International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-7, Issue-2, February2021
ISSN: 2395-3470
www.ijseas.com

Influence of Grasses Amended With Organic Manure on Soil Physico-Chemical Properties in Crude Oil Polluted Soil In Niger Delta Of Nigeria

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ABSTRCT

In a field study carried out at Rivers State University teaching and Research farm, PortHarcourt to evaluate the effect of of phytoremadiation grasses on soil physic-chemical properties in crude oil contaminated soil: the soil was polluted with fresh Bonny light crude oil at 0 and 2% v/w, remediated with vetiveria (Vetiveria zizanioides) and Guinea grass (Panicum maximum) amended with organic manures (poultry and rabbit) for a period of twelve months in two season (wet and dry season). Two weeks after pollution, poultry and rabbit manures were applied at 0, 10, 20 and 30 tons per hectare respectively. Two weeks later, vetiver and guinea grasses were planted at a spacing of 20×30cm and 30×30cm respectively. A total of 24 treatment combinations were laid in a factorial fitted into a split plot randomized complete block design. Result of the study showed that the treatments exhibited varied effects on the physic-chemical properties of the soil. Result after analysis of soil samples showed that contamination of the soil with crude oil significantly ($P<0.01$) increased the soil pH, electrical conductivity, percentage total organic carbon, total nitrogen and the C:N ratio of the soil and a decrease in available phosphorus and exchangeable cations in the two grasses in both dry and rainy season periods. Amendment of the soil with organic manures (poultry and rabbit) significantly ($P<0.01$) increased soil available phosphorus, total organic carbon, exchangeable cations and the C:N ratio and a decrease in electrical conductivity and soil pH in the plots remediated with the two grasses. The increase was more in vetiver with poultry manure than guinea grass with rabbit manure. Treatment of the soil affected the soil textural class from loamy sand in control to sandy loam in contaminated plots. Available phosphorus was slightly higher in vetiver remediated plots amended with poultry manure than guinea grass plots amended with rabbit manure. Total nitrogen was significantly higher in dry season on plots remediated with vetiver and guinea grasses than in rainy season. As the level of organic manure increases, C:N ratio also increases. The increase was more in rabbit than poultry manure. The study showed higher conductivity for both vetiver and guinea grasses remediated plots in dry season over those of rainy season.

KEY WORD: Vetiver, Guinea grass, Crude oil; Pollution; Remediation; Poultry; Rabbit; Manure;
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INTRODUCTION

A major problem facing oil producing areas especially Niger Delta Area of Nigeria is environmental degradation associated with oil exploration and exploitation. Crude oil production operation results in accidental spills on soil with petroleum hydrocarbon (Vasudevan and Rajaran, 2001).

Environmental impacts of oil spills are numerous, the organic contaminants that make up petroleum hydrocarbon are harmful when introduced to the environment (Zabbey et al., 2017).

Niger Delta of Nigeria has one of the world wetlands covering over 20,000km^2 in the south Eastern Nigeria (World Bank, 1995). PortHarcourt in Rivers State of Nigeria is situated at the heart of Niger Delta where intense petroleum activities are taking place and is regarded as one of the richest part of Nigeria in terms of natural resources which include large oil and gas deposits, extensive forest, good agricultural resources (Horsfall and Spiff, 2001). Despite these numerous natural resources, the region is threatened by diverse environmental problems of which oil pollution is most paramount.

Presence of crude oil in the soil adversely affects the physical, chemical and micro-biological properties which in turn inhibit growth of cultivated plants on soil (Kayode et al., 2009). A concentration that is beyond 3% has been reported to be progressively harmful to functional ability of the soil and plant growth (Ekundayo et al., 1989, Chukwu and Udoh, 2014).

Ekundayo and Obuekwu, (2000) observed in their study on an oil spill site of typic udipsamment of Niger Delta Basin of Nigeria an increase in total organic carbon, a decrease in total nitrogen, exchangeable cations, available phosphorus in impacted soil; a reduction in the concentration of nitrate nitrogen (Osuji and Nwoye, 2007) a reduction in the fertility status of the soils and unavailability of essential nutrients needed by plants (Abii and Nwosu, 2009).

