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Assessment of Chemical Properties of Soil under the Influence of Spent Motor Oil Remediated with Vetiver Grass (*Vetiveria zizanoides*) in South – South, Nigeria.

Chukwumati, J.A; Anozie, H.I

Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, PMB 5323, Port Harcourt, Nigeria.

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****Corresponding Author***
Chukwumati, J.A
E-mail: *johnprint2005@yahoo.com*
Phone: *+23408063573269*

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ABSTRACT

The study investigated the physicochemical properties of soil under the influence of spent engine oil (SEO) on cultivated vetiver. Soil samples were sampled in mechanic workshops located in 2 communities: Elikohia and Choba both in Rivers States of Nigeria. Composite samples of spent oil contaminated soils were collected randomly at a depth 0-15, 15-30, 30-45cm from the two sites respectively and uncontaminated samples (control) at 100 meters away from the two sites with spade. Ten (10kg) each of harmonized composite soil samples of contaminated and no vetiver (ctm no vet), contaminated and remediated with vetiver (ctm + vet) and control samples were placed into 10 litre perforated plastic buckets. Two splits of vetiver plant were transplanted per plastic bucket. At the end of three months, soil samples were collected and analysed for physicochemical properties. Results of the study revealed that contamination of the soil with spent engine oil significantly (P<0.05) increased the soil total organic carbon, total nitrogen and the electrical conductivity of the soil compared to control in all the soil depths investigated, while a decrease in concentration were observed in available phosphorus and exchangeable cations (Ca, Mg and K) in contaminated over control samples. There was consistent decrease in concentration of total organic carbon, cation exchangeable bases available phosphorus and total nitrogen along the soil profile depth. Cultivation of vetiver plant (*Vetiveria zizanioides*) significantly increased the concentration total nitrogen, available phosphorus, total organic carbon and exchangeable cations and a reduction in electrical conductivity of the soil in both sites (Choba and Elikohia) and along the soil depths. There was no significant (P>0.05) difference between the contaminated and control samples in both sites, however soil contaminated with SEO were slightly higher in Elikohia than those of Choba. The soil pH decreases with depth of soil profile. The study therefore showed that cultivation of vetiver plant in spent engine oil contaminated soil improves the fertility status of the soil.

INTRODUCTION

Soil ecosystem is an essential component of life and man depends on it for food and natural resources while plants depend on it for their growth. It is also a medium for the biochemical cycling of soil nutrients (Adewole and Uchegbu 2010). Soil is a vital natural resource and must be well managed for sustainable agricultural production (Benton, 2003). Managing soil resources for food security and sustainable environment is quite apt and deserves great attention; considering the increasing pressure on our soils due largely to population increase and intensive agricultural production (Ogeh and Ukodo, 2012).

Pollution of the soil ecosystem is a major source of soil degradation (Mbagwu, 2008). Study by Kayode et al., (2009) opined that soil pollution with crude oil and spent lubricating oil destroys soil structure, increased bulk density, soil porosity reduction in soil capillary, aeration and nutrients availability and uptake by plants.

Spent engine oil (SEO) is waste lubricating oil collected from automobile workshops, garages and industrial sources like hydraulics oil, turbine oil, process oil and metal working fluids (Olugboji et al., 2008). Spent engine oils are mixtures of different chemicals including petroleum hydrocarbons, chlorinated biphenyls, chlorodibenzofuran, lubricant additives, decomposition products and heavy metal that are from engine parts as they wear away (Wang et al., 2000).

Different petroleum products are common soil contaminants and often contained hazardous chemicals especially the polycyclic aromatic hydrocarbon (Sharifi et al., 2007). There are relatively large amounts of hydrocarbons in used oil including the highly toxic polycyclic aromatic hydrocarbons (Okonokhua et al., 2007)

In Nigeria, increased automobile repairs activities have contributed markedly to the problems of soil contamination (Mba et al., 2009). The automobile activities usually involve changing of lubricating oil, servicing and greasing of motor parts and replacement of worn-out parts (Ajayi, 2005). This result in the disposal of spent lubricating oil and other wastes used in cleansing during auto-mobile servicing on the soil. Contamination of soil with toxic substances can degrade its capacity to provide habitat for soil organism and to grow plants that are safe to eat (Brady and Weil, 1999).

