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The Effect of Cassava Peel on Phytoremediation Potential of *Chromolaena Odorata* in Hydrocarbon Contaminated Soil

By

Jude,K.; Tanee, F.B.G.and Mensah, S.I
Department of Plant Science and Biotechnology
Faculty of Science
University of Port Harcourt
Port Harcourt, Nigeria

Email: keayiabaridojude@yahoo.com; franklin.tanee@uniport.edu.ng.

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ABSTRACT

An investigation of the efficiency of cassava peel powder on phytoremediation potential of Chromolaena odorata in hydrocarbon contaminated soil was carried out at a crude oil impacted site in Botem community in Tai Local Government Area of Rivers State. Four treatments were set up; A1 (polluted soil + C. odorata), A2 (polluted soil phytoremediated with C. odorata and amended with 500 g cassava peel powder), A3 (polluted soil phytoremediated with C. odorata and amended with1000 g cassava peel powder) and the control A4 (polluted soil without plant and amendment). The treatments were arranged using Latin Square Design (LSD). Physicochemical properties and hydrocarbon content of soil were analyzed. Result showed higher percentage reduction in total petroleum hydrocarbon (TPH) and total hydrocarbon content (THC) concentration in phytoremediated soil; with or without amendment; A1 (88.95% and 93.57%), A2 (88.43 % and 94.18%), and A3(87.39 % and 93.46 %)) than in polluted soil alone (14.76% and 32.90%) respectively. Result also showed significant (P = 0.05) increase in total nitrogen, total organic carbon, total organic matter in soil. This is an indication that phytoremediation of hydrocarbon contaminated site using Chromolaena odorata and cassava peel was more effective and should be considered in the remediation of crude oil contaminated soil.

Keywords: phytoremediation, cassava peel, Chromolaena odorata, pollution, crude oil, soil.
*Correspondence author

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Introduction

The main recipient of most chemicals used in the society, other forms of waste (farmyard) and pollutants such as crude oil is the soil(Abdel-Moghny *et al*., 2012) and it is a major constituent of the ecosystem on which sustainability of environment largely depend (Adenipekun 2008;Srivastava *et al*.,2016).). The spill of crude oil into the environment and the improper management and disposal of oily sludge may cause pollution (Hu *et al*., 2013), particularly to the soil and underground water systems, due to their low volatility and aqueous solubility (Zhang *et al*., 2016). Pala *et al*. (2006) stated that "petroleum has been commercially explored since the middle of the 19th century for illumination and as lubricants. Also, the invention of the internal combustion engine and its fast adoption in all transport forms has increased the use of this natural resource (Chorom *et al*., 2010).This increases its production, demand, transport, stockpiling and distribution (Difiglio, 2014).

Oil spill occur through leakage from off shore wells, tankers, leakage pipelines, trucks while transporting crude products and also from storage tanks underground (Ite *et al*., 2013). These activities increase pollution risks that cannot be completely eradicated, though may be minimized thus creating numerous hazards for the environment (Kjellstrom *et al*., 2006).

Petroleum hydrocarbon pollution in our environment (particularly on farmlands) is currently on the increase, (Augustina *et al*., 2015) and is an issue to the living organisms of contaminated areas, firms or organizations participating in oil prospects and exploration (Ambituuni *et al*., 2014). Thus pollution caused by petroleum and its derivatives is a prevalent problem in the Niger Delta environment (Tanee and Albert,2015).

.Crude oil is a complex mixture of hydrocarbons alongside other constituents such as sulfur, nitrogen and oxygen found naturally in the ocean bed in different parts of the world (Speight, 2014) and it varies greatly in its property as a result of the different field where it is gotten. However, the constituents of hydrocarbons are usually not in the same ratio or proportion. Hence, it becomes the basis on which different types of crude oil is known (Ding *et al*., 2016).

Comparing crude oil and water, approximately all crude oils are less dense than water and flow readily (Fingas, 2010), while the heavy ones do not, though crude oil from one location may be colourless while that from another location may be black (Merola *et al*., 2016). Hydrogen and carbon atoms in hydrocarbon molecules of petroleum vary in number and in pattern of atom arrangement (Speight, 2014). The heavier and thicker fragments of crude oil like asphalt usually have higher number ofatoms while the lighter parts like gasoline has lower number of atoms(Hyne, 2012).

Under natural environment, Crude oil pollution increase percentage of organic carbon and decreased phosphorus of soil ((Ogboghodo, *et al.,* 2004). These manifest in the alteration of the ecological equilibrium such as change in biodiversity and soil biomass, and alteration of physical and chemical status, with subsequent abandonment of such lands (Kibblewhite*et al*.,2008).