Contaminants of crude oil contaminated soil are remediated using different approaches, all aimed at reducing or complete removal of the contaminants to enhance restoring contaminated environment to its near original status.

Several remediation techniques both Ex-situ and In-situ have been adopted to clean polluted sites. Among these are burying and excavation, dispersants, organic and inorganic manures, bioremediation and phytoremediation techniques (Chukwumati and Omovbudo, 2020., Akamigbo and Jidere, 2004., Pivetz, 2001., Romantschuk et al., 2000 and Bartha,1986). This research will focus on phytoremediation.

Phytoremediation uses plants to clean up pollutants in the environment. It depollutes the contaminated soil, water and air with plants able to degrade, contain, eliminate metals, pesticides, solvents, explosives, crude oil and its derivatives from the medium that is contaminated (Pivetz, 2001). It is environmentally friendly, simple, cost effective, non environmentally destructive and its by-products can find a range of other uses (Truong, 2003).

Vetiver (Vetiveria zizanioides) and Guinea grass (Panicum maximum) amended with organic manures were used in the study as phytoremediation materials. These grasses have been applied in different crude oil, mine tailings, land fill and waste water (Chukwumati and Omovbude, 2020., Hanping and Honghua, 2003) for remediation purposes. It can survive under extreme temperature due to its C4 nature (NRC,1993) and has high tolerance and adaptability to extreme edaphic conditions such as soil with high acidity, alkalinity and wide range of pH (Truong 2004, Fakayode and Onianwa, 2004). The use of these grasses amended with organic manures will restore the physico-chemical and biological properties of the soil.

The study is aimed at using vetiver and guinea grasses amended with organic manures to restore the physico-chemical properties of the soil back to its original status.

MATERIALS AND METHODS

The study was carried out at Rivers State University, Nkpolu, PortHarcourt teaching and research farm. The site is situated at latitude $4^0\ 5^1$ N and longitude $7^0\ 0^1$ E with an elevation of 18m above sea level (FAO, 1984). Mean annual rainfall ranges from 3000 to 4000mm (FAO, 1984). Annual temperature varies between 22 to 31^0C (FDRD, 1981), while the relative humidity (RH) is between 35 to 90% depending on the particular period of the year.

SOIL OF THE STUDY SITE

The soil was from coastal plain sands geomorphic region. It is typically sandy loam (typic paleudult) formed over sedimentary rocks and belongs to the ultisol order of the United State Soil Taxonomy (Soil Survey Staff, 1975).

SOURCES OF CRUDE OIL

Nigerian Bonny light crude oil (fresh) obtained from shell Petroleum Company Nigeria limited, Bayelsa State flow station was used and a concentration of 0 and 2% was used in the studied area. Each of the experimental plots (3 × 4m) with exception of the control plot was treated with crude oil from a watering can; evenly sprayed and worked into the soil with garden fork.

AMENDMENT MATERIALS

Poultry and rabbit manures were used as amendment materials. The organic manures (poultry and rabbit) were applied unto the soils with the exception of control plots two weeks after contaminating the soil with crude oil. The organic manures were broadcast and worked into the soils at the rate of 0, 10, 20 and 30 tonnes per hectare, respectively.

PREPARATION AND PLANTING OF PLANT MATERIALS

The site of the study has been under continuous cultivation with different crops, the last being cassava and maize.

EXPERIMENTAL DESIGN

TABLE 1: TREATMENT COMBINATIONS ARE AS FOLLOWS:

