# INFLUENCE OF BIOCHAR ON THE PHYSICOCHEMICAL PROPERTIES OF CRUDE OIL POLLUTED SOILS AND GROWTH OF MAIZE (*Zea mays .L.*) IN OGONILAND OF SOUTHERN NIGERIA.

**[1]Peter, K.D. and [2]Onweremadu, E.U.**

[1]Department of Crop/Soil Science, Faculty of Agriculture, Rivers State University, Nkpolu-Oroworukwo, PMB. 5080, Port Harcourt, Rivers State, Nigeria.

[2]Derpartment of Soil Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri Imo State, Nigeria.

**Email: dumkapbase@yahoo.com, Tel: +234 08036738302**

## ABSTRACT

In Ogoniland, crude oil exploration and exploitation activities occur, and sometimes rupture of oil pipeline take place leading to massive crude oil spillage and consequent pollution and alteration of soil, vegetal and aquatic resources and known ecosystem characteristics. This study was conducted at Peter's farmland in Baa-Lueku Town, Nyokhana District of Khana Local Government Area, Rivers State, Nigeria to evaluate effects of biochar on physicochemical properties of Crude oil polluted Ogoni sands planted to maize (*Zea mays L*). Different biochar materials were used as treatments. Six treatments: Control (No pollution: NP), 10tha$^{-1}$ of Cassava Peels (CP), 10tha$^{-1}$ of Water hyacinth (WH), 10tha$^{-1}$ of Palm bunch (PB), 10tha$^{-1}$ of Goat dung (GD) and 10tha$^{-1}$ of Poultry materials (PM) were used and replicated four times. The biochar treatments were arranged in a Randomised Completely Block Design (RCBD); while the experimental plot of 2 x 2 m size was polluted with 5 litres of fresh Bonny light crude oil and allowed to fallow for two weeks. The parameters determined were particle size, bulk density, base saturation, $_{p}$H, carbon:Nitrogen (C:N) ratio, organic Carbon, total Nitrogen, available Phosphorus and exchangeable bases (Calcium, Magnesium, potassium and sodium). Results showed that the soil was predominantly sandy loam in texture (760 – 789gkg$^{-1}$ sand, 80 – 150gkg$^{-1}$ silt and 51 – 90gkg$^{-1}$ clay). Bulk density increased from 1.21 – 1.49 gcm$^{2}$, Percent Base Saturation was high across treatment (90.24 – 98.6%Mg/m$^{3}$). The soil was slightly acidic to neutral (5.20 – 6.91) with low total N (0.05 – 0.14gkg$^{-1}$) and low to moderately high organic carbon (8.1 – 14.1gkg$^{-1}$). Available P increased from 17.8gkg$^{-1}$ in control to 53.8mgkg$^{-1}$goat dung treated plot, CN ratio ranged from 0.25 – 20.02%. Exchangeable Ca was low (1.47cmol kg$^{-1}$) in control and among treatments (5.16 – 5.92cmolkg$^{1}$), exchangeable Mg (1.29 – 4.6cmol kg$^{-1}$), exchangeable K ranged from 0.09 – 0.23cmol kg$^{-1}$. Application of biochar materials improved the physicochemical properties of crude oil polluted soils planted to Maize. Therefore, more intense investigations should be carried out using other biochar sources in the remediation of crude oil polluted soils.

**Keywords**: Biochar, Crude oil, Maize, Ogoni Sands, Pollution, Remediation.

## INTRODUCTION

Ogoni sands are highlysusceptible to degradation and environ mental pollution due to intense oil exploration and exploitation for several decades by ShellPetroleum DevelopmentCompany resulting to frequent oil spillage occurring from the outburst of oil pipelines crisis-crossing the entireOgoniland.

Degraded soils are subject to low productivity and exhibit certain attributes that make its management very necessary for sustainable agricultural production.Soil degradation affectsphysical and chemical properties of soil to a threshold that limitsmaximization of agricultural production on such soils (Ezeaku and Davidson, 2008).Soil physical and chemical properties are significant in agricultural production and sustainabilitybecause,they serve as a set of important tool in the determination of soil health, quality, productivity and stability against degradation. Deforestation makes management of such soils very necessary using environmentally friendly materials and practice most appropriate.Soilphysical and chemical properties affect plant growthas well as retention and supply of plantnutrient making them available to plants for their growth andgeneral development.