The undesirable ecological and socio- economic consequence associated with crude oil pollution has given rise to the development of remediation techniques targeted towards reducing the unfavorable effects of crude oil on the soil (Panel, 2013). Natural restoration of polluted soil usually takes time due to the fact that there is increase in land use as population rise hence it may be difficult to allow lands to fallow or recover naturally(Ogboghodo, *et al.,* 2004, Akpan*et al*., 2013).

Recently, phytoremediation a technique in bioremediation is known to be progressing in reducing hydrocarbon content in crude oil in polluted soil. Plants such as *Axonopuscompressus* (Sw.) P. Beauv, *Cyperus brevifolius* (Rottb.) Hassk and *Cyperus rotundus* Linn. have been identified and reported to have shown optimum performance when planted in hydrocarbon –contaminated soil (Bordoloi *et al*., 2012; Basumatary *et al*., 2012; Basumatary *et al*., 2013). However,phytoremediation effectiveness is usually speed- up when it is combined with agricultural practices such as the application of organic and inorganic fertilizers which supply of limiting nutrient to soil (Ayotamuno *et al*., 2006).Thus the use of plants and biostimulation by the addition of nutrients in combination become a viableoption for speedy recovery of crudeoil contaminated soil. The objective of this study is to evaluate effect of cassava peel on phytoremediationpotential of*Chromolaen aodorata* in crude oil contaminated soil.

MATERIALS AND METHODS

Description of experimental site

The experimental site was a crude oil polluted land in Botem community in Tai Local Government Area of Rivers state, situated in the Niger Delta area of Nigeria.

The polluted site is located on the GPS coordinates N 4°43' 29.5608", E 7°16' 8.382". It is an oil impacted site from a broken oil pipe owned by Shell BP over a year before the study was done.

Sources of materials

Dried and ground cassava peel (organic amendment) used in the study was collected from local farmers who removed these peels during Garri processing. The peel collected was sun- dried for two weeks and ground. The chemical composition was analyzed thus: pH 5.3 phosphorus 0.12 mg/kg Nirtogen.1.686%, potassium 2459.5 mg/kg, sodium 636.52 mg/kg, magnesium409.38 mg/kg calcium 193.77 mg/kg. Seedlings of *Chromolaenaodorata* used for phytoremediationwere obtained from unpolluted sites in Botem community.

Experimental design

A Latin Square Design (LSD) comprising four (4) treatments with four replications (4) was used for the experiment. The four treatments were as follows:

A1= polluted soil + *C. odorata*

A2=polluted soil phytoremediated with *C. odorata* and amended with 500 g cassava peel powder

. A3 =polluted soil phytoremediated with*C. odorata* and amended with1000 g cassava peel powder

A4 =polluted soil without any phytoremediation and amendment (control)

The polluted site was subdivided into four (4) subplots of 1m x 1m dimensions with intervals of 0.5m in between plots. Each subplot was replicated four (4) times.

A1	A2	A3	A4
A2	A3	A4	A1
A3	A4	A1	A2
A4	A1	A2	A3

Fig. 1 Experimental design

PLANTING

The phytoremediation site was tilled (scarification) in preparation for planting. Dried ground cassava peel (500 g and 1000 g) was added to soil in A2 and A3 respectively and allowed to stand for one week. These subplots were tilled with shovel before planting was done on them. Young seedlings of *Chromolaena odorata* and were collected from the wild (unpolluted site) and were transplanted into their respective plots (A1, A2 and A3). Treatment A4 was without plant. A minimum of thirty (30) seedlings of the plant were planted per subplot.

Soil collection and Analysis

Pre-Treatment Collection: Before planting was done, samples of soil were collected from all subplots in the polluted site. The samples were collected from the soil at a depth of 0 – 15 cm using a soil auger. Soil samples collected from different subplots were mixed homogenously to form a composite sample. This was put into a perforated nylon bag and then labeled.

Post-Treatment Collection: This was done at two month interval. Soil samples around the rhizosphere (root zone) of the plants in the different treatment plots were taken. Soil samples were also taken from the untouched subplots of the polluted sites (polluted alone).

Analysis of Samples: Soil samples were taken to the laboratory for analysis. Soil chemical properties examined are: Potassium (K), Phosphorus (P), Total Organic Carbon (TOC), Total Nitrogen (N), Total Hydrocarbon Content (THC), Total Petroleum Hydrocarbons (TPH), Soil pH and electrical conductivity.

Determination of measured parameters

The electrical conductivity and pH of the soil were determined electronically using a glass electrode pH metre (PHS. 25 Model) and conductivity metre (Labtech Model), respectively. TNRCC Tx Method 1005, (1997) was used to determine the total petroleum hydrocarbon in soil and plant. The API-RP45 Colorimetric method used by Aigberua *et al.* (2016) was used to determine the Total Hydrocarbon Content (THC) of soil and plant sample. Black Method (Black, 1965) was used to determine Total Organic Carbon (TOC). Total Organic matter content of soil was determined by calculation, using the formula outlined by Combs and Nathan (2011). Kjeldahl Method (Stewarte *et al*., 1974) was used to determine total nitrogen of the soil. Black Method (Black, 1965) was used to determine potassium in the soil. Bray No.1 Method (Bray and Kurtz, 1945) was used to determine available phosphorus in soil.

