International Journal of Plant & Soil Science
6(1): 16-25, 2015; Article no.IJPSS.2015.093
ISSN: 2320-7035

SCIENCEDOMAIN *international*
www.sciencedomain.org

Remediation of Soil Contaminated with Motor Spirit using Compost Material

O. O. AdeOluwa[1*], A. O. Ogundeji[1] and D. O. Agbeyegbe[2]

[1]Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan, Nigeria.
[2]Department of Soil Science and Land Management, Federal University of Agriculture Abeokuta, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author OOA conceptualized the research, designed, supervised and contributed to the manuscript. Author AOO wrote the first draft of the manuscript, while both authors AOO and DOA managed the experimental process. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/14788
Editor(s):
(1) Marco Trevisan, Institute of Agricultural Chemistry and Environmental Research Centre BIOMASS, Catholic University of the Sacred Heart, Italy.
(2) L.S Ayeni, Adeyemi College of Education, Ondo State, Nigeria.
Reviewers:
(1) Elżbieta Sitarz-Palczak, Department of Inorganic and Analytical Chemistry, Rzeszow University of Technology, Poland.
(2) Anonymous, Japan.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=953&id=24&aid=7913

Original Research Article

Received 22nd October 2014
Accepted 12th January 2015
Published 28th January 2015

ABSTRACT

Spillage of premium motor spirit (PMS) on land, due to either vandalisation of pipelines or accidents during transportation of petroleum in developing countries like Nigeria, could pollute agricultural lands and reduce productivity. This study considered compost to remediate a premium motor spirit polluted soil for agricultural purposes using *Amaranthus caudatus* as a test crop. The experiment was conducted in two years and two sowing phases each. The 1st study was done using potted soil samples while the 2nd study was a field trial. Compost treatment was applied in both experiments at 100 kgN/ha, 200 kgN/ha and 300 kgN/ha and Pollution treatments were heavy (^{3}P), Medium (^{2}P), and Light (^{1}P) pollution at 1,384 ba/ha, 692 ba/ha and 384 ba/ha respectively. Treatment combinations were varied for both experiments. Results showed nil growth of *amaranths* for the 1st study due to premium motor spirit pollution and also showed that compost applied at 300 kgN/ha at all levels of pollution in the two studies resulted in better response of *amaranths,* while the 200 kg N/ha compost under Medium pollution (^{2}P = 692 ba/ha) also resulted in better yield of *amaranths* in

**Corresponding author: E-mail: adeoluwaoo@yahoo.com;*

the residual field experiment. The results indicate that ameliorative effects of compost seem to increase with the increase in the level of amendment. This could be a cheap way for local farmers in Nigeria and other developing countries with similar occurrences to remediate their farmlands in case of premium motor spirit pollution.

Keywords: Soil remediation; organic amendments; amaranths; premium motor spirit; compost.

1. INTRODUCTION

Oil pollutions through accidental leakages are common features in many developing countries that are yet to perfect their oil delivery systems. Nigeria and some coastal countries along the western Indian Ocean region are examples of such countries. In Nigeria, it is a regular occurrence to hear about accident involving petroleum tankers and vandalisation of pipelines carrying petroleum products. Also, the Mozambique Channel which borders some of the countries along the western Indian Ocean was identified as a high risk area for pollution of the marine environment, from ship-borne and ground sources [1]. Approximately 30% of world's hydrocarbon oil is transported through conduits (sub or underground) and in recent years, the traffic has intensified, including the number of vessels transporting the oil. This situation has consequently increased the risk of accidents from the point of conveying the oil from one point to the other. Premium Motor Spirit (PMS) is one of the hydrocarbon products often spilled on the ground in areas prone to these eventualities. When PMS is spilled on agricultural lands, it could lead to chemical toxic situations that could be biologically damaging and thus inhibit crops' growth and development. It has been noted that even in very small concentrations; the hydrocarbon pollutants could kill or inhibit soil organisms, thereby disrupting the balance of the soil ecosystem [2,3].

Premium Motor Spirit commonly (called petrol or gas) is one of the refined products of crude oil and it is transported via pipelines from refineries to flow stations to oil terminal for loading into tankers to supply various filling stations. Spillage of PMS on agricultural land in Nigeria is mainly due vandalisation of its pipes, road accidents involving tankers or corrosion of pipelines [4]. These occurrences have affected a lot of productive agricultural lands; turning them to unproductive lands for crop production [5]. [6,7] studies have reported negative effects of spillage of hydrocarbon on agricultural lands. It has been reported that crop yield has been reduced by 13% in minor situations, Odjuwuederhie et al. [8]; however, there could be total loss of crops in severe situations.

