OIL PALM LEAF TREATMENT ALTERS SOIL ENZYME ACTIVITIES OF CRUDE OIL POLLUTED SOIL

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Abstract: One problem in crude oil producing regions of the world is pollution of farmlands. As a result, researches are being conducted worldwide to avail a simplified way of reclaiming petroleum polluted soil. In this study the possible ameliorative effect of oil palm leaf, a major waste product of oil palm plantation was evaluated on soil enzyme activities. A laboratory experiment was setup thus: Group 1: 400 g of unpolluted soil, Group 2: 400 g of unpolluted soil + 50 g of oil palm leaf, Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf, Group 4: 400 g of polluted soil, Group 5: 400 g of polluted soil + 50 g of oil palm leaf and Group 6: 400 g of polluted soil + 100 g of oil palm leaf. Soil samples were collected from each treatment once a week for three weeks to determine the activities of alkaline phosphatase, acid phosphatase, urease, dehydrogenase and catalase using standard procedures. The results show that addition of oil palm leaf increased the activities these enzymes relative to the untreated crude oil polluted soil. Thus, oil palm leaf is a candidate for improving soil productive potentials as well as possessing the ability to remediate petroleum impacted farmlands.

Keywords: Crude oil, oil palm, pollution, soil enzymes

Introduction

Agricultural lands pollution is common in oil producing areas, which culminates in decease in productivity (Onuoha *et al.*, 2003; Sztompka 1999; Atuanya 1987; Osuji and Nwoye 2007; Amadi *et al.*, 1996; Osuji *et al.*, 2006); thereby altering the physiochemical properties as well as the enzymatic activities of the soil (Osuji and Adesiyan, 2005; Osuji *et al.*, 2004; 2006]; Osuji and Nwoye, 2007]; Achuba and Peretiemo-Clarke, 2008;Wyszkowska and Kucharski, 2000; Achuba, 2015; Achuba and Okoh, 2014).

Soil enzyme is one important biotic component of soil that is responsible for soil biochemical reactions (Zahir *et al.*, 2001). Petroleum hydrocarbon pollution alteration of soil enzyme activities had been reported previously (Li *et al.*, 2005; Achuba and Peretimo-Clarke, 2008; Wyszkowska *et al.*, 2002; Wyszkowska and Kucharski, 2000). The activity of soil enzyme, such as the dehydrogenases, is a marker of soil metabolic condition (Li *et al.*, 2005; Utobo and Tewari, 2015). The adverse effects of crude oil pollution on agricultural lands have led to various soil treatment strategies in an attempt to correct polluted soil (Ijah *et al.*, 2008; Onuh *et al.*, 2008a, 2008b; Okolo *et al.*, 2005, 2000; Raskin *et al.*, 1997; Achuba and Okunbo, 2015). The aim of this study was to investigate the effect of oil palm leaf treatment of crude oil polluted soil on soil enzyme activities.

Materials and Methods

Test soil

The soil was obtained from a fallow land in the premises of site III of The Delta State University, Abraka. The soil was air dried and sieved using 2 mm mesh and kept in a cool dry place in the laboratory. The property of the soil used is shown in Table 1.

Table 1: Physicochemical properties of test soil

Parameter	Values
pH	7.01 ± 0.02
Organic Matter (%)	0.47 ± 0.12
Total Nitrogen (%)	0.16 ± 0.01
Phosphorus (ppm)	3.31 ± 0.32
Cation Exchange Capacity (Meq/100g)	6.64 ± 0.70

Oil palm leaf

Oil palm leaf was collected from an oil palm plantation in Abraka, Nigeria. The leaf was sun dried to ensure accurate use of plant biomass, ground and sieved into fine powder with a 2 mm mesh to remove coarse materials.

Soil treatment

Fifty kilograms (50 kg) of the dried soil was measured into a big rubber bowl. This is followed by the addition of one litre of crude oil and thoroughly mixed with hand to ensure homogeneity. From this bulk treated soil, four hundred grams (400.0 g) was measured into polythene bag. Thirty bags were made and were divided into three groups. Each group is made up of ten bags. Another thirty bags were prepared from the unpolluted soil and divided into three groups of ten bags each. The groups were treated as described thus:

Group 1: 400 g of unpolluted soil.
Group 2: 400 g of unpolluted soil + 50 g of oil palm leaf
Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf
Group 4:400 g of polluted soil.
Group 5: 400 g of polluted soil +50 g of oil palm leaf.
Group 6: 400 g of polluted soil +100 g of oil palm leaf

At the end of one week, two weeks and three weeks the activities of selected soil enzymes were determined to ascertain the effect of treatment of crude oil contaminated soil with ground oil palm leaf on soil enzyme activities.