Data Analyses

Statistical evaluation such as means, standard error means (SEM), two- way ANOVA and Least significant difference (LSD) were determined using Duncan Multiple Range Test (DMRT), 2018 version. Results were presented as mean ± SD using Charts and Tables.

RESULTS

Result for Total petroleum hydrocarbon and total hydrocarbon content of soil is presented in Figures 2 and 3. Result obtained showed reduction in Total petroleum hydrocarbon content of soil in all the treatments. Higher reduction in TPH was observed in phytoremediated soil; with or without cassava peels (A1, A2, and A3) than in polluted soil alone at both months. Reduction in Total hydrocarbon content was also observed in all the treatments. Higher reduction was recorded in cassava peel amended phytoremediated than phytoremediated soil without amendment. Polluted soil alone had the least reduction in THC. There was significant difference (P= 0.05) in THC reduction between cassava peel amended phytoremediated soil (A2 and A3) and treatments A1 (phytoremediated soil without amendment), A4 (polluted soil alone) at 2 months. At 4months, the significant difference was between polluted soil alone (A4) and phytoremediated soil with or without amendment (A1, A2 and A3).

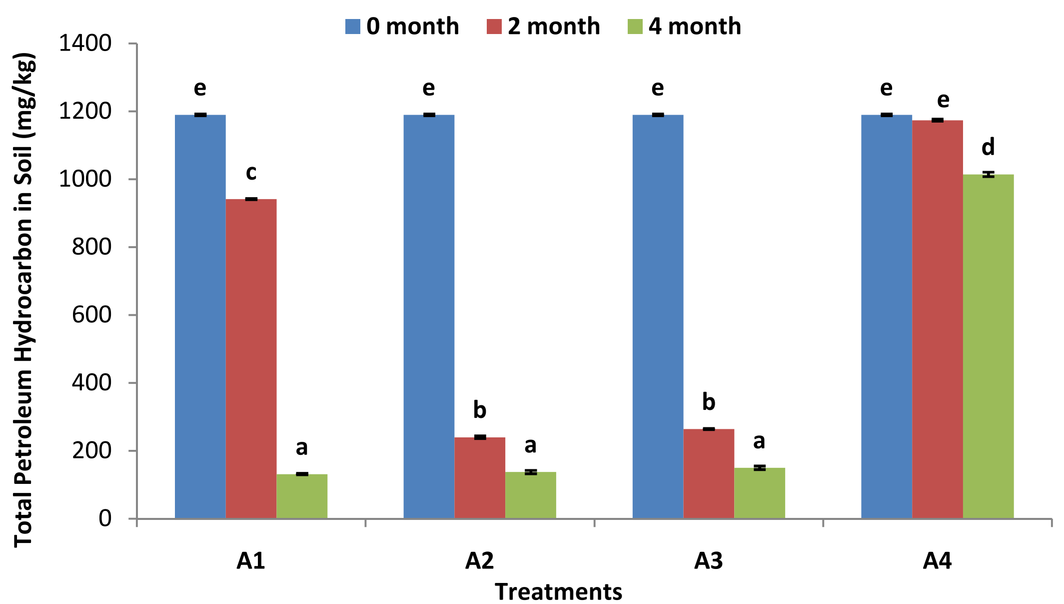

Fig. 2: Effects of treatments on total petroleum hydrocarbon in soil

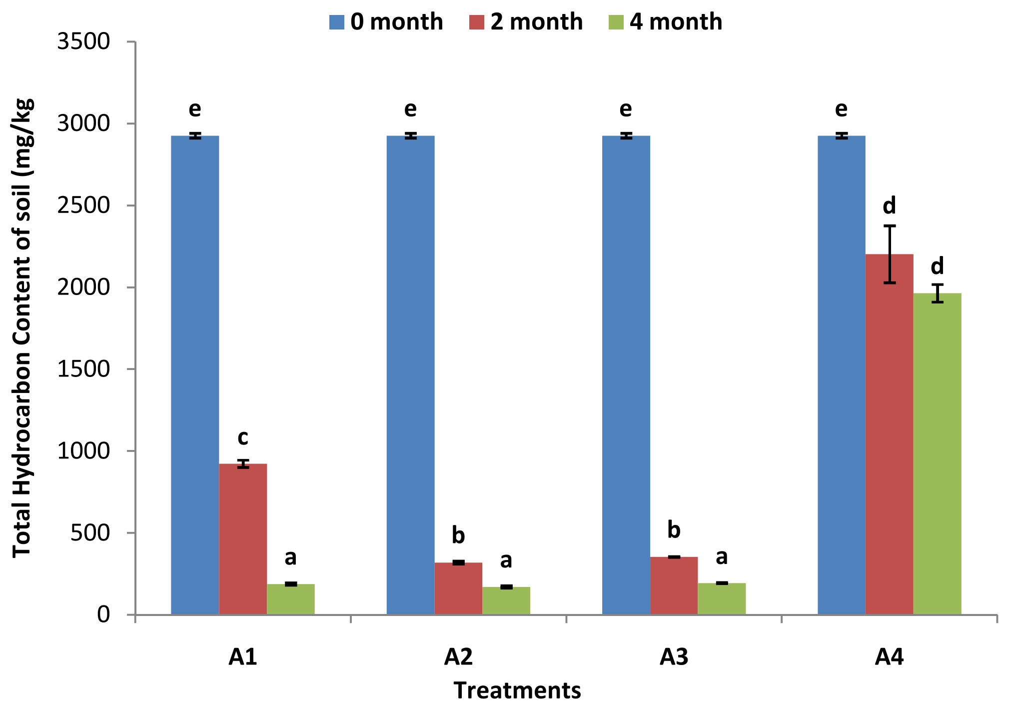

Fig. 3: Effects of treatments on total hydrocarbon content of soil

Result for soil pH and conductivity is shown in Figures 4 and 5. Soil pH increased in all the treatments. Higher increase was observed in cassava peel amended phytoremediated soil than other treatments (phytoremediated soil without amendment and polluted soil alone). There was significant difference (p = 0.05) between cassava peel amended phytoremediated soil and treatments; A1 (phytoremediated soil without amendment), A2 (polluted soil alone). Result showed increase in electrical conductivity of soil in cassava peel amended phytoremediated soil while decrease was observed in other treatments (phytoremediated soil without amendment and polluted soil alone) at 2 months. There was significant difference (p = 0.05) between 1000g cassava peel amended phytoremediated soil (A3) and A2 (500 g cassava peel amended phytoremediated soil), A1 (phytoremediated soil without amendment). There was also significant difference between 500 g cassava peel amended phytoremediated soil (A2) and polluted soil alone (A4). The reverse was observed at 4 month.