TREATMENTS	CODE	KEY
C0P0	T1	Control, planted with vetiver grass, no organic manures, no crude oil
C0P2	T2	No crude oil, 20 tons/hectare poultry manure, vetiver planted
C0R0	T3	No crude oil, no rabbit manure, veyiver planted
COR2	T4	No crude oil, 20 tons per hectare rabbit manure, vetiver planted
C1P0	T5	Contaminated with crude oil, no poultry manure, vetiver planted
C1P1	T6	Contaminated with crude oil, amended with 10tons/ha poultry, vetiver planted
C1P2	T7	Contaminated with crude oil, amended with 20tons/ha poultry, vetiver planted
C1P3	T8	Contaminated with crude oil, amended with 30tons/ha poultry, vetiver planted
C1R0	T9	Contaminated with crude oil, no rabbit manure, vetiver planted
C1R1	T10	Contaminated with crude oil, amended with 10tons/ha rabbit, vetiver planted
C1R2	T11	Contaminated with crude oil, amended with 20tons/ha rabbit, vetiver planted
C1R3	T12	Contaminated with crude oil, amended with 30tons/ha rabbit, vetiver planted
C0P0	T13	No crude oil, no poultry manure, guinea grass planted
C0P2	T14	No crude oil, amended with 20tons/ha poultry, guinea grass planted
C0R0	T15	No crude oil, no rabbit manure, planted with guinea grass
C0R2	T16	No crude oil, amended with 20tons/ha rabbit manure, guinea grass planted
C1P0	T17	Contaminated with crude oil, no poultry manure, guinea grass planted
C1P1	T18	Contaminated with crude oil,amended with 10tons/ha poultry, guinea grass planted
C1P2	T19	Crude oil contaminated, amended with 20tons/ha poultry, guinea grass planted
C1P3	T20	Crude oil contaminated, amended with 30tons/ha poultry, guinea grass planted
C1R0	T21	Crude oil contaminated, no rabbit manure, guinea grass planted
C1R1	T22	Crude oil contaminated, amended with 10tons/ha rabbit, guinea grass planted
C1R2	T23	Crude oil contaminated, amended with 20tons/ha rabbit, guinea grass planted
C1R3	T24	Crude oil contaminated, amended with 30tons/ha rabbit, guinea grass planted.

The area was ploughed, harrowed with tractor, marked and pegged. Vetiver grass (Vetiveria zizanioides) and guinea grass (Panicum maximum) collected from National Root Research Institute Umudike, Abia State and

Rivers State University Teaching and Research Farm, respectively were planted two weeks after amendment materials were added at a spacing of 20 by 30cm and 30 by 30cm for vetiver and guinea grasses respectively. A total of 24 treatment combinations (Table 1)above were laid out in a factorial fitted into a split plot randomized complete block design with contaminated and uncontaminated as the main plots, other factors served as sub plots. All the treatments were replicated three times making a total of 72 plots.

COLLECTION AND PREPARATION OF SOIL SAMPLE FOR LABORATORY ANALYSIS

Soil samples were randomly collected from a depth of 0-20cm from each of the plots with bucket auger. The soil samples were crushed with hands, composited and left to air-dry at a room temperature in the laboratory. The samples were later pulverized with mortar and pestle, sieved in a 2mm mesh screen and stored in a polythene bag for analysis.

Some soil physic-chemical properties were analyzed using the following methods: Soil pH was determined in 1:2.5 soil/ water ratio using pH meter with glass electrode (Mclean, 1982). Electrical conductivity was determined in 1:2.5 soil water ratio using conductivity bridge (Rhaodes, 1996), particle size distribution of the soil was carried out using Bouyocous hydrometer method as described by Benton, (2001). Total organic carbon (TOC) by wet oxidation method according to Nelson and Somners, (1986), while Available phosphorus was determined using Bray-2 method Jones, (1998). Total nitrogen (TN) was determined by macrokjeldahl digestion and distillation method Bremner, (1996), while carbon :nitrogen (C:N) ratio was obtained by dividing percent organic carbon with total nitrogen. Exchangeable basic cations (Ca^{2+} and Mg^{2+}) were determined by ammonium acetate leaching method.

RESULT AND DISCUSSION

Results of the study showed that the treatments exhibited varied effects on the physico-chemical characteristics of the soil. One of the outstanding physico-chemical properties of soil solution is its reaction. This is probably due to the fact that higher plants and micro-organisms respond highly to their environment.