Determination of soil enzyme activities

The extract for the preparation of soil catalase activity was prepared as previously described (Achuba and Peretiemo-Clarke, 2008) and the enzyme activity determined with the method described by Rani *et al.* (2004).Soil dehydrogenase activity was assayed as reported by Casida *et al.* (1964) Alkaline and acid phosphatases were assayed according to the method described by Samuel *et al.* (2010). Soil urease activity was determined as described by Kandeler and Gerber (1988).

Statistical analysis

Data was subjected to Analysis of variance (ANOVA) as well as Post Hoc Fisher's test for multiple comparisons with statistical package for social science (SPSS), version 21. Significance level was set at P values < 0.05

Results and Discussion

The result (Table 2) indicated that crude oil significantly ($p<0.05$) reduce the activities of the three enzymes (alkaline phosphatase (ALP) acid phosphatase (ACP) and urease) relative to the control and unpopulated soil treated with oil palm leaf. However, treatment of the polluted soil after seven days of incubation did not restore the activities of ALP, ACP and urease to control values. After two weeks of incubation the activities of all the enzymes significantly ($p<0.05$) increase in the unpolluted soil treated with oil palm leaf (Groups 1 and 2) and polluted soil treated with oil palm leaf (Groups 5 and 6) relative to crude oil polluted soil (Table 3). Similarly, after three weeks of incubation of all the treatments of crude oil polluted soil, the activities of the enzymes were restored near the levels in the unpolluted soil. The unpolluted soil treated with oil palm leaf (Groups 2 and 3) exhibited significantly ($p<0.05$) higher activity relative to control and the polluted soil treated with oil palm leaf (Groups 5 and 6) (Table 4).

The activities of the enzymes: dehydrogenase and catalase after one, two weeks and three weeks of incubation of various treatments, unpolluted soil, unpolluted soil treated with oil palm leaf, crude oil polluted soil and crude oil polluted soil treated oil palm leaf are shown in Tables 5, 6 and 7. The result showed that the activity of soil dehydrogenase and catalase significantly ($p<0.05$) increased in the unpolluted soil treated with oil palm leaf (Groups 2 and 3) and polluted soil treated with oil palm leaf (Groups 5 and 6) relative to crude oil polluted soil (Group 4). Although, the activities of soil dehydrogenase fluctuated, it tended to increase after two weeks of incubation and deceased after three weeks when compared to after one week of incubation. However, the activities of catalase across the different periods of determination did not show significant change.

Soil enzymes serve as bio-indicators of reactions in soil (Zhang *et al*. 2010; Salazar *et al*., 2011; Bhavya *et al* 2017), whose activities increase with increase in soil biomatter (Salazar *et al*., 2011; Achuba and Ja-anni, 2018). This study showed that addition of oil palm leaf to the unpolluted soil enhanced the activities of acid phosphatase, alkaline phosphatase and urease (Tables 2 – 4). This could be the basis why addition of oil palm leaf to polluted soil had a positive effect on the enzyme activities. The increased phosphatases and urease activities in the polluted soil treated with oil palm leaf compared to polluted only soil could be due to organic matter mediated increase in microbial activity (Wolińska and Stępniewska, 2011; Yuan and Yue, 2012).

Table 2: Effect of oil palm leaf treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after seven days of incubation

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
ALP (U/L)	14.50 ±1.3^{a}	15.8 ± 1.10^{a}	18.41 ± 2.4^{b}	7.87 ± 0.51^{c}	9.87 ± 1.52^{c}	11.42 ± 2.2^{a}
ACP (U/L)	7.6 ± 1.6^{a}	8.95 ± 1.16^{a}	10.11 ± 1.82^{b}	4.88 ± 0.53^{c}	6.44 ± 1.21^{c}	5.82 ± 1.66^{c}
Urease (Mg/g)	1.88 ± 0.61^{a}	2.60 ± 0.52^{b}	2.93 ± 0.58^{b}	1.36 ± 0.37^{c}	2.07 ± 0.62^{a}	2.23 ± 0.40^{a}

Results expressed as Mean ± SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

Table 3: Effect of oil palm treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after two weeks of incubation

Parmeters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
ALP (U/L)	14.50 ±1.3^{a}	17.91 ± 2.75^{b}	21.01 ± 1.64^{b}	7.63 ± 1.41^{c}	10.2 ± 1.41^{d}	12.22 ±1.71^{a}
ACP (U/L)	7.6 ± 1.6^{a}	8.67 ± 1.20^{b}	11.52 ± 1.36^{b}	5.30 ± 1.10^{c}	6.66 ± 0.52^{a}	6.97 ± 0.30^{a}
Urease (Mg/g)	1.88 ± 0.61^{a}	2.93 ± 031^{b}	2.97 ± 1.21^{b}	1.21 ± 0.11^{c}	1.72 ± 0.55^{a}	1.75 ± 0.15^{a}