El-Nawawy et al. [9] reported that a soil polluted by petroleum has a high salt concentration, with an acidic pH range of 4-5 and a very low water holding capacity with organic matter of <0.2%.

All these negative features dovetail into poor soil productivity, resulting into poor / zero yield, poor soil bacterial population, as well as those of hydrocarbon degrader bacteria too.

There are several alternatives to correcting pollution of agricultural lands by petroleum products. Chemicals, mechanical and biological means have been used in many circumstances. However, these methods of pollution mitigation are often too expensive for poor resource farmers that are often at the receiving end of agricultural land pollution. Thus, there is a need to investigate an affordable means of remediating PMS polluted agricultural lands. Compost, a form of organic fertilizer is considered as a positive alternative that could remediate PMS pollution in soils. Remediation through composting is a biological technique considered to be an insitu treatment technology and this could be a less expensive means of remediating oil pollution in developing countries [10]. This paper therefore reports the assessment of the ameliorative effect of a commercial compost on petroleum polluted soil, using *Amaranthus caudatus* as the test crop. *Amaranthus caudatus* is a tropical crop grown in most parts of Sub Saharan Africa, as a leaf vegetable and sometimes, for its edible seeds. This crop was used in this investigation because of its high level sensitivity to soil many environmental factors like water stress, chemical pollution and nutrient deficiency.

2. MATERIALS AND METHODS

The study was carried out in two planting seasons. The 1st study was a screen house experiment, using potted soil samples while the 2nd study was a field experiment. Compost source for both studies was the sunshine organic fertilizer plant, Akure, Ondo state, southwest, Nigeria. The compost was made from city waste and cow dung. Both experiments were laid in randomized complete block design, replicated four times.

2.1 Screen House Experiment

This was conducted at the screen house of the Department of Agronomy, University of Ibadan, Nigeria. The soil (0 –15 cm depth) used was collected from the faculty's farmland along parry road of the university and screened (2 mm sieve). The premium motor spirit used was bought at the NNPC mega station Iwo road, Ibadan, Oyo state, southwest, Nigeria. The pot experiment was a randomized complete block design replicated four times. The weight of the soil per pot was 2 kg. A. caudatus was planted twice successively to investigate the impact of petroleum pollution on the plant's growth, and development in the 1^{st} phase and to investigate the effects of compost as a means of remediation on a polluted soil in the 2^{nd} phase. Three different levels of compost were applied at rates of 100 kgN/ha, 200 kgN/ha and 300 kgN/ha in four replicates each. While the pollutant was applied at two levels of rates 692 barrels/ha of PMS (medium pollution) and 1,384 barrel/ha of PMS (heavy pollution).

2.2 Field Experiment

The study of the field experiment was carried out at a site behind the department of Agronomy, University of Ibadan, Ibadan, Nigeria. The premium motor spirit used was obtained at a petrol station in Ibadan. Seven treatment combinations were used (letter coded as shown below) and applied as follows;

a) ${}^{0}P_{100}$ – No pollution with 100 kg N/ha of compost
b) ${}^{1}P_{200}$ – Light pollution with 200 kg N/ha of compost
c) ${}^{2}P_{200}$ – Medium pollution with 200 kg N/ha of compost
d) ${}^{1}P_{300}$ - Light pollution with 300 kg N/ha of compost
e) ${}^{2}P_{300}$ - Medium pollution with 300 kg N/ha of compost
f) C -No compost applied, No pollution applied (control)
g) M - Mineral fertilizer (NPK 15-15-15)

Medium pollution was applied at rate of 692 barrel/ha and light pollution was applied at rate of 346 ba/ha.

The experiment was conducted in two planting phases. The 2^{nd} phase was carried out to observe the residual effects of the compost on the soil. The experiment consisted of seven treatments of four replicates in a randomized complete block design. For both experiments, parameters observed were fresh and dry weights (g/pot and ton/ha respectively), bacteria and hydrocarbon degrader population were checked for the screen house study. The dry weights were obtained by oven drying the harvested samples to constant weight at 60°C and expressed as g/pot. For both experiments, compost was applied 2 weeks after pollution and sowing was carried out 5 weeks after compost application. Though, for the field trial, the residual sowing was carried out 11 weeks after pollution. The soils were bulked and analysed for particle-size and chemical characteristics. In this experiment, the soil was the source of the hydrocarbon consuming microbes, while the compost was a substrate to induce the microbial activities.