The pH of the soil as presented in table 2 below revealed an increase from 4.7 in control to 5.4 in contaminated unamended with a mean of 5.05 and 5.07 for both vetiver and guinea grasses respectively in rainy season, while that of dry season from 4.9 to 5.4 with a mean of 5.08 to 5.1 for vetiver and guinea grass respectively. The significant ($P<0.01$) difference in contaminated unamended over control is in line with the work of Uquentan et al.,(2017), Essien and John, (2010) and Asuquo et al., (2005) who inferred that pH of soil increases as the soil is contaminated with crude oil. The mean pH values showed that the soil is slightly acidic in both rainy and dry season with a slight increase in dry than rainy season. This agrees with the finding of Aiyesanmi, (2005) who reported a pH range of 4.56-5.62 and 4.75-5.75 for rainy and dry season respectively

The relatively lower values obtained for rainy season may not be unconnected with possible dilution by rainy water which may have affected the concentration and dynamic of the metals in the soil. This slightly low pH observed may lead to solubility of metals in the soil and percolation of underground water body. There was no significant ($P>0.01$) difference in the pH mean 5.07 and 5.09 between the two grasses. Amendment of the soil with organic manures slightly decreased the pH from contaminated unamended C1P0 (5.4) to contaminated amended with 30 tons per hectare of poultry and rabbit manures C1P3 and C1R3 (5.0 and 5.1) for both grasses.

Table 2: Effect of treatment on physic-chemical properties of crude oil polluted soil remediated with vetiver and guinea grasses in dry season period

TRT	GRASSES	PARAMETER				DRY SEASON							
		TN	Ecμs/g	%TOC	% Clay	% Silt	% Sand	TC	Pmg/kg	pH	C:N Ratio	Ca +Mg	K Cmol/kg
C0P0	Guinea Gr	0.17	0.07	1.28	10.62	10.2	79.18	LS	93	4.9	7.56	2.83	0.31
	Vetiver	0.177	0.07	1.28	10.2	10.57	79.23	LS	93.37	4.9	7.26	2.85	0.32
C0P2	Guinea Gr	0.178	0.06	1.35	11.8	10.97	77.23	SL	93.5	5	6.72	3.18	0.35
	Vetiver	0.217	0.062	1.42	11.47	11.3	77.23	SL	94.83	5	6.54	3.32	0.38
C0R0	Guinea Gr	0.168	0.06	1.25	10.5	10.37	79.13	LS	91.8	4.9	7.43	2.77	0.31
	Vetiver	0.168	0.064	1.23	10.23	10.57	79.2	LS	92.77	4.9	7.47	2.62	0.31
C0R2	Guinea Gr	0.182	0.07	1.38	12.4	11.1	76.5	SL	91.13	5	7.62	2.77	0.36
	Vetiver	0.178	0.064	1.37	12.5	11.3	76.2	SL	91.5	5	7.66	2.75	0.35
C1P0	Guinea Gr	0.277	0.31	3.75	11.8	11.73	76.47	SL	62.43	5.4	13.54	2.07	0.12
	Vetiver	0.293	0.3	3.89	12.5	11.37	76.13	SL	63	5.4	13.75	2.12	0.12
C1P1	Guinea Gr	0.343	0.179	4.28	12.1	11.5	76.4	SL	64.17	5.2	12.24	2.53	0.18
	Vetiver	0.367	0.172	4.38	12.3	11.43	76.27	SL	65.23	5.2	13.24	2.65	0.2
C1P2	Guinea Gr	0.382	0.167	4.47	12.2	11.9	75.9	SL	67.9	5.2	11.7	2.82	0.3
	Vetiver	0.403	0.172	4.62	12.4	11.77	75.83	SL	68.57	5.1	11.95	2.9	0.31
C1P3	Guinea Gr	0.427	0.16	4.63	12.2	12.17	75.63	SL	73.43	5	10.86	3.35	0.34
	Vetiver	0.433	0.158	4.77	12.5	11.93	75.57	SL	74.53	5	10.92	3.45	0.36
C1R0	Guinea Gr	0.277	0.29	3.78	12	11.3	76.7	SL	56.5	5.4	13.68	2.05	0.12
	Vetiver	0.282	0.3	3.85	12.3	11.23	76.47	SL	57.4	5.4	13.67	2.14	0.11
CIR1	Guinea Gr	0.323	0.167	4.1	12.3	11.33	76.37	SL	63.5	5.2	12.68	2.47	0.15
	Vetiver	0.297	0.175	3.93	11.87	11.53	76.6	SL	63.73	5.2	13.31	2.5	0.18
C1R2	Guinea Gr	0.36	0.161	4.28	12.6	11.77	75.63	SL	66.83	5.1	11.9	2.75	0.25
	Vetiver	0.317	0.165	4.02	12.5	11.57	75.93	SL	65.83	5	12.68	2.78	0.27
C1R3	Guinea Gr	0.407	0.16	4.77	12.4	12.03	75.57	SL	72.77	5	11	3.17	0.3
	Vetiver	0.363	0.148	4.22	12.6	11.73	75.67	SL	72.87	4.9	11.61	3.17	0.3
	LSD	0.011	0.075	0.075	0.283	0.320	0.349		0.798	0.101	0.258	0.131	

