oil palm bunch ash at 30g/2kg soil positively enhanced remediation and *Zea mays* emergence. Odugwu and Onianwa (1987) observed that the presence of PHC in soils hindered seed germination, attributing this condition to the hydrophobic nature of these soils which reduced or prevented the availability of water and oxygen essential to seed germination (Adam and Duncan 2002). In this study oil palm bunch ash enhanced seed germination, an indication of the reversal of the hydrophobic nature of the soil which has resulted to availability of water and oxygen for germination.

3.2 Effect of oil palm bunch ash treatment on remediation and plant height of *Zea mays* at four weeks after planting (4 WAP)

The result of the effect of oil palm bunch ash treatment on remediation and plant height of *Zea mays* at four weeks after planting (4 WAP) is presented in table 3 and figures 3, 4.

Table 3: Effect of Oil Palm bunch ash treatment on plant height (cm) of *Zea mays* at 2, 3 and 4 weeks after planting on eight months post-treated soils.

Treatment	Residual Effect Plant Height (cm)			Cumulative Effect Plant Height (cm)		
	2WAP	3WAP	4WAP	2WAP	3WAP	4WAP
No Pollution No treatment	36.373	37.417	37.99	36.373	37.417	37.99
10g	0	0	0	14.00	16.033	18.98
20g	12.70	14.467	15.36	14.013	18.60	20.103
30g	12.913	15.917	17.84	19.493	23.567	24.40
40g	16.317	21.233	22.773	6.773	10.467	12.97
50g	11.40	14.033	14.673	5.80	7.80	9.057
60g	1.85	2.50	4.29	2.79	6.067	8.787

Person chi-square test for residual and cumulative treatments shows that treatments do not differ significantly from each other at 0.05 levels. Although the control experiment shows high level of significance when compared with other treatments.

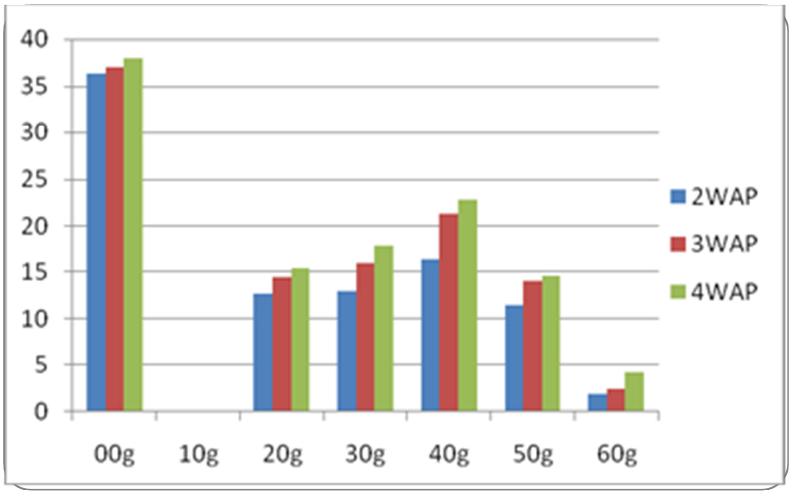

Fig. 3: Effect of Oil Palm Bunch Ash and Plant Height (cm) of *Zea mays* at 2, 3 and 4 weeks after planting at eight months post-treated soils.(Residual Effect)

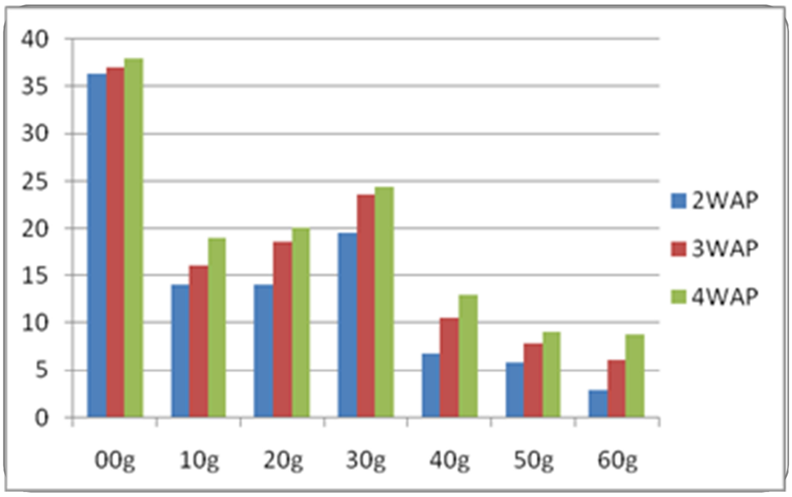

Fig. 4: Effect of Oil Palm Bunch Ash and Plant Height (cm) of *Zea mays* at 2, 3 and 4 weeks after planting at eight months post-treated soils.(Cumulative Effect)

The result of oil palm bunch ash treatment on remediation and *Zea mays* plant height is presented in table 3 and fig. 3. Result showed that oil palm bunch ash treatment improved soils with consequent variability in plant height for both residual (Fig. 3) and cumulative treatments (Fig. 4) with rate of application. Residual treatments favoured 40g treatment per 2kg soil (22.77cm) as optimum when compared with normal untreated soils with 37.99cm height. The cumulative treatment had 30g treatment per 2 kg soil as optimum plant height with 24.40cm against normal untreated soils of 37.99cm plant height. The above positive growth in plant height is attributable to improvement in oxygen, water and soil nutrient.