2.3 Soil Microbial Population (Bacteria Colony)

25 g of soil (on a dry basis) was added to 240 ml of sterile water and shaken vigorously by using glass rod for five minutes. Dilutions were made using sterile pipette for each transfer after it settled. 1ml of suspension (1) was added to 9ml of sterile water giving $1{:}10^{2}$ dilutions (2). This continued till the 6th transfer ($10{:}10^{6}$). 1ml portion of each dilution (6) was transferred to Petri dishes using two dishes for each dilution. To each plate was added about 8.10 ml medium nutrient agar for bacterial, melted, autoclaved at 121°C for 15minutes and allowed to cool to about 45°C immediately after pouring the plates tip and rotated gently to secure a uniform mixture. The agar was allowed to set on a level surface for at least 30minutes. Finally, the plate was inverted and incubated at a temperature of about 28°C. On the second day the colony of each plate was counted.

2.4 Determination of Hydrocarbon Degrader

Counts of hydrocarbon utilizing bacteria were obtained by plating out low dilutions (10^{1} to 10^{2}) of the samples on medium salt Agar. The composition of the medium salt Agar is as follows (g/L): Na_2HPO_4 (2.13 g); KH_2PO_4 (1.3 g); NH_4Cl (0.5 g); $MgSO_4.7H_2O$ (0.2 g); Agar (15.0 g); Distilled water (1000 ml); and pH (7.2) – isolation of the bacteria. The medium was autoclaved at 1.0 kg/cm^2 for 15 minutes. The inoculated medium salt agar plates were then inverted over sterile membrane filters moistened with crude oil (Escravos light) and held in the lid of the Petri dishes. The dishes were taped round with a masking tape so as to increase the vapour pressure within the Petri dishes while the plates were incubated at 30°C for 10 days. The percentage of hydrocarbon degraders in each sample was subsequently computed.

2.5 Chemical Analyses

Composite samples were got by randomly collecting soil samples from each vegetable pot and beds used and were bulked. The samples were air-dried for routine physical and chemical analysis. Particle sized distribution was determined by hydrometer method [11], using sodium-hexametaphosphate as the dispersing agent. The soils were sieved for physical analysis using 2 mm sieve soil pHs were determined by suspending the soil samples in distilled water (1:1) using glass electrode (EILPH meter), [12]. Organic carbons were analysed by the dichromate wet-oxidation method of Walkey-Black as described by Black [13]. Total Nitrogen (N) was determined by macro Kjedahl method, available phosphorus by Bray's I method [14]. Exchangeable cations (potassium, calcium, sodium and magnesium) were extracted with IN Ammonium acetate (NH_4OAC). Micronutrients (Manganese, Iron, Copper, and Zinc) were extracted with 0.1NEDTA and determined using Atomic Absorption spectrophotometer [15]. The results of the experiments were subjected to analysis of variance and the means compared using Duncan Multiple Range test (Wagner, 1992) for the 1st study and Standard Error Difference of Means for the field trial.

3. RESULTS AND DISCUSSION

The soils for both experiments were loamy sands with pH of 6.8 for the 1st study and pH 7.1 for the 2nd study (Table 1). The nitrogen content of the compost used was 17.5 g/kg, phosphorus content was 11.0 g/kg and potassium content was 5.0 g/kg (Table 2).

Results from the 1st phase of the 1st study showed that at 6weeks after sowing, plants from the control had yield (mean fresh weight of 7.39 g/pot) which was significantly different from the polluted soils (medium pollution, 692 ba/ha and heavy pollution,1384 ba/ha) (P=.05). At 6weeks after sowing, no plant emerged from the polluted soil (Table 3).

The result of the 2nd phase, showed that at 6weeks after sowing, among the polluted soils, yield was highest from the soil that had medium pollution (^2P=692 barrel/ha) with 300 kg N/ha compost ($^2P_{300}$) with the highest mean fresh weight (9.52 g/pot) and it also had the highest mean dry weight (0.92 g/pot) (Table 4).

Table 1. Physico-chemical properties of the experimental soils

	Parameters	Values	
		Study 1	**Study 2**
$pH(H_20)_{1:1}$		6.8	7.1
Organic Carbon(g/kg)		8.0	10.1
Total N(g/kg)		1.9	1.6
Av.P(mg/kg)		44	68
Exchangeable base (cmol/kg)	K	0.2	0.6
	Na	0.1	0.3
	Mg	0.7	2.0
	Ca	1.0	3.8
	Exchangeable Acidity	0.6	0.4
Extractable Micro-nutrients (mg/kg)	Mn	183	202
	Fe	270	213
	Cu	3	3
	Zn	105	26
Particle size (g/kg)	Sand	852	767
	Silt	114	145
	Clay	34	88
	Textural class	Loamy sand	

Table 2. NPK composition of the compost

compost parameters	Value (g/kg)
Nitrogen	17.5
Phosphorus	11
Potassium	5

Table 3. Effects of PMS Polluted Soil on Weight (g/plant) of *A caudatus* in the screen house

Treatments	6WAP (fresh g/pot)	6WAP (dry g/pot)
Control	7.39a	0.53a
Heavy Pollution.	0.00b	0.00b

Means with the same letters in a column are not significantly different by DMRT at (P=.05).