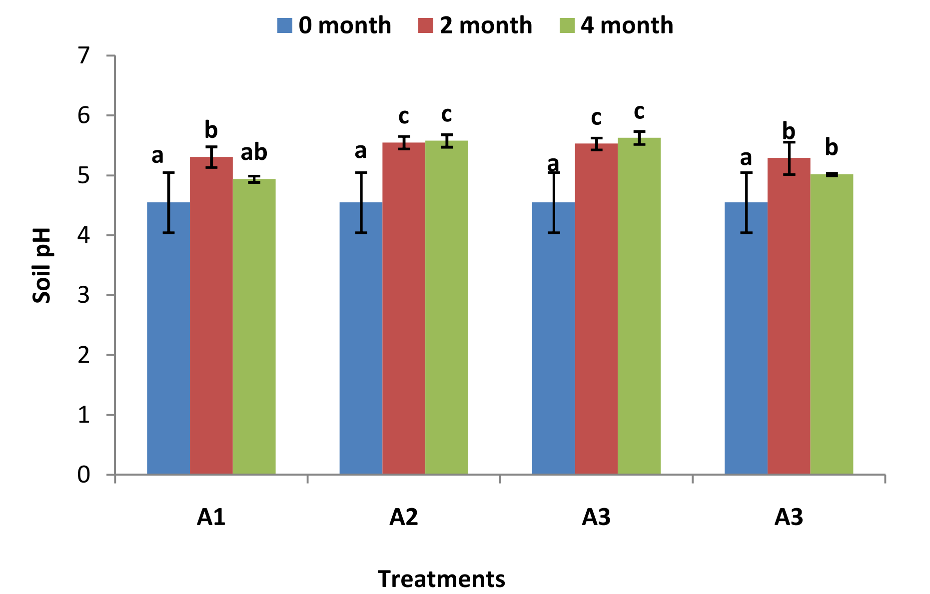

Fig. 4: Effects of treatments on Soil pH

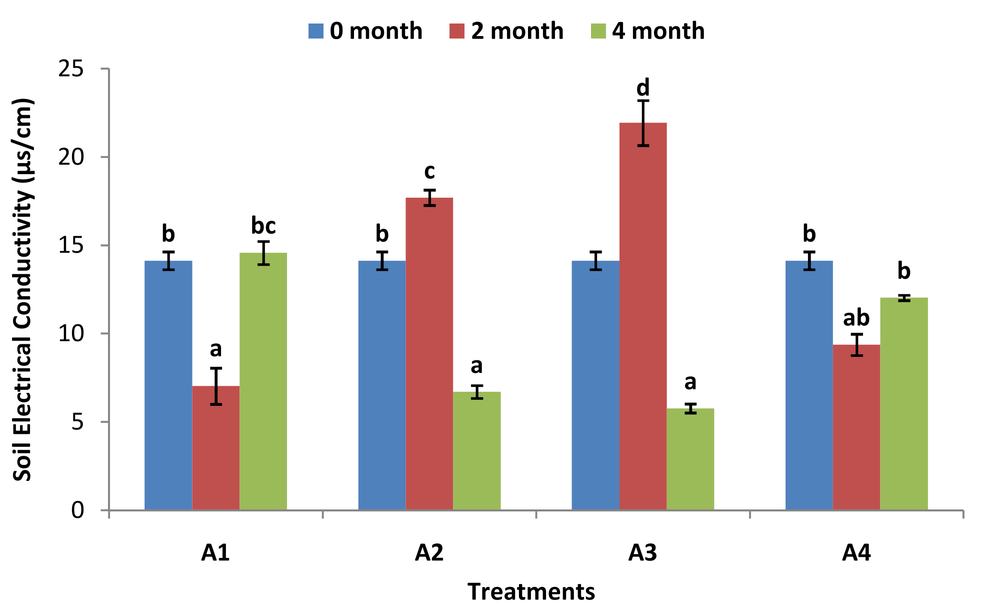

Fig. 5: Effects of treatments on Soil electrical conductivity

Result showed increase in nitrogen in amended phytoremediated soil (A2 and A3) at the end of the study (Figure 6). There was significant difference (p = 0.05) between amended phytoremediated soil (A2 and A3) and other treatments (phytoremediated soil without amendment and polluted soil alone).

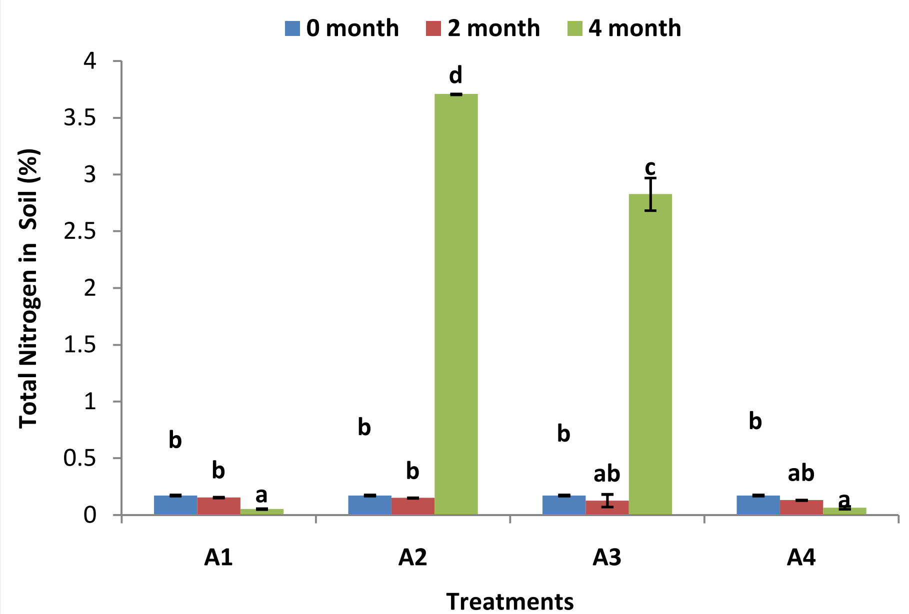

Fig. 6: Effects of treatments on total Nitrogen in soil

Figures 7 and 8 shows results of total organic carbon (TOC) and total organic matter (TOM). Result showed increase total organic carbon in amended phytoremediated soil while phytoremediated soil without amendment (A1) and polluted soil alone (A4) recorded decrease in TOC. Highest increase in TOC was observed in 1000 g cassava peel phytoremediated soil. There was significant difference (p = 0.05) between cassava amended phytoremediated soil and other treatments (A1 and A4) at 4 months. Within amended treatments there was significant difference (p = 0.05)between 1000 g cassava peel amended phytoremediated soil and 500 g cassava peel amended phytoremediated soiltotal organic matter increase in amended phytoremediated soil. Highest increase was observed in 1000g cassava peel amended phytoremediated soil. There was significant difference (p= 0.05) between cassavapeel phytoremediated soil (A2 and A3) and treatments A1, A4 (phytoremediated soil without amendment and polluted soil alone) at the end of the study (4 months). Within amended treatment there was significant difference between 1000 g cassava peel amended phytoremediated soil and 500 g cassava peel amendedphytoremediated soil.