P value: (<0.001)

Trt =treatment, Guinea gr = Guinea grass, TN = total nitrogen

TABLE 3: EFFECT OF TREATMENTS ON PHYSICO-CHEMICAL PROPERTIES OF CRUDE OIL POLLUTED SOIL REMEDIATED WITH VETIVER AND GUINEA GRASSES IN RAINY SEASON PERIOD

		RAINY				PARA METERS						
TRT	GRASSES	TN	Ecμs/g	%TOC	% Clay	% Silt	% Sand	TC	P mg/kg	pH	C:N Ratio	Ca/Mg	K Cmol/
C0P0	Guinea gr	0.152	0.062	1.23	10.57	9.8	79.63	LS	91.2	4.7	8.09	2.71	0.27
	Vetiver	0.15	0.062	1.24	10.93	9.9	79.5	LS	91.87	4.8	8.32	2.76	0.28
C0P2	Guinea gr	0.183	0.057	1.42	11.73	10.4	77.53	SL	92.13	5.1	7.73	2.73	0.31
	Vetiver	0.187	0.057	1.37	11.67	10.73	77.6	SL	93.13	5	7.33	3.17	0.33
C0R0	Guinea gr	0.153	0.06	1.25	10.73	9.67	79.6	LS	91.33	4.8	8.15	2.73	0.27
	Vetiver	0.143	0.059	1.21	10.9	9.7	79.47	LS	91.63	4.7	8.48	2.67	0.27
C0R2	Guinea gr	0.173	0.057	1.37	11.7	10.43	77.87	SL	90.27	5	7.89	2.67	0.33
	Vetiver	0.187	0.066	1.4	11.77	10.73	78.5	SL	91.43	5.1	7.48	3.07	0.35
C1P0	Guinea gr	0.25	0.247	3.85	11.6	11.47	76.93	SL	55.57	5.4	15.4	2.03	0.09
	Vetiver	0.25	0.211	3.73	11.4	11.67	76.93	SL	56.27	5.4	14.92	2.03	0.1
C1P1	Guinea gr	0.337	0.178	4.23	11.73	11.2	77.02	SL	61.33	5.2	12.58	2.43	0.16
	Vetiver	0.35	0.172	4.22	12.23	11.77	75.93	SL	62.03	5.1	12.05	2.52	0.16
C1P2	Guinea gr	0.353	0.162	4.35	12.5	11.57	76.27	SL	64.67	5.1	12.2	2.67	0.24
	Vetiver	0.37	0.153	4.42	12.47	11.67	75.87	SL	65.67	5.1	11.94	2.74	0.26
C1P3	Guinea gr	0.403	0.147	4.52	12.43	11.8	75.77	SL	70.6	5	11.2	3.07	0.3
	Vetiver	0.403	0.133	4.62	12.53	11.73	75.73	SL	71.93	4.9	11.45	3.13	0.3
C1R0	Guinea gr	0.243	0.283	3.78	11.7	11.57	76.73	SL	54.53	5.4	15.55	1.97	0.1
	Vetiver	0.257	0.208	3.72	11.77	11.63	76.63	SL	54.17	5.4	17.82	2.05	0.1
C1R1	Guinea gr	0.313	0.264	4.07	11.67	10.83	77.5	SL	59.97	5.2	12.98	2.35	0.15
	Vetiver	0.343	0.167	3.92	12.1	11.27	76.47	SL	62.93	5.2	11.41	2.35	0.16
C1R2	Guinea gr	0.337	0.163	4.23	12.47	11.37	76.5	SL	64.12	5.1	12.58	2.62	0.2
	Vetiver	0.347	0.155	3.93	12.67	11.53	75.53	SL	64.57	5	11.35	2.52	0.21
C1R3	Guinea gr	0.353	0.152	4.27	12.67	11.6	75.73	SL	68.67	5	12.08	2.9	0.24
	Vetiver	0.353	0.148	4.07	12.67	11.53	75.73	SL	65.67	4.9	11.51	2.72	0.26
LSD		0.011	0.012	0.074	0.298	0.341	0.429		1.259	0.091	2.108	0.098	