Table 4. Effects of PMS on *A. caudatus* as influenced by compost remediation in the screen house mean weight (g/plant)

Treatments kgN/ha	6WAP (fresh g/pot)	6WAP (dry g/pot)
C	7.58a	0.72a
$^0P_{100}$	10.92a	1.02a
$^2P_{200}$	5.76ab	0.58ab
$^2P_{300}$	9.52a	0.92a
$^3P_{200}$	2.28b	0.22b
$^3P_{300}$	5.24ab	0.50ab

Means with the same letters in a column are not significantly different by DMRT at (P =.05)
$^0P_{100}$= No pollution with 100 kgN/ha compost
$^2P_{200}$= Medium pollution with 200 kgN/ha compost
$^3P_{200}$ = Heavy pollution with 200 kgN/ha compost
C= Control;$^2P_{300}$ = Medium pollution with 300 kgN/ha compost; $^3P_{300}$ = Heavy pollution with 300 kgN/ha compost

The results of the field experiment were analysed using the standard error difference of means. Results of the field trial showed that for the main sowing, at five weeks after sowing, among the plants from the polluted soils, soils with light pollution (^{1}P=346 ba/ha) with 300 kgN/ha of compost ($^1P_{300}$) had the highest yield with mean fresh weight (56.2 t/ha) and this was significantly different from the control, (32.4 t/ha) (*P* =.05). [Fig. 1]

The result showed that at 5 weeks after sowing, among the plants from polluted soils, medium pollution (^{2}P=692 ba/ha) with 300kgN/ha compost ($^2P_{300}$) had the highest mean dry weight (15.1 t/ha) and this was not significantly different from the plants of light pollution (^{1}P=346 ba/ha) with 300 kgN/ha compost ($^1P_{300}$), (12.1 t/ha) as well as the control (12.5 t/ha) (*P*=.05). [Fig 2].

To investigate the residual effects of the compost applied on the polluted soils, a residual sowing was done, and it was found out that at 5 weeks after sowing, among plants with polluted soils, (^{2}P=692 ba/ha) medium pollution with 200 kgN/ha had the highest mean fresh weight (39.4 t/ha) followed closely by light pollution (^{1}P=346 ba) with 300 kgN/ha compost (38.7 t/ha). Both were significantly different from the control (24.5 t/ha) and other treatments except the medium pollution (^{2}P=692 ba/ha) with 300 kgN/ha compost (31.9 t/ha) (*P*=.05) [Fig 3]

3.1 Soil Microbial Population

Among the polluted treatments for the screen house experiment, medium pollution (^{2}P=692 barrel/ha) with 200 kgN/ha compost had the highest mean bacterial population (154 x 10^{-6} cfu/gsoil) while heavy pollution (^{3}P=1,384 barrel/ha) with 300 kgN/ha compost had the second highest (140 x 10^{-6} cfu/g soil) and they are significantly different from the control (104 x 10^{-6} cfu/g soil). (Table 5).

Table 5. Effects of compost remediation PMS polluted soil on bacteria and hydrocarbon degrader population in the screen house study

Treatments	Bacterial Colony (cfu/gsoil)	Hydrocarbon degrader (cfu/gsoil)
C	104 x 10^{-6}a	0.05c
$^0P_{100}$	121 x 10^{-6}b	0.03b
$^2P_0$	131 x 10^{-6}c	0.02ab
$^2P_{100}$	134 x 10^{-6}d	0.05c
$^2P_{200}$	154 x 10^{-6}g	0.01a
$^3P_0$	132 x 10^{-6}c	0.07d
$^3P_{100}$	136 x 10^{-6}e	0.03b
$^3P_{200}$	136 x 10^{-6}e	0.02a
$^3P_{300}$	140 x 10^{-6}f	0.02a