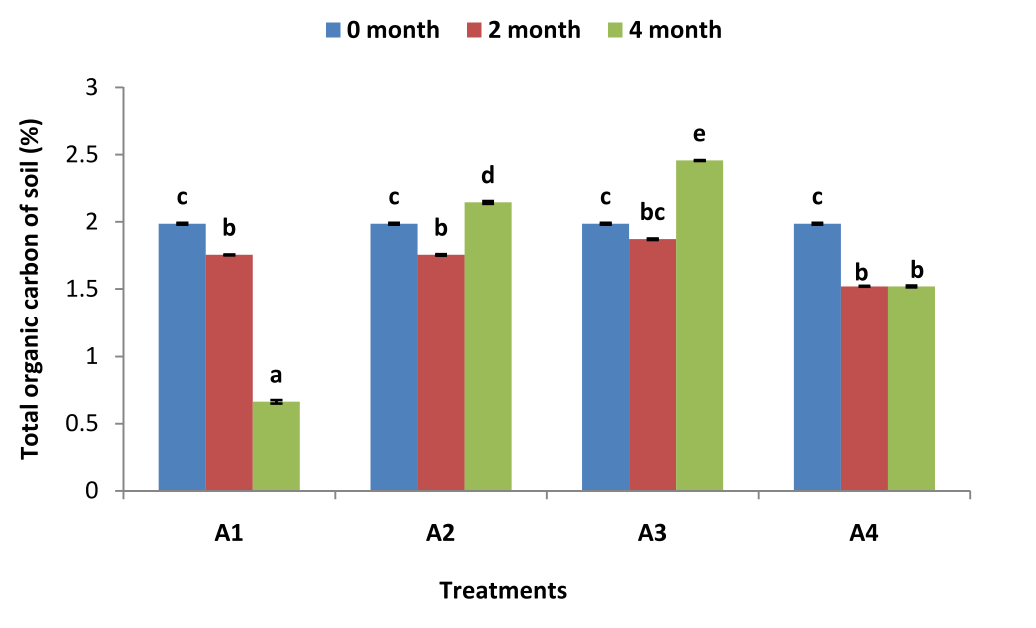

Fig. 7:Effects of treatments on total organic carbon of soil

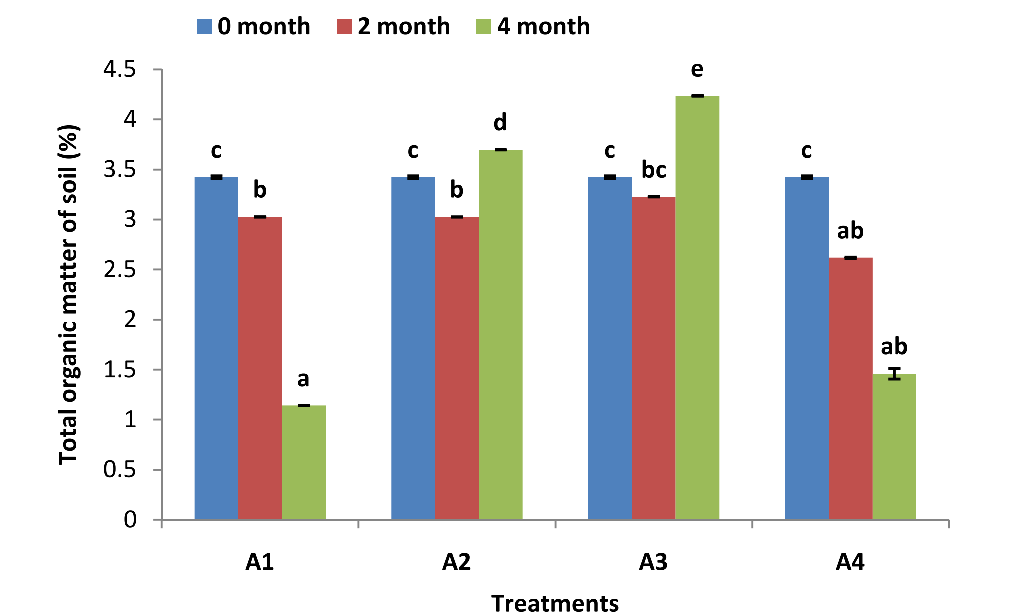

Fig. 8: Effects of treatments on total organic matter of soil

Result showed increase potassium in all the treatments at 2 month (Figure 9). There was significant difference (p = 0.05) between all the treatments. At 4 month, increase in potassium was observed in all phytoremediated treatments (with or without amendment). Within phytoremediated soil there was significant difference between treatment A2 (500 g cassava peel amended phytoremediated soil) and treatments; A1 (phytoremediated soil without amendment), A3 (1000 g cassava peel amended phytoremediated soil).