*Zea mays .L.* is one of the most widely world cultivated cereal that provide food for man and feed for lives stock Therefore, its production is imperative even in crude oil polluted environment by usingenvironmentally friendly soil amendments such as biochars. Biochars are plants and animal materials produced through a thermochemical process under anaerobic condition. The organic materials are thermochemically decomposed at a high temperature in the absenceof oxygen.Biochar is a charcoal produced from the pyrolysis process of plant and animal biomass at relatively lowtemperature (Lehmann *et al, 2010*).Biochar influenced both soil physical and chemical properties by enhancing soil pH, increasingcation exchange capacity, and reducing Aluminum availability in soils. It also increase soil water retention and improves soil surface structure, decrease soil bulk density due to soil moderate aggregationsand aerations (Laird *et al 2010*).

These help to increase soil macro and micro pores; thereby improving movement of soil solvents, soil fertility and the release of essential nutrients needed by plants for their growth.According toFagbenro*et al* (2016), Lehman *et al* (2006) andLehman (2007), they reported that whenbiochar is used as a soil amendment and fertilizer, itboosts the soil fertility, improve soil quality and enhance crop yield.

Therefore, there is need to carry out research on the effects of some biochar materials on soil properties in crude oil polluted soils. Hence the main objective of this study was to evaluate the physicochemical properties of crude oil polluted soils supporting maize (*Zeamays.L.*)as influenced by biochar in Ogoniland, Southern Nigeria,

## MATERIALS AND METHODS

### Study Site Description:

This experiment was conducted at Peter's private farm in Baa-Lueku Town, Nyokhana District ofKhana Local Government Area of Rivers State. Baa-Lueku lies between Latitude$4^{0}.76^{!}40^{!!}$N and Longitude$7^{0}.44^{!}02^{!!}$7E.The elevation of land surface is 33m above sea level. Soilsof the study area are derived from coastal plain sandand situated in low lying area of the agroecology.Rainfall distribution of the study area ranges from 2000 – 3000 mm per annum in a bimodal formwhile the average annual temperatureranges from 28 to $35^{0C}$depending on the season of the year (Peter and Ayolagha, 2012).