Means with the same letter(s) are not significantly different by DMRT at (P= .05); C = Control; 0P100 = No Pollution with 100 kg N/ha compost; 2P0 = Medium Pollution with no compost; $^2P_{100}$ = Medium Pollution with 100 kg N/ha compost; 2P200 = Medium Pollution with 200 kg N/ha compost; 3P0 = Heavy Pollution with No compost; 3P100 = Heavy Pollution with 100 kg N/ha compost; $^3P_{200}$ = Heavy Pollution with 200 kgN/ha compost; $^3P_{300}$ = Heavy Pollution with 300 kgN/ha compost

3.2 Soil Petroleum Hydrocarbon Content

Among the polluted treatments, also for the screen house experiment, medium pollution (^{2}P=692 barrel/ha) with 200 kgN/ha compost ($^{2}P_{200}$) had the lowest mean hydrocarbon degrader (0.01 cfu/gsoil), heavy pollution (^{3}P=1,384 barrel/ha) with 300 kgN/ha compost ($^{3}P_{300}$) had (0.02 cfu/gsoil) and they are significantly different from the control (0.05 cfu/gsoil). (Table 5).

3.3 Effects of Compost Remediated PMS Polluted Soil on Some Soil Chemical Characteristics (Post Study Characteristics).

The post study soils for both experiments showed positive responses in the chemical parameters tested for. (Table 6).

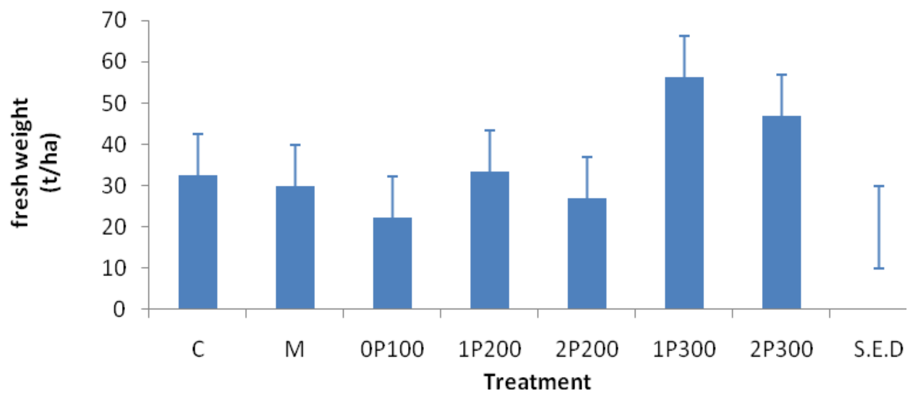

Fig. 1. Effects of compost remediation on fresh weight (t/ha) at 5 weeks of main sowing

a) $^{0}P_{100}$ – *No pollution with 100 kgN/ha of compost*
b) $^{1}P_{200}$ – *Light pollution with 200 kgN/ha of compost*
c) $^{2}P_{200}$ – *Medium pollution with 200 kgN/ha of compost*
d) $^{1}P_{300}$ - *Light pollution with 300 kgN/ha of compost*
e) $^{2}P_{300}$ - *Medium pollution with 300 kgN/ha of compost*
f) *C-No compost applied, No pollution applied (Control)*
g) *M- Mineral fertilizer (NPK 15-15-15)*

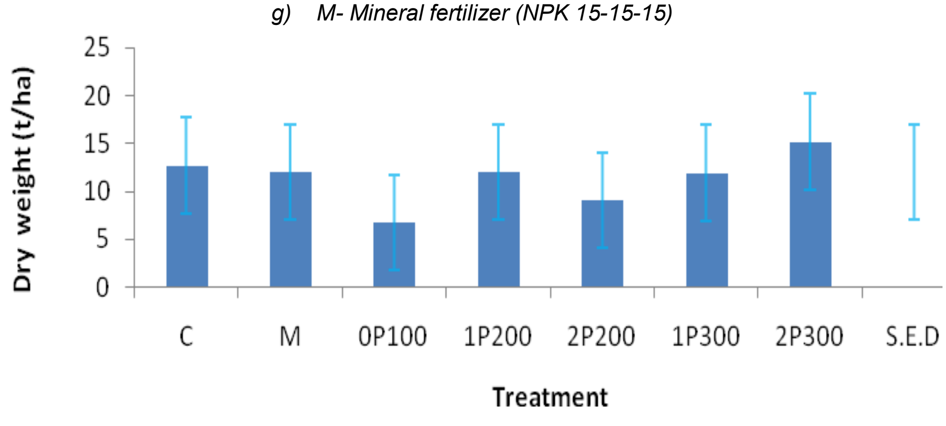

Fig. 2. Effects of compost remediation on dry weight (t/ha) at 5 weeks of main sowing

a) $^{0}P_{100}$ – *No pollution with 100 kgN/ha of compost*
b) $^{1}P_{200}$ – *Light pollution with 200 kgN/ha of compost*
c) $^{2}P_{200}$ – *Medium pollution with 200 kgN/ha of compost*
d) $^{1}P_{300}$ - *Light pollution with 300 kgN/ha of compost*
e) $^{2}P_{300}$ - *Medium pollution with 300 kgN/ha of compost*
f) *C -No compost applied, No pollution applied (control)*
g) *M- Mineral fertilizer (NPK 15-15-15)*