Port Harcourt is a city in South-South a major oil producing area of Southern Nigeria. In the area, automobile mechanics abound and spread SEO on agricultural land rendering the land uncultivable. With the teeming population of Nigeria, it has become essential to investigate the effect of SEO on agricultural land. This study aims to evaluate the effects of SEO on properties of soil grown with vetiver.

MATERIALS AND METHODS

The experiment was conducted at the University of Port Harcourt Teaching and Research farm, department of crop and soil science. The area is situated between latitude 4^0 54' and longitude 6^0 55' East of the equator on an elevation of 20 meters above sea level. Annual rainfall distribution ranges from 3000 to 4000mm (FAO, 1984). Annual temperature varies from 22 to 31^0C (FDRD, 1981). The relative humidity (RH) varies between 35 to 90% depending on the particular period of the year.

Location for Soil Sample Collection

Soil samples used for the study were collected from Elikohia mechanic workshop (site 1) and Choba mechanic workshop (site 2). Composite samples of spent oil contaminated soils were collected randomly from the two sites at a depth of 0-15, 15-30 and 0-45cm respectively and uncontaminated samples (control) at 100 meters away from the two sites with shovel.

Soil Sample Preparation and Planting of Vetiver Grass

The experiment was carried out using perforated plastic pots. Ten (10kg) each of harmonized composite soil samples of depths 0-15, 15-30 and 30-45cm of contaminated and no vetiver (ctm no vet), contaminated and remediated with vetiver (ctm + vet) and control samples were placed into 10 litre perforated plastic buckets. The experiment was replicated thrice giving a total of 54 pots.

The pots were watered thrice weekly with 200mls of water through a watering can. Two weeks later, vetiver grass (*Vetiveria zizanioides*) rhizomes obtained from National Root Research Institute, Umudike, Abia State, Nigeria were transplanted, 2 seedlings per pot. Emerging weeds were removed by hand pulling. The experiment was a '3×2 ×3' factorial fitted into a completely randomized design (CRD) consisting of three depths, three treatments, two sites replicated thrice making a total of 54 pots. The experiment was left for a period of twelve weeks.

Soil Sampling and Data Collection

Composite soil samples uncontaminated (control), contaminated and no vetiver and contaminated and remediated with vetiver were collected from each of the pots, labelled and air dried at room temperature in the laboratory. The samples were pulverized with mortar and pestle, sieved in a 2mm mesh screen and sent to the laboratory for the determination of the selected parameters. Samples were collected before and after the experiment.

Laboratory Analysis

P^H 1:1 soil water ratio using pH meter with glass electrode (McLean, 1982). Electrical Conductivity (EC) – 1:2.5 soil water ratio using Conductivity Bridge (Rhodes 1996). Organic Carbon (OC) – Dichromate wet oxidation method Nelson and Nelson, (1986). Total Nitrogen (TN) by micro Khejahl digestion and distillation method (Brenner, 1996). Available Phosphorus – Bray P1 method (Bray and Kurtz, 2003).

Statistical Analysis

The data were analysed using the analysis of variance (ANOVA) technique and the Duncan's multiple range test was used to compare the means (Alika, 1997)

RESULTS AND DISCUSSIONS

Results of the study as presented in table 1 above showed that the contaminated soils were darker than the control.

Dark soils absorb more heat than light ones. Donahue et al., (1990) reported that some black coal mining wastes and dark coloured oil-shale residues reached temperatures of 65 ^oC – 70 ^oC, which are lethal to many plants that would otherwise grow in those soils. Soils polluted with waste-oil result in the soil remaining unsuitable for crop growth and depending on the degree of contamination, type of soil and soil environment, the soil may remain unsuitable for crop growth for months or years until the oil is degraded to tolerable levels (Atuanya, 1987).