Adedokun and Ataga (2007) reported increase in plant height when sawdust and cotton were used to biostimulate remediation, and bioaugmented with *Pleurotus pulmonarium*. In this work, only biostimulation technique was adopted with positive result.

3.3 Effect of oil palm bunch ash on remediation and *Zea mays* dry matter yield

The result of mean dry matter yield of *Zea mays* at 4 weeks after planting (4 WAP) is presented in table 4 and figure 5.

Table 4: Mean dry matter yield (g) of *Zea mays* 4 weeks after planting (4 WAP)

TREATMENT	RESIDUAL EFFECT	CUMMULATIVE EFFECT
Normal untreated soil	1.0362	1.0362
10g	0	1.0224
20g	0.5654	0.7060
30g	0.6777	0.8202
40g	0.7235	0.6338
50g	0.5034	0.5204
60g	0.3190	0.5686

t-test statistics for residual and cumulative effects shows that there is significant effect of treatments on soil samples at 0.05 level.

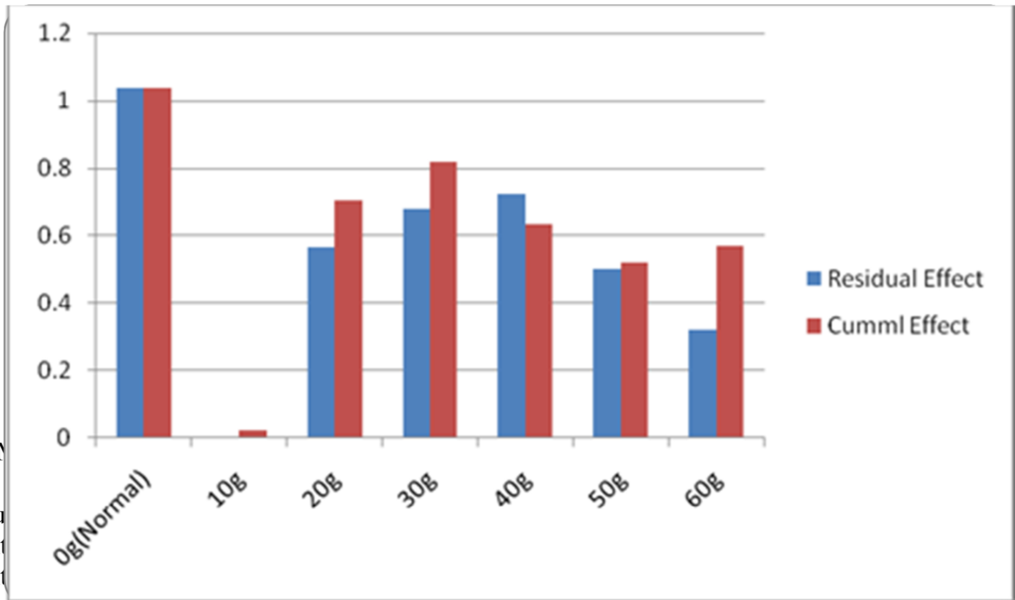

Fig 5 N

This resu … r residual
treatment … /2kg soil
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The above result followed the trend reported by Adedokun and Ataga (2007) who reported improvement in biomass of *Vigna unguiculata* when biostimulated with sawdust and cotton and augmented with *Pleurotus pulmonarium*.

4. Conclusion

Following plant growth data studied in this work, treatment of petroleum hydrocarbon polluted soil with oil palm bunch ash reduced the hydrophobic nature of the soil which resulted to improvement in the availability of water, oxygen and mineralization of soils, with consequent improvement in *Zea mays* emergence at 7 WAP, plant height and dry matter yield or biomass at 4 WAP. Generally, the optimum residual treatment favored 40g oil palm bunch ash/2kg soil, while cumulative treatment shows 30g oil palm bunch ash/2kg treatment as optimum. This study has shown that treatment of oil palm bunch ash at the above treatment levels significantly enhanced remediation in soils polluted with PHC and consequently improved crop growth. It is therefore recommended that oil palm bunch ash at the above treatment levels be utilized as inorganic nutrient for remediation of petroleum hydrocarbon polluted soils. An in situ experimentation is also recommended.

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