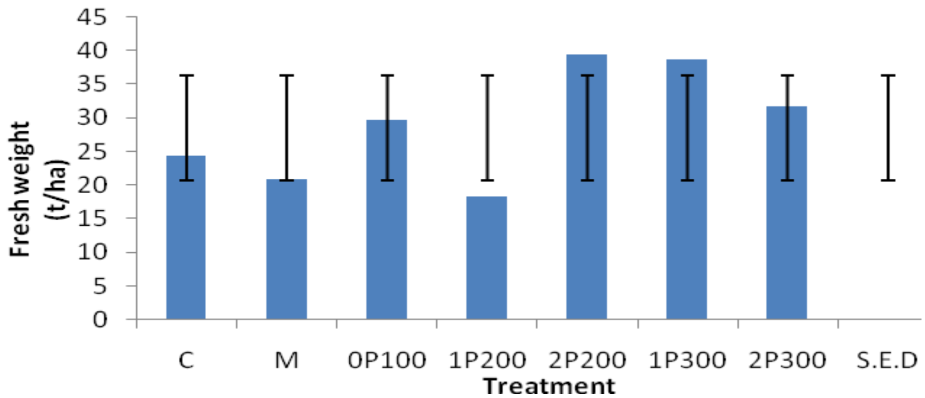

Fig. 3. Effects of compost remediation on fresh weight (t/ha) at 5 weeks of residual sowing

a) $^{0}P_{100}$ – No pollution with 100 kgN/ha of compost
b) $^{1}P_{200}$ – Light pollution with 200 kgN/ha of compost
c) $^{2}P_{200}$ – Medium pollution with 200 kgN/ha of compost
d) $^{1}P_{300}$ - Light pollution with 300 kgN/ha of compost
e) $^{2}P_{300}$ - Medium pollution with 300 kgN/ha of compost
f) C -No compost applied, No pollution applied (control)
g) M - Mineral fertilizer (NPK 15-15-15)

Table 6. Effects of compost remediated PMS polluted soil on some soil chemical characteristics (Post study characteristics)

Parameters		Values	
		Study1	**Study 2**
pH(H_20)		7.1	7.3
Organic Carbon(g/kg)		12.6	15.4
Total N(g/kg)		1.8	2.4
Av.P(mg/kg)		47	65
Exchangeable base (cmol/kg)	K	0.4	0.7
	Na	0.5	0.6
	Mg	0.5	2.5
	Ca	3.1	4.3
	Exchangeable Acidity	0.8	0.7