Table 1: Physico-chemical properties of soil contaminated with spent engine oil, remediated with Vetiver Grass (Vetiveria zizanioides).

Depth	Treatment	Sites	% Total Nitrogen	P mg/kg	% TOC	pH	Ca Cmol/kg	Mg Cmol/kg	K Cmol/kg	EC µs/g
0-15	Control	Choba	0.118	43.43	1.18	6.2	1.48	1.25	0.433	2.25
		Elikohia	0.117	45.3	1.23	6.2	1.62	1.39	0.527	2.4
	Ctm + vet	Choba	0.137	24.17	1.93	6.4	1.15	0.883	0.303	4.18
		Elikohia	0.127	22.57	1.97	6.3	1.217	1.05	0.323	4.77
	Ctm no vet	Choba	0.16	15.23	3.62	6.0	0.712	0.54	0.113	13.67
		Elikohia	0.16	11.6	3.78	6.0	0.807	0.64	0.095	15.7
15-30	Control	Choba	0.065	39.83	1.027	6.2	1.417	1.083	0.41	2.093
		Elikohia	0.06	40.08	1.05	6.2	1.513	1.227	0.417	2.133
	Ctm + vet	Choba	0.081	22.9	1.807	6.35	0.933	0.75	0.237	4.067
		Elikohia	0.093	19.83	1.817	6.3	0.983	0.917	0.253	4.267
	Ctm no vet	Choba	0.097	9.43	2.367	6.0	0.59	0.417	0.055	11.267
		Elikohia	0.10	9.87	2.733	5.9	0.663	0.583	0.062	12.2
30-45	Control	Choba	0.034	37.6	0.867	6.1	1.233	0.833	0.353	2.083
		Elikohia	0.030	36	0.95	6.0	1.34	1.15	0.31	2.208
	Ctm + vet	Choba	0.043	19.13	1.55	6.3	0.783	0.633	0.21	3.933
		Elikohia	0.048	18.13	1.617	6.2	0.81	0.727	0.187	3.683
	Ctm no vet	Choba	0.082	8.57	1.667	6.28	0.483	0.323	0.035	9.467
		Elikohia	0.085	13.77	1.933	6.3	0.527	0.467	0.038	10.267
LSD P>0.1			0.009	3.658	0.071	0.41	0.724	0.119	0.038	0.329

Ctm = contaminated, Vet = Vetiver grass, Trt = Treatment, TOC = Total Organic Carbon, THC = Total Hydrocarbon Content, TN = Total Nitrogen, Electrical Conductivity,

pH

Soil pH is a major factor influencing the availability of elements in the soil for plant uptake (Marschner, 1995). The soil pH as shown in table 1 above ranged from 5.8 to 6.4. There is no significant ($P > 0.05$) different in soil pH in control (6.20) samples between the two sites (Choba and Elikohia). The study revealed that the soil pH increases with depth of the soil profile. There is no significant difference observed in soil pH between control and contaminated samples indicating that spent engine oil has no serious negative impact on soil pH. This agrees with the findings of Okonokhua et al., 2007 who inferred that soil contaminated with spent engine oil had no effect on the pH of the soil. However, the pH of the contaminated samples (ctm no vet) were slightly higher than the control samples. Remediation of the SEO contaminated soil with vetiver (ctm+vet) increased slightly the pH of the soil. Generally, the soils were slightly acidic.

Total Nitrogen

Total nitrogen (TN) in the soil increases from 0.045 % to 0.16 % and 0.048 % to 0.16 % in Choba and Elikohia sites respectively. Significant ($P < 0.05$) difference was observed between the soil contaminated with no vetiver (ctm no vet) and control in both sites (Choba and Elikohia) in all the depths indicating that contamination of the soil with spent motor oil increased the % total nitrogen in the soil. This corroborates with the reports of (Chukwumati and Abam, 2021; Nwite and Alu, 2015) who reported significant higher total nitrogen in spent oil contaminated soil over control. There is no significant ($P > 0.05$) difference between the two sites (Choba and Elikohia) in the study investigated, though % TN was slightly higher in Elikohia than Choba.