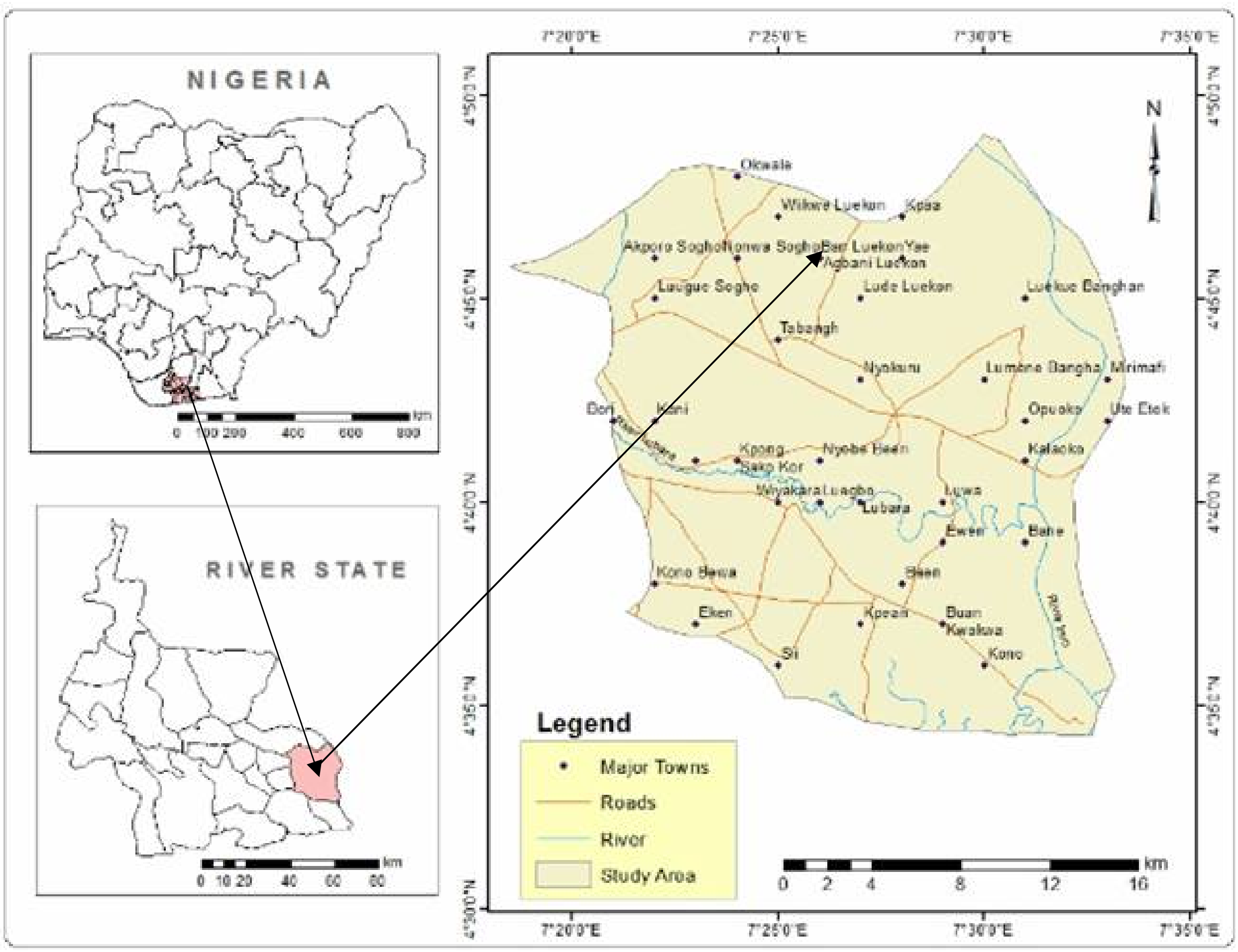


**Fig. 1. Map of Khana Local Government Area**

### Experiment

The experiment involves six treatmentsreplicated four times in a randomized completely block design (RCRD). The experimental plot size was 2x2M size. Each plot was polluted with 5 litres of fresh Bonny light crude oil with specific gravity of 0.835 that is equivalent to Twopercent2 % pollution (ELF 2000). Pollution was done by measuring 5 litres of crude oil into a watering can and spread evenly on each plot. The polluted plot was allowed to fallow for two weeks before the application of biochar materials and subsequent planting. The biochar materials used are;

cassava peels, water hyacinth, palm bunch, goat dung andpoultry manure. The treatments administered were; Control (Nopollution) Cassava peels, Waterhyacinth,Palm bunch, Goat dung and Poultry manure. The biochar materials were applied at the rate of 48g which is equivalentto 10tha$^{-1}$.

**Method of Biochar Preparation**

Five types of biochars were produced using cassava peels, waterhyacinth, palm bunch, goat dung and poultry manure. Large quality of cassava peels were collected from local garri producers; while large quality of fresh water hycinth was harvested from the Mbima river water way in Ahoada East Local Government Area, Rivers State.Palm bunches were sorted locally from community palm oil producers and splits into smaller pieces using cutlass, while Goat dung and Poultrymanure were purchased from Swart Farm in NonwaSogho in Nyokhana district of Khana Local Government Area of Rivers State, Nigeria

These materials werethermochemicallyconverted separatelyto biochar using locally made drum depleted of oxygen at a temperature of 400$^{oc}$ for 3 – 4 hours respectively. The biochar materials obtained after heating were allowed to cool and grounded into fine powder using local mortar and pestle and sieved through a mesh sizemeasuring 150um.

Two weeks after planting, biochar materials were measured according to the rate of application48gequivalentto 10tha$^{-1}$ and later worked into the soil with a hand trowel. Four weeks of application/planting, the second rounds of biochar were applied using the ring method of application except the control plot.

**Laboratory Studies**

Soil samples were collected from all the treatment plots at a depth of 0-30cm after harvest. These soil samples were sieved using 2-mm sieveand soil properties were determined. Soil pH was assessed using soil: water of 1:25 (Thomas, 1996) while organic carbon was estimated byoxidation method of Nelson and Sommers (1982). Total nitrogen was determined by semi micro–kjeldahl method (Bremner, 1996),available P by Bray 1 method (Nelson and Sommers1982),exchangeable basiccations were all determined; while particle size analysis was measured suing theBouyoucos hydrometer method (Gee and Or, 2002).

The data generated were subjected to analysis of variance (Anova), while the means were separated usingthe fisher's least significant difference (LSD).