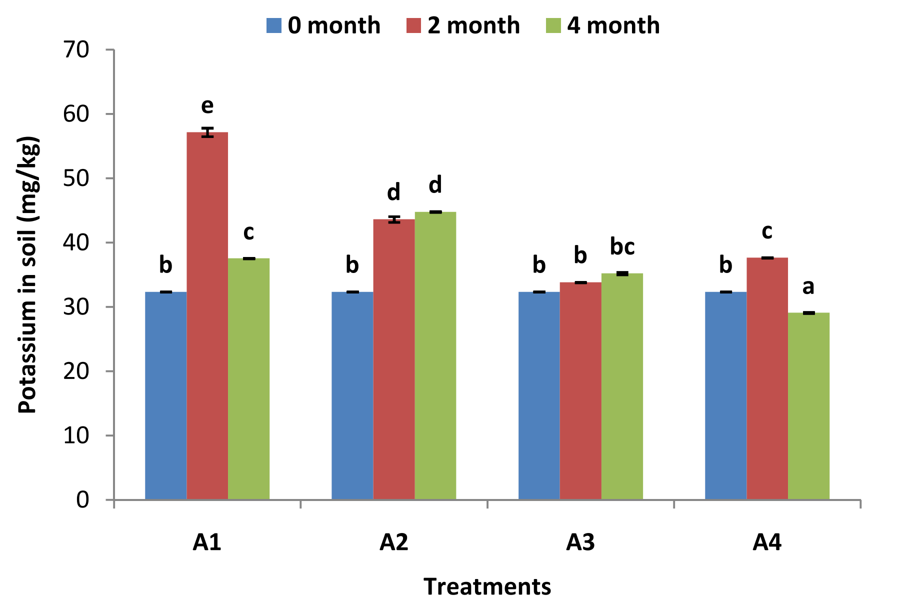

Fig. 9: Effects of treatments on Potassium in soil

Result presented in Figure 10 shows increase in phosphorus in all the treatment at 2 months. Highest increase was observed in polluted soil alone while 1000 g cassava peel amended phytoremediated soil had the least. There was significant difference between amended phytoremediated soil (A2, A3) and other treatments (A1 and A4) at 2 and 4 months.

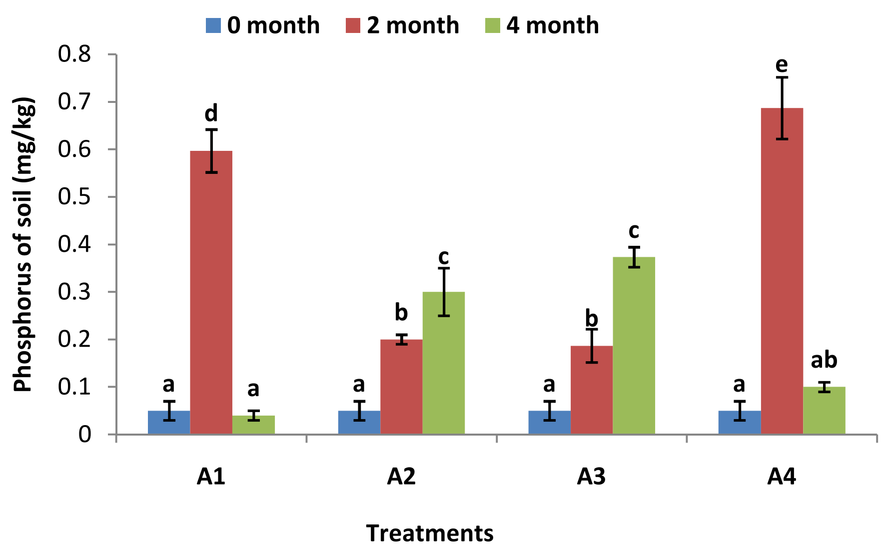

Fig. 10: Effects of treatments on Phosphorus of soil

DISCUSSION

The reduction in hydrocarbon content of soil observed in phytoremediated soil (A1) compared to polluted soil alone (A4) may be attributed to the tolerance (resistance) of *C.odorata* to crude oil pollution and its toxicity (Kirk *et al.,* 2002; Harrison, 2011*).* Similarly, Etsuko *et al*.(2007) observed a more significant decrease in the TPH concentration in the planted diesel-contaminated soil than in the unplanted soil. This result is also supported by the report of Raymond and Harrison (2018) that *C.odorata* and other plantsdemonstrated the ability to grow in soil with high levels of total hydrocarbon in soil and could potentially phytoremediate a hydrocarbon-contaminated soil which shows they are tolerant to hydrocarbon in soil.The growth of*C.odorata*on the contaminated soil affected the physico- chemical properties of the soil thus enhancing the degradation of petroleum hydrocarbon (Njoku *et al*., 2009; Boniface, 2011).It could also be tied to the interaction of the plant and microorganisms at the rhizophereof plant which led to utilization of the hydrocarbon by the microbes for growth and development. It has been reported that plants influence degradation of hydrocarbon by altering the physical and chemical conditions of soil (Cunningham *et al*., 1996; Akpor *et al*., 2014) by releasing organic and inorganic substances usually referred to as exudates. These exudates act as substrates for microorganisms'metabolic activities leading to degradation of hydrocarbon (Jha*et al*. 2015).