Generally, percentage total nitrogen was low both in contaminated and uncontaminated samples respectively. The low levels of nitrogen in the study sites is typical of the highly weathered soils of the humid tropics and may be attributed to high nitrogen losses through leaching resulting from high rainfall (Brady and Weil, 1999). The study also revealed that total nitrogen decreases as you go down the profile.

Phosphorus (P)

Available phosphorus of the spent engine oil contaminated soils with no vetiver (ctm no vet) were significantly ($P < 0.05$) reduced compared to control soils. The values of available phosphorus in the studied areas decrease from 43.43mg/kg to 9.43mg/kg in Choba site and 45.30mg/kg to 9.87mg/kg in Elikohia sites. The observed decrease in available phosphorus in contaminated soils conform to the report of Ihem et al., (2015) who inferred that crude oil pollution encourage nutrients element in balance as well as phosphorus fixation among other elements.

The result also agrees with the finding of Uquetan et al., (2017) who related the decrease to the conversion of $H_2P0_4^-$ (most available form for plant uptake) to HPO_4^{2-} (less available form) as a result of the adjustment in soil pH in the polluted soils. There is no significant difference in available P between the two site locations. The result indicates that spent oil contamination of soils significantly affects negatively availability of phosphorus in the soil as well as its uptake in plants.

Remediation of the contaminated soils with vetiver grass (ctm + vet) significantly ($P < 0.05$) increase the concentration of available phosphorus in the soil possibly due to the ability of vetiver grass to establishing symbiotic association with soil microbes in its rhizosphere. This corroborates with Chukwumati and Abam, (2021) who reported an increase in available phosphorus due to remediation of crude oil contaminated soil with vetiver grass. Khan, (2005) and Sunanthaposuk, (2000), reported that vetiver grass has the potential of establishing a strong symbiotic association with wide range of soil microbes in the rhizosphere that provide nutrients (nitrogen fixing bacteria, phosphate solubilising bacteria and fungi (mycorrhizal fungi) for plant growth.

Percentage Organic Carbon

Percentage carbon (organic and inorganic) represent the extent of hydrocarbon in the soil. The greater the carbon content, the higher the level of organic pollutants present Mansur et al., (2003). The organic carbon (OC) content increases from 0.86 % in control to 3.62 % in contaminated soil with no vetiver in Choba site and 0.95 to 3.78 % at Elikohia for control and contaminated with no vetiver respectively. (Table 1).

A significant ($P < 0.05$) difference was observed in total organic carbon between spent oil contaminated soil with no vetiver (3.62 %) and control (1.18 %) in Choba site. Similar trend was also observed between contaminated no vetiver and control in Elikohia site. This implies that contamination of the soil with spent engine increased the percentage total organic carbon over uncontaminated (control) samples. This finding agrees with the work of Chukwumati, et al., (2019), Chukwu, and Udoh, (2014) who reported higher percentage of organic carbon in crude oil contaminated soil over control.

The increase in total organic carbon in contaminated over control samples could possibly be as a result of the carbon substrate which may have being added into the soil by spent automobile oil/spent engine oil. Ihem et al., (2015) attributed it to high mineralization process in the organic content of the soil. Similar finding was reported by Okonokhua et al., (2007). This was in contrast to the observation of Kayode et al., (2009) who adduced a reduction in nitrogen content in soil treated with spent lubricant oil.

It is worthy to note that the increased values of OC and TN contents of the contaminated soils compared to the control (Table 1) could also be attributed to the application of the SEO to soil. Crude oil, from which the engine oil is produced, contains principal elements such as oxygen, nitrogen and sulphur other than hydrogen and carbon (Selley, 1998). The increase in percentage

total organic carbon and total nitrogen in spent engine oil contamination of soil may also implies that spent lubricant oil play beneficial effect in soil.
Percentage organic carbon was observed to be slightly higher in Elikohia site than Choba, though not significant. The increase in concentration of organic carbon at Elikohia over Choba could possibly be due to heavy volume of vehicle always found at the site for repairs because of its location at the heart of the city thus leading to increase in pollutants.