**Table 1: Physiochemical Properties of the soil before pollution**

| Soil Properties | Value |
|---|---|
| Soil Particle size (%) | |
| Sand | 77.8 |
| Silt | 14.3 |
| Clay | 7.9 |
| Textural Class | Sandy loam |
| Bulk density (mg m$^{-2}$) | 1.63 |
| Base Saturation (%) | 90.01 |
| pH ($H_20$) | 5.21 |
| C/N Ratio | 4.2 |
| Organic c (g/kg) | 0.8 |
| Total N (g/kg) | 0.42 |
| Available P (Mg/kg) | 64.70 |
| Ca (Cmol/kg) | 1.89 |
| Mg (Cmol/kg) | 2.0 |
| K. (Cmol/kg) | 2.43 |
| Na (Cmol/kg) | 1.81 |

**NP = No pollution, CP = cassava peels, WH = water hyacinth, PB = palm bunch, GD = goat dung and PM = poultry manure**

**Table 2: Physiochemical Properties of the soil after pollution**

| Soil Properties | Value |
|---|---|
| Soil Particle size (%) | |
| Sand | 77.8 |
| Silt | 14.3 |
| Clay | 7.9 |
| Textural Class | Sandy loam |
| Bulk density (mg $m^{-2}$) | 1.54 |
| Base Saturation (%) | 87 |
| pH ($H_20$) | 5.9 |
| C/N Ratio (%) | 6.5 |
| Organic c (g/kg) | 1.28 |
| Total N (g/kg) | 0.14 |
| Available P (Mg/kg) | 522 |
| Ca (Cmol/kg) | 1.81 |
| Mg (Cmol/kg) | 1.43 |
| K. (Cmol/kg) | 3.40 |
| Na (Cmol/kg) | 1.60 |

**NP = No pollution, CP = cassava peels, WH = water hyacinth, PB = palm bunch, GD = goat dung and PM = poultry manure**

**Table 3:Physicochemical of Biochar used as Amendment Materials**

| Biochars Properties | CP | WH | PB | GD | PM |
|---|---|---|---|---|---|
| pH ($H_20$) | 9.21 | 10.09 | 11.10 | 5.91 | 8.20 |
| C/N Ratio | 12 | 10 | 13 | 9 | 10 |
| Organic c (g/kg) | 48 | 47.4 | 49.1 | 41 | 22.5 |
| Total N (g/kg) | 0.13 | 0.152 | 0.171 | 0.25 | 0.29 |
| Available P (Mg/kg) | 6.1 | 7.2 | 7.81 | 6.83 | 6.21 |
| Ca (Cmol/kg) | 1.3 | 0.92 | 3.1 | 1.41 | 4.21 |
| Mg (Cmol/kg) | 1.30 | 1.32 | 1.95 | 1.39 | 0.75 |
| K (Cmol/kg) | 0.27 | 1.26 | 1.28 | 1.82 | 2.7 |
| Na (Cmol/kg) | 0.25 | 0.2 | 0.28 | 0.3 | 2.31 |

**NP = No pollution, CP = cassava peels, WH = water hyacinth, PB = palm bunch, GD = goat dung and PM = poultry manure**

## RESULTS AND DISCUSSION

Results of initial physicochemical properties of soils from the studied area before pollution and after pollution and selected chemical properties of biochar used are presented in Table 1, 2 and 3 respectively.

**Influence ofBiochar application on physical properties of crude oil polluted soilssupporting maize (*Zea may .L.*).**

**Texture (particle size distribution).** According to the analytical results of the physical properties of soil, it revealed that the soil fall within the Sandy loam textural class. Fine sand increased from 76.0% in Poultry manure treated plots to 78.6% in cassava peels amended plot. Silt increased from 8.0% in the control plot to 15.0% in the poultry manure treated plot; while clay increased from 5.1% in the control plot to 9.0% in the poultry manure treatedplot.

**Table 4: Influence of Biochar on physical properties of crude oil polluted soil supporting maize (*Zea may .L.*)**

| Treatments | BD ($gcm^{-3}$) | Sand | Silt % | Clay | Textural classes |
|---|---|---|---|---|---|
| NP | 1.49- | 76.9 | 8.0 | 5.1 | Sandy loam |
| CP | 1.24 | 78.9 | 14.8 | 7.0 | Sandy loam |
| WH | 1.27 | 77.8 | 14.2 | 7.0 | Sandy loam |
| PB | 1.29 | 78..0 | 14.0 | 8.0 | Sandy loam |
| GD | 1.21 | 780 | 14.8 | 7.2 | Sandy loam |
| PM | 1.27 | 76.0 | 15.0 | 9.0 | Sandy loam |