The nil-growth of seeds from the polluted soils and the subsequent significant difference noticed at the 1st phase of the potted experiment may be as a result of the petroleum hydrocarbon treatment of those soils which would have inhibited seed germination; it would have prevented the absorption of essential plant nutrients by the seeds. This agreed with the report of Odjuwuederhie et al. [8] that in the Niger-delta of Nigeria, oil spill reduced crop yield and greatly depressed farm income as a 10% increase in oil spill reduced crop yield by 13%. It was also reported by Chinda and Braide [16] that spills caused great damage to plants due to high retention of oil in the soil, the oil hampers soil aeration as oil film on the soil surface. It also affects physicochemical properties of the soil, inhibiting transpiration and respiration. Akpor et al. [17] in a study revealed that high values of K^+, Na^+ and Mg^{2+} were recorded in a PMS polluted soil but Ca^{2+} was found to be lowest in the sample tested, and this findings could result in a number of alterations to the growth process of the crop plant. The level of yield and significant differences of both the 2nd phase of the potted experiment and the 1st phase of the field experiment could be as a result of increased quantity of compost at 300 kg N/ha incorporated into the polluted soil. The quantity increased nutrients bioavailability within the medium, the compost being the substrate for the microbes to multiply and increase breakdown rate of the organic compounds in the pollutant. Bacteria colony counts were high during the study. It is suggested that the higher counts of bacteria, could be due to an increase in soil organic matter that occurred with application of compost at high application rates (200 kgN/ha compost and 300 kgN/ha compost). Kornillowicz-Kowalska and Bohacz [18], reported similar results following land application of composted feather waste, where an initial spike in bacteria was succeeded by higher counts of fungi. Bailey and Lazarovits [19], suggested that increase in total bacterial colony in amended plots was a result of enhanced microbial development due to compost, which furnishes a sizeable pool of accessible nutrients to the microorganisms. The microbes could have consumed the contaminants, digesting, metabolising and transforming them into humus and other by-products such as carbon IV oxide, water and salts in the soil. According to the guideline of US EPA, bioremediation is feasible when there is about 10^3 CFU/g soil of the microbial population [20]. The population trend agreed with the report of Schaffner et al. [21] that when the mean population densities of bacterial in samples from contaminated soils are higher, the pollutants are being utilised. The report suggested that microbial enumeration is a screening level tool which can be used to evaluate the response of microbes to hydrocarbons. It has also been reported that the dissipation of organic pollutants has been attributed mainly to increased microbes numbers and selection of specialized microbial communities in the soil [22,23]. Though, this is enhanced with improved physical and chemical soil conditions [24] and increased humidification and absorption of pollutants increasing their bioavailability [25]. Microbial biomass C (C_{mic}) also can be considered a useful indicator of soil quality more than organic matter, since it responds more rapidly to changes. Biomass measurements are early indicators of the response by the organic matter cycle to management changes within soils[26]. Majority of research indicates an increase in C_{mic} upon organic amendment of the soil [26, 27]. This increase could be attributed to an increase in available substrates and nutrients, that consequently stimulates microbial growth. The increase of C_{mic} is however not sustainable and usually declines with time after application of the organic amendment. The decline is probably due to exhaustion of the readily available substrate and this could be responsible for the decrease in hydrocarbon degrader in the study.

The result of the residual effects of the compost amendments would have been due to the gradual decomposing effect of the compost and its ability to improve soil fertility over a period of time as is the general case with organic matter. The result is also an indication that the commercial compost could serve as a storehouse for nutrients essential for plant growth. The findings agree with the report of Gestel et al. [28] and Dutra et al. [23] that total petroleum hydrocarbon contaminated soils were remediated by mixing the soil with matured compost of diverse genus.

4. CONCLUSION

The results indicated that commercial compost can have ameliorative effects on petroleum polluted soils and that the effects seem to increase with the increase in the level of amendment. For both experiments, Compost applied at 300 kgN under light pollution (^{1}P=346 ba/ha) resulted in better response of *A. caudatus*. While the 200 kgN compost under medium pollution (^{2}P=692 ba/ha) and 300 kgN compost with light pollution resulted in better response of *A. caudatus* in the residual experiment of the field study. Although, the study was a preliminary one, it has given an overview of the ameliorative effects of commercial compost on a PMS polluted soil. This could be a less expensive way for local farmers who live near polluted sites or hot spots to remediate their farmlands. The economic ease, with which the compost can be got by the farmers, lessens the burden of remediation on the government and the oil company involved and it allows the use of their farmlands without waiting for long periods of time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Bank. Mozambique Channel mapping: Oil spill detection and coral reef monitoring. A report by the World Bank on sustainable development; 2012. Available:http://go.worldbank.org/QZO9IMNOI0 2012-05-30.
2. Brady NC, Wein RR. The nature and properties of soil. The Nature and Properties of soils *(*13th ed*.)*. U.S., New Jersey: Prentice Hall. Prentice Hall, Upper Saddle River, New Jersey. 2002;881. ISBN 0-13-016763-0.
3. Sakineh L, Gunale VR, Rajurkar NS. Petroleum hydrocarbons pollution in soil

and its bioaccumulation in mangrove species, avicennia marina from alibaug mangrove ecosystem maharashtra, India. International Journal of Advancements in Research & Technology. 2013;2(2):1. ISSN2278-7763. SciResPub.