Microorganisms use chemical contaminants as an energy source during metabolic processes, rendering the contaminants harmless or less toxic products.

The higher reduction in hydrocarbon (TPH and THC) observed in phytoremediated soil amended with cassava peel is an indication that cassava peel can enhance biodegradation of petroleum hydrocarbon in hydrocarbon contaminated soil (Akpe *et al*., 2015). Inputs of nutrient in the soil from the cassava peel may have led to improve soil properties, increase in microbial and plant growth, interaction and activities thus enhancing higher reduction in hydrocarbon. The high reduction of hydrocarbon in cassava peel amended soil is in line with previous reports (Tanee and Kinako, 2008; Obasi *et al*., 2013; Onuoha, 2013; Ahamefule and Oyemisi, 2015). Increase in soil pH observed in phytoremediated soil (A1) may be attributed to the growth of *Chromolaena odorata* on the soil. This is in line with the findings of Njoku *et al*. (2009) who reported increase pH of soil grown with *Glycine max*. Increase in pH provided favourable conditions for the growth of soil microorganisms which play important role in the breakdown of crude oil and reduction of hydrocarbon content of soil as observed in this study. Higher increase in soil pH observed in amended phytoremediated soil may due to improvement of soil properties through the application of cassava peel (organic material) in the contaminated soil. This is in agreement with Akpe *et al*. (2015) who reported increase in pH of cassava peel amended soil.Soil conductivity increased in amended phytoremediated soils. This may have resulted from the supply of nutrients in soil from the cassava peel. Atiyeh *et al*. (2012) also reported increase in conductivity of contaminated soil treated with organic amendments. However, the decrease in conductivity recorded in phytoremediated soil without amendment (A1) could be link to the concentration of the pollutant. Increase in nitrogen in amended phytoremediated soil observed at the end of the study could be tied to increase in soil nutrient that resulted from the addition of cassava peel in the contaminated soil which enhanced plant growth creating an aerobic (favourable) condition for microorganism to fix atmospheric nitrogen in soil. Addition of manure to contaminated soil improves soil fertility and boost degradation of petroleum hydrocarbons. Similar results have been reported by Dadrasnia *et al*. (2015), Amajuoyi and Wemedo (2015) and Latifa *et al*. (2018).

Increase in total organic matter (TOM) and total organic carbon (TOC) in amended phytoremediated soil could be attributed to carbon input from cassava peel addition in the soil which repaired previously altered soil properties.This observation is supported by the report of Eneje and Nwosu (2012) that organic materials from cassava peels and cow dung affected effective cation exchange capacity, electrical conductivity of soil. It has been reported that organic matter and organic carbon from wastes can enhance the ability of microorganisms to break-down (degrade) pollutants (Mbah *et al*., 2006: 2009) thus, increase in TOM and TOC could also be attributed to microbial mineralization of pollutant (Onuh *et al*., 2008a & b, Das and Chandran, 2011). Increase in potassium in phytoremediated soil could be to the addition cassava peel (organic amendment which improved soil chemical properties. This agrees with the reports of Giwa and Ojeniyi (2004) and Olatunji and Oboh (2012) that manure increased soil organic matter, Nitrogen, Phosphorus, exchangeable potassium, Calcium and Magnesium.

Higher increase in Potassium of soil observed in amended phytoremediated soil may be due to inputs from the incorporation of cassava peel in the soil. This resultconcurswith Iren *et al*. (2015), who reported increase in potassium contentof treated with cassava peel and other organic material singly or in combination.

Increase in phosphorus observed in all the treatments at 2 month may be linked to input of phosphorus from the crude oil spilled on the soil. Similar result have been reported by Agbogidi *et al*. (2007) and Moses and Uwah (2015) in their researches.

Conclusion

Phytodegradation of petroleum hydrocarbon is animportant and promising aspect in phytoremediationwhich is described as the use of plant to degrade (reduce) contaminant from contaminated media through plant root – microbial association. This is supported by the result of this study which showed significant reduction in hydrocarbon content of contaminated soil phytoremediatedusing*Chromolaenaodorata* as compared to polluted soil alone. However, the application of cassava peel in contaminated soil improved the rate of hydrocarbon degradation. Thus, cassava peel can be used as a biostimulating agent in polluted sites to speed -up phytoremediation rate.

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