**NP = No pollution, CP = cassava peels, WH = water hyacinth, PB = palm bunch, GD = goat dung and PM = poultry manure**

Bulk density ranged from 1.21 $gcm^3$ in the goat dung amended plot to 1.49$gcm^3$ in the control plot. The results showsthat No polluted plot had the highest BD (1.49 $gcm^{-3}$); while the least BD (1.21gcm) was observed in the goat dungtreated plot. The higher BD in the control (No pollution) andthe least in biochar treated plots is in line with the findings of Onwuka andNwangwu (2016),Mankasinghe*t al*, (2011) and Mukherjee et al (2013) who reported that there is a decrease in soil bulk density and penetrationresistance in biochar amended soil is due to good soil aggregation and aeration improvement. The decrease in BD ofbiochar amended soils also agreed withBusscher*et al* (2011) who observedthatincreasing totalorganic carbon by the addition of organicamendments in soils could significantly decrease bulk density. It is also inline with the findings of Jejada andGonzalezs, (2007) who indicated that biochar amended soils appears to have decreased bulk density as a result of alteration of soil aggregate sizes.

**Influence of Biochar on chemicalproperties of crude oil polluted soils supporting maize (*Zea mays .L.*).**

**Soil pH and Base saturation (Bs)**

Table 5 showed the results of the chemical properties of crude oil pollutedOgoni sands supporting maize (*Zea mays .L.*) as influenced by the application of biochar.Soil pH in water ranged from 5.5 to 6.91 with amean of 6.3 in biochar amended soil. The least pH value (5.20) was observed in the control (No pollution) plot. The results showed that pH increased withapplication of biochar indicating the high liming potential of biochar when applied to soil. The soil pH value ranged from slightly acidic(5.20) tomildly alkaline in biochar amended soil. BS increased significantly after application of biochar. The highest of Base saturation was observed in WH treated plot (98.167), followed by GD (97.81%), PB (96.32%), PM (96.17%) and CP (95.21) in that order. The least BS was observed in the control (No pollution) plot (90.24%). The amended soils had higher base saturation than the control plot. be attributed to the Non application to soil in the plot leading to low base saturation. This is also in line with the findings ofShin-haoandChien-sheng(2013) who reported that additionbiochar material to the soil caused a significant increase in BS particularly at the application rate of 5%.

**Carbon-Nitrogen ratio, organic carbon (OC), Total Nitrogen (TN) and Available P**

The application of biochar materials has great positive influenced on some selected chemical properties such as, C/N ratio, organic carbon (OC), Total Nitrogen (TN) and Available phosphorus (Av.P) as showed in Table 5. The no pollution plot (control) had 0.25C/N ratio, 0.81 $gkg^{-1}$ OC, 0.05 $gkg^{-1}$TN and 17.8$mgkg^{-1}$ Av. P level.Application of biocharsincreased C/N ratio in cassava peels treated plot to 20.02, followed by GD (3.41), PB (3.11) WH (2.00).

**Table 4: Physiochemical of Soils afterBiochar Application and Harvest.**

**Soil Properties**

| Soil Particle size (%) | Control | CP | WH | PB | GD | PM |
|---|---|---|---|---|---|---|
| Sand | 76.9 | 78.9 | 77.8 | 78.0 | 78.0 | 76.0 |
| Silt | 18.0 | 14.1 | 14.2 | 14.0 | 14.8 | 15.0 |
| Clay | 5.1 | 7.0 | 7.0 | 8.0 | 7.2 | 9.0 |
| Textural Class | SL | SL | SL | SL | SL | SL |
| Bulk density | 1.49 | 1.24 | 1.27 | 1.29 | 1.21 | 1.27 |
| Base Saturation % | 90.24 | 95.21 | 98.16 | 96.32 | 97.81 | 96.17 |
| pH ($H_20$) | 5.20 | 5.5 | 6.59 | 6.20 | 6.4 | 6.91 |

| | | | | | | |
|---|---|---|---|---|---|---|
| C/N Ratio | 0.25 | 20.02 | 2.00 | 3.11 | 3.41 | 0.38 |
| Organic c (g/kg) | 0.81 | 1.25 | 1.41 | 1.20 | 1.25 | 0.84 |
| Total N (g/kg) | 0.05 | 0.13 | 0.17 | 0.11 | 0.14 | 0.08 |
| Available P (Mg/kg) | 17.8 | 50.29 | 50.21 | 50.56 | 53.8 | 52.99 |
| Ca (Cmol/kg) | 1.47 | 5.41 | 5.31 | 5.35 | 5.16 | 5.92 |
| Mg (Cmol/kg) | 1.29 | 4.05 | 4.61 | 4.21 | 4.01 | 2.40 |
| K. (Cmol/kg) | 0.09 | 0.10 | 0.12 | 0.23 | 0.20 | 0.09 |
| Na (Cmol/kg) | 0.14 | 0.22 | 0.23 | 0.24 | 0.24 | 0.14 |