Results expressed as Mean ± SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

Table 4: Effect of oil palm leaf treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after three weeks of incubation

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
ALP (U/L)	14.50 ±1.3^{a}	16.32 ± 1.11^{b}	18.83 ± 2.11^{b}	6.95 ± 0.21^{c}	8.92 ± 1.35^{d}	12.21 ±1.23^{a}
ACP (U/L)	7.6 ± 1.6^{a}	10.42 ± 1.20^{b}	11.61 ± .2. 42^{b}	8.50 ± 1.51^{a}	7.78 ± 0.27^{a}	7.82 ± 1.25^{a}
Urease (Mg/g)	1.88 ± 0.61^{a}	2.98 ± 0.52^{b}	2.96 ± 0.25^{b}	1.20 ± 0.30^{c}	1.64 ± 0.14^{a}	1.75 ± 1.31^{a}

Results expressed as Mean ± SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

Table 5: Effect of oil palm leaf treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after one week of incubation

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Dehydrogenase activity mg/g dry soil	8.88 ±1.7^{a}	14.54 ± 1.82^{b}	16.83 ± 1.91^{b}	5.85 ± 0.11^{c}	6.21 ± 1.50^{a}	6.86 ±1.31^{a}
Catalase activity k/min	6.62 ± 1.8^{a}	8.52 ± 1.30^{b}	10.21 ± 1. 62^{b}	3.80 ± 1.33^{c}	7.70 ± 1.25^{a}	7.87 ± 1.32^{a}

Results expressed as Mean ± SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

Table 6: Effect of oil palm leaf treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after two weeks of incubation

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Dehydrogenase activity mg/g dry soil	8.88 ± 1.7^{a}	16.34 ± 1.82^{b}	18.77 ± 2.01^{b}	6.03 ± 1.21^{c}	7.01 ± 1.82^{a}	7.36 ± 1.43^{a}
Catalase activity k/min	6.62 ± 1.8^{a}	8.66 ± 1.60^{b}	10.33 ± 1.62^{b}	4.64 ± 1.41^{c}	7.71 ± 1.25^{a}	7.88 ± 1.20^{a}

Results expressed as Mean $\pm$ SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

Table 7: Effect of oil palm leaf treatment of crude oil polluted soil on alkaline phosphatase, acid phosphatase and urease activities after three weeks of incubation

Parameters	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Dehydrogenase activity mg/g dry soil	8.88 ± 1.7^{a}	20.24 ± 2.52^{b}	24.86 ± 1.94^{b}	6.86 ± 1.42^{c}	8.45 ± 1.21^{a}	8.64 ± 1.82^{a}
Catalase activity k/min	6.62 ± 1.8^{a}	8.81 ± 1.72^{b}	10.67 ± 2.43^{b}	4.85 ± 1.90^{c}	7.98 ± 1.63^{a}	7.98 ± 1.35^{a}

Results expressed as Mean $\pm$ SD. Values of the same row followed by different superscript are statistically different at $p < 0.05$; Group 1: 400 g of unpolluted soil; Group 2: 400 g of unpolluted soil +50 g of oil palm leaf; Group 3: 400 g of unpolluted soil + 100 g of oil palm leaf; Group 4:400 g of polluted soil; Group 5: 400 g of polluted soil +50 g of oil palm leaf; Group 6: 400 g of polluted soil +100 g of oil palm leaf

That soil dehydrogenase activity increase in tandem to organic matter content was reported earlier (Chodak and Niklińska, 2010; Moeskops *et al*., 2010; Romero *et al*., 2010; Zhao *et al*., 2010; Yuan and Yue, 2012; Macci *et al*., 2012). This is consistent with this study. The treatment of unpolluted soil with oil palm leaf increased soil dehydrogenase activity relative to the control (Tables 5 - 7). Similarly, the activity of soil catalase increased in unpolluted soil treated with oil palm leaf. Cellulose in soil stimulated increase in catalase activity was earlier reported (Wyszkowska *et al.,* 2013). Most importantly, treatment of crude oil contaminated soil with oil palm leaf restored soil dehydrogenase and catalase activity close to the values in unpolluted soil. These observations indicate that oil palm leaf when added to the soil can improve soil productive potentials and can correct crude oil polluted farm lands.

Conclusion

This study indicated that addition oil ground oil palm leaf to both polluted and unpolluted soils improved the activities of soil enzymes. This suggests that oil palm leaf is a potential candidate for improving the productive potentials of soil and has the ability to remediate crude oil polluted farm land.

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