P Value (<0.001)

Significant (P<0.01) difference was observed in the electrical conductivity of the soil between contaminated unamended and control plots. This implies that addition of crude oil affected the ionic stability of the soil. This tally with the work of Asuquo et al., (2005) who reported an increase in electrical conductivity in crude oil contaminated soil. The study showed higher conductivity for both guinea grass and vetiver in dry season C1P0 (0.310 and 0.300) respectively over rainy season C1P0 (0.247 and 211µs/cm). Augmentation of the soil with organic manures significantly (P<0.01) decreased the electrical conductivity from C1P0 (0.310 and 0.300µs) to C1P3 (0.166 and 0.158µs) for guinea grass and vetiver plots respectively in dry season.

The textural class for control plots was loamy sand while that of contaminated unamended plots were sandy loam. Amendment of the soil with organic manures did not show any significant (P>0.01) difference in textural classification in contaminated and uncontaminated soil, though there was a variation in their percentage composition. The reason for no significant difference in textural composition could possibly be due to short period of time the study was conducted (twelve months) which is quite too small to make any significant difference. The dominant textural composition is sandy loam.

Results of the study as shown in tables 1 and 2 revealed that available phosphorus decreased from 94.83 to 57.4mg/kg and 93.5 to 56.5mg/kg in vetiver and guinea grass plots in dry season and 93.13 to 55.17mg/kg and 92.13 55.57mg/kg in vetiver and guinea grass plots respectively in rainy season. Available phosphorus obtained in both dry and rainy season samples in contaminated unamended plots were significantly (P<0.01) lower than the control plots. The observed decrease in available phosphorus agrees with the report of Ihem et al., (2015) who inferred that crude oil pollution encourages nutrient element imbalance and phosphorus fixation among other elements. Similar findings was reported by Uquetan et al., (2017) who related the decrease to the conversion of H_2P0_4 to $HP04^{2-}$ possibly due to adjustment of soil pH in polluted soils.

There was no significant (P>0.01) difference between the two grasses, however, available phosphorus was slightly higher in vetiver than guinea grass plots. A significant (P<0.01) increase was recorded between contaminated unamended C1P0 (63.0 and 62.43mg/kg) and contaminated augmented with (poultry and rabbit) manures C1P3 (74.53, 73.43mg/kg) and C1R3 (72.87, 72.77mg/kg) in vetiver and guinea grasses respectively in dry season. Similar trend was also observed in vetiver and guinea grasses plots in rainy season (Table 2). The significant increase can be attributed to the degradation action of micro-organisms on the oil polluted soils and organic manures. However the concentration of available phosphorus was slightly higher in poultry manure than in rabbit manures and in dry season than rainy season.

Organic carbon is a measure of the remains of plants, animal and micro-organisms in all stages of decomposition. The result as presented in tables 1 and 2 showed that total organic carbon (TOC) of the soils were significantly (P<0.01) higher in contaminated unamended C1P0 (3.73, 3.85)% soil than the control C0P0 (1.24, 1.23)% in vetiver and guinea grasses plots for rainy season while in dry season, C1P0 (3.89, 3.75)% as against control of (1.28,1.28)%. The significant increase of TOC in contaminated unamended over control agrees with the report of Uquetan et al., (2017), Agbogidi et al., (2007), Ekundayo and Obuekwe, (1997) who observed an increase in total organic content of polluted soil over control. The observed low total organic carbon in control plots could be attributed to high mineralization process in the organic content of the soil (Ihem et al., 2015).

Amendment of the soil with organic manures significantly (P<0.01) increased the TOC of the soil in both vetiver and guinea grasses remediated plots. This is in line with the assertions of Odu, (1972) who attributed it to degradation of crude oil in polluted soil and any organic substrate during remediation process. Similar finding was reported by Chukwumati, et al., (2019), Adeli, et al., (2009), Adedoku and Atika, (2007). A significant (P<0.01) was observed in poultry remediated plots over that of rabbit in both vetiver and guinea

grass plots. This could be due to the superiority of poultry manure over other manures as reported by Yayock and Awoniyi, (1974) and Pratt et al., (1973) due to its composition and mineralization of its nitrogen decay rate.