**NP = No pollution, Cp = cassava peels, WH = water hyacinth, PB = palm bunch, GD = goat dung, PM = poultry manure and SL = Sandy loam**

The leastcarbon-nitrogen was observed in poultry manure (0.38) and control (0.25). Organic Carbon increased from10.25gkg$^{-1}$ in cassavapeelstreated plot to 14.1gkg$^{-1}$ in waterhyacinth treatedplot. Least organic carbon level was observed in control (8.1gkg$^{-1}$) and Poultry manure treated plot (8.4gkg$^{-1}$).Biochar application also increased total N, and Av.Pcontent of soil. Total N increased from 0.08gkg$^{-1}$ in poultry manure treated plot to 0.17gkg$^{-1}$ in waterhyacinth treatedplot; the least was also observed in the control (0.05gkg-1).Whilethere was also an increased in Av.P from 50.21mgkg$^{-1}$ in the waterhyacinth treated plot to 53.8Mgkg$^{-1}$ in the Goat dung treated plot and the leastAv.P was observed in the controls (17.8mgkg$^{-1}$). The increase in the level C/N ratio, OC, TN and Av.P inthe soil were attributed to the application of biochar materials to the soil. This also inline with the report of Steiner*et al*(2008), Warnock et al, (2007) and Onwuka and Nwangu(2016), that whenbiochar is applied to the soil, it improves the fertility status of the soil by adding to the soil some essential nutrient elements needed by plant for their proper growth and development.

**Exchangeable bases (Calcium, Magnesium, Potassiumand Sodium).**

Exchangeable Ca increased from 5.16cmolkg-$^{1}$in goat dung treated plot to 5.92cmolkg$^{-1}$ in poultry manure plot. Poultrymanuretreated plot had the highest exchangeable Ca (5.92cmolkg$^{-1}$) followed by cassava peels (5.41cmolkg$^{-1}$), palm bunch (5.35 cmolkg$^{-1}$), water hyacinth (5.31 cmolkg$^{-1}$) and Goat dung (5.16 cmolkg$^{-1}$) respectively. The No pollution plot (control: 1.47 cmolkg$^{-1}$) had the least exchange Ca. The high Ca content in soil treated with poultry manure might be attributed to the high Ca content of the feed fed to the layer birds from which the poultrymanure was obtained. This in line with the findings of Peter and Anthony, (2017) who reported the broken egg shell increased the calcium content of soils Exchangeable Mg increase in waterhyacinth treated plot (4.61 cmolkg$^{-1}$)followed by palm bunch (4.21 cmolkg$^{-1}$), Cassava peels (4.05 cmolks$^{-1}$) and Goat dung (4,01 cmolkg$^{-1}$) treated plots, but there was a decreased incontrol (1.29 cmolkg$^{-1}$) and poultry manure (2.40 cmolkg$^{-1}$). Exchangeable K increased in PB (0.23 cmolkg$^{-1}$) treated plot to 0.09cmolkg-1 in PM and NP (Control) respectively, while exchangeable Naincreased in PB and GD (0.24 cmolkg$^{-1}$) treated plot to 0.14 cmolkg$^{-1}$ in PM and NP (Control) treated plot. The increase in exchangeable bases inthe biochar treated polluted soils might also be as a result of the ashcontent of the biochar materials applied. The ashes help to release minerals such as Ca, Mg, K and Na in theSoil (Peter and Anthony, 2017).

## CONCLUSION

Biochar prepared from plant and animalwaste materials through a slow pyrolysis process is a good remediation material for crude oil polluted soils.They are good source of fertilizer due to their high nutrient potentials. However there was decrease in soil total N even afterbiochar application. Application of biochar materials such as poultry manure at 10tha$^{-1}$ improved the physicochemical crude oils polluted soils supporting maize (*Zea may .L.)* plant at 10tha$^{-1}$.Therefore, more investigation should be carried out using sources in the remediation of crude oil polluted soils.

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