4. Badejo OT, Nwilo PC. Management of oil spill dispersal along the Nigerian coastal areas. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences (ISPRS). Natural Resources Canada. 2004;35(7): 1271-1277
5. Uzokwe A. Devastating effects of pollution in Nigeria. An article of Nigeriaworld.com. All Africa.com, Africa Recovery - A United Nations publication; 2003. Accessed 10/03/2008.
6. Agbogidi OM. Effects of crude oil contaminated soil on biomass accumulation in *Jatropha cuorcas* L. seedlings. Journal of Ornamental and Horticultural Plants. 2011;1(1):43-49.
7. Agbogidi OM, Eruotor PG, Akparobi SO. Effects of crude oil levels on the growth of maize (*Zea mays L*). American Journal of Food Technology. 2007;2(6):529-535.
8. Odjuwuedarhie EI, Douglason GO, Felicia NA. Journal of central European Agriculture. 2006;17(1):41-48.
9. El-Nawawy A, El Bagari I, Abdal M, Kalafada M. Biodegradation of oil sludge in Kuwait soil. World Journal of Microbiology biotechnology. 1992;8(6):18-100.
10. Coker C. Environmental Remediation by composting Biocycle. 2006;47(2):18. Available: www.jgpress.com accessed 05/03/2008.
11. Bouyoucus CH. A recalibration of the hydrometer method for making mechanical analysis of soil. Agron J. 1951;43:434-438.
12. Peech M. Hydrogen-ion activity. In methods of soil analysis Part 2. Chemical and microbiological properties. agronomy monograph, American Society of Agronomy, Madison, WI, USA. 1965;9: 914-926.
13. Black CA. Methods of soil Analysis Part 2. Chemical and microbiological properties. Agronomy monograph. American society of Agronomy, Madison. WI. 1965;9:123-133.
14. Bray RH, Kurtz. Determination of total organic and available forms of phosphorus. Soil Sci. 1945;59:45-49.
15. Aubert H, Pinta M. Trace elements in soil. In developments in soil science Elsevier, Amsterdam, Oxford, New York. 1977;7: 395.
16. Chinda AC, Braide SA. The impact of oil spills on the ecology and economy of the Niger-Delta of Nigeria. In the procedures of the workshop on sustainable remediation development technology held at the Institute of Pollution studies, Rivers State University of Science and Technology, Port Harcourt, Nigeria; 2000.
17. Akpor OB, Igbinosa OE, Igbinosa OO. Studies on the effect of petroleum hydrocarbon on the microbial and physico-chemical characteristics of soil. African Journal of Biotechnology. 2007;6(16): 1939-1943.
Available:http:/www.academicjournals.org/AJB
18. Korniłłowicz-Kowalska T, Bohacz J. Dynamics of growth and succession of bacterial and fungal communities during composting of feather waste. Bioresource Technology. 2010;101(4):1268-276.
19. Bailey KL, Lazarovits G. Suppressing soilborne diseases with residue management and organic amendments. Soil Tillage Res. 2003;72:169–180.
20. Lin TC, Pan PT, Cheng SS. Ex-situ bioremediation of oil-contaminated soil. Journal of Hazardous Materials. 2009;176:27-34.
21. Schaffner JR, Wieck JM, Wright CF, Katz MD, Pickering EW. Microbial enumeration and lab-scale microcosm studies in assessing enhanced bio-remediation potential of petroleum hydrocarbon. 11th annual conference on contaminated soil, University of Massachsetts at Amherst. A technical paper Index of tier 2 papers in Bioreferences of the Bioremediation Discussion Group; 1996.
Available: www.bioremediationgroup.org
22. Ojo OA. Petroleum-hydrocarbon utilization by native bacterial population from a wastewater canal Southwest Nigeria, Afr. J. Biotechnol. 2005;5(4):333-337.
23. Dutra ES, Pascon, RC, Vallim MA. São Paulo Zoo composting as a source of bacteria with bioremediation potential. African Journal of Microbiology Research. Academic Journals. 2013;7(45):5200-5206,
DOI: 10.5897/AJMR2013.5874
ISSN:1996-0808.
Available:http://www.academicjournals.org/AJMR

24. Yateem, Balba AM, El-Nawawy AS, Al-Awadhi N. Plants associated microflora and the remediation of oil contaminated soil. Intl J. Phytoremediation. 2000;2(3): 183-191.
25. Yoshitomi KJ, Shann JR. *Zea mays* L. root exudates and their impact on C-pyrene mineralization. Soil. Biol. Biochem. 2001; 33:1769-1776.
26. García-Gil JC, Plaza C, Soler-Rovira P, Polo A. Long-term effects of municipal solid waste compost application on soil enzyme activities and microbial biomass. Soil Biology and Biochemistry. 2000;32: 1907-1913.
27. He ZL, Alva AK, Calvert DV, Li YC, Stofella PJ, Banks DJ. Nutrient availibility and changes in microbial biomass of organic amendments during field icubation. Compost Science and Utilisation. 2000; 8:293-302.
28. Gestel KV, Mergaertb J, Swingsb J, Coosemansa J, Ryckeboera J. Bioremediation of diesel oil-contaminated soil by composting with biowaste. Environmental Pollution. Elsevier Science Ltd. All rights reserved. 2003;125:361–368. DOI:10.1016/S0269-7491(03)00109-X.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=953&id=24&aid=7913