The study also revealed that total nitrogen (TN) in contaminated unamended plots were significantly ($P<0.01$) higher than the control plots in both dry and rainy season periods, thus confirming the report of Asuquo et al., (2005)., Ayolagha et al., (2006) and Coulon et al., (2005). The increase in TN could be attributed to mineralization activities of micro-organisms during decomposition of crude oil. This corroborates with the findings of Odu, (1972) and Amadi et al, (1993) who stated that mineralzaton of nitrogen increase total nitrogen content of the soil.

There was significant ($P<0.01$) difference in total nitrogen between vetiver remediated plots and that of guinea grass and between the dry season and rainy season. The lower TN content in rainy season could be as a result of the high leaching nature of nitrogen occasioned by enhanced rains during rainy season. This could also be attributed to rate of decomposition and mineralization by micro-organisms in dry season than rainy season.

Amendment of the soil with organic manures (poultry and rabbit) significantly ($P<0.01$) increased the TN content of the soil over that of unamended (C1P0, C1R0) plots in both dry and rainy seasons. The increase was more of vetiver and poultry than guinea grass and rabbit manures.

The carbon nitrogen (C/N) ratio of the soil increased from 6.54 to 13.75 in dry season period and 7.33 to 15.40 in rainy season for control and contaminated unamended plots respectively in all the studied soils. A significant ($P<0.01$) difference was observed between the contaminated unamended and control plots in both season.

As the level of amendment material increased, the C:N ratio also increased (tables 1 and 2). This agrees with Amadi et al., (1993) and Odu, (1972) who reported an increase in C:N ratio of crude oil contaminated soil amended with organic manures. The increase could be as a result of the activities of micro-organisms (hydrocarbon oxidizer) which may have destroyed the petroleum molecule by adding oxygen to them, while the oxygenated molecules are consumed leaving behind biomass and carbon dioxide. Increase in C:N ratio were more in rabbit than poultry manures.

The exchangeable cations (Ca and Mg)of the soil under study decreased from 3.35 to 2.07Cmol/kg in dry season period and 3.13 -1.97Cmol/kg in rainy season (tables 1 and 2) respectively. The Ca+Mg of contaminated unamended soil was significantly ($P<0.01$) lower than the control plots in both seasons. The decrease in contaminated unamended over control compares well with Asuquo et al., (2005) who reported a decrease on crude oil contaminated soil over control. The decrease could be due the fact that petroleum contaminated soil makes available toxic elements to plants which easily hinders availability of some exchangeable cations to plants. Similar trends was observed in potassium ions (K^+)

Statistical analysis of the result revealed significant ($P<0.01$) increase between contaminated unamended (C1P0) and contaminated amended soil with different levels of organic manures; implying that remediation of the soil with vetiver and guinea grasses enriched with organic manures increased the exchangeable cations (Ca, Mg and K) of the soil. This corroborates with the work of Amadi et al., (1993, 1992) and Obilonu, (1995) who reported an increase in Ca^{2+}, K^+ and Mg^{2+} contents: three of the main exchangeable cations.

Generally, basic cations in the soil were low. This could be due to the fact that the soil under study has been on intense agricultural cultivation for several years, therefore, the nutrients levels in the soil may have depleted greatly.

CONCLUSION

The study showed that vetiver and guinea grasses as remediation materials amended with organic manures were effective in improving the physico-chemical properties of the soil in crude oil polluted soil; however, vetiver plots amended with poultry manure was more effective than guinea grass amended with poultry or rabbit manure. There was an increase in in available phosphorus, total organic carbon exchangeable cations and total nitrogen and a reduction in C:N ratio, electrical conductivity in both dry and rainy season .

Total nitrogen was higher in dry season augmented soil than rainy season. As the level of organic carbon increases, C:N ratio also increases. The study also revealed higher conductivity for both vetiver and guinea grasses plots. Generally result of the study revealed an improvement in the physic-chemical characteristics of the soil, an indication of improved nutrient status of the soil.

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