Significant ($P < 0.05$) differences were also seen in soil depth between the soil surface and sub soil as you go down the profile. The high percentage total organic carbon in the top soil over sub soil could be as a result of high concentration of the remains of plants, animal and micro-organisms at different stages of decomposition in surface soil. The study also revealed that remediation of the soil with vetiver grass significantly increase percentage total organic carbon in all the samples studied.

Electrical Conductivity (EC)

The electrical conductivity (EC) of the studied samples increased from 2.083 µs/g in control to 13.67 µs/g in contaminated soil with no vetiver (cmt no vet) and 2.093 in control to 15.7 µs/g in contaminated with no vetiver (ctm no vet) for Choba and Elikohia sites respectively; implying that contamination of the soil with spent lubricant oil affected the ionic stability of the soil.

This corroborates with the findings of Chukwumati and Abam, (2021) and Asuquo et al., (2005) who reported higher electrical conductivity in crude oil contaminated soil over control. This is in contrast to the result of Osuji and Nwoye, (2007) whose result showed low electrical conductivity.

The electrical conductivity of the soil decreases with depth as you go down the soil profile in both Choba and Elikohia sites. The value of electrical conductivity was significantly higher in Elikohia than Choba. Remediation of the soil with vetiver grass (ctm + vet) significantly reduced the electrical conductivity of the soil from the contaminated (ctm no vet) across all the soil depths investigated.

Exchangeable Cations (Ca, Mg and K).

Exchangeable cations are the cations which can be exchanged by a cation of an added salt solution (Thomas, 1982). The results of this study focuses on exchangeable basic cations (Ca^{2+}, Mg^{2+}, and K^{+}). The concentration of calcium (Ca) ranged from 1.48 to 0.483 Cmol/kg in Choba site and 1.62 to 0.527 Cmol/kg in Elikohia. The content of magnesium increased from 0.323 to 1.25 cmol/kg in Choba and 0.467 to 1.39 cmol/kg in Elikohia while potassium increased from 0.035 to 0.433 cmol/kg and 0.038 to 0.527 cmol/kg for Choba and Elikohia respectively.

Exchangeable bases (Ca, Mg and K) investigated in this study were significantly ($P < 0.05$) higher in control over spent oil contaminated (ctm no vet) soil in both sites and in all the profile depths studied, showing that contamination of soil with spent engine oil decreases the concentration of exchangeable bases (Ca, Mg and K). This agrees with the finding of Chukwumati et al., (2016), Uhegbu et al., (2012) and Kayode et al., (2009) who reported decrease of exchangeable bases in soil treated with spent lubricant oil. The significant reduction in exchangeable basic cations in contaminated over control soil samples could possibly be as a result of immobilization of the nutrients by spent oil (Oyedele and Amoo (2014).

The observed values of exchangeable bases in the study were below the critical levels of Ca, Mg and K (3.8, 1.9 and 0.24 cmol/kg) for soils in Nigeria as established by Agboola and Ayodele (1987) thus implying that the soil is low in fertility.

A significant ($P < 0.05$) difference was observed in the exchangeable basic cations between soil contaminated and remediated with vetiver (ctm + vet) and soil contaminated with no vetiver (ctm no vet) in both sites and within the soil depths indicating that remediation of the soil with vetiver grass significantly increase the exchangeable bases. The reason for the observed increase in exchangeable basic cations in SEO contaminated soil remediated with vetiver over over contaminated unremediated samples could be attributed to the presence of soil micro-organisms in rhizosphere of vetiver plants growing in contaminated soils. This corroborates with the studies of Khan, (2005) and Sunanthaposuk, (2000) who reported that vetiver grass establishes strong symbiotic association with wide range of soil microbes in their rhizospheres which enables it to provide nutrients (nitrogen fixing bacteria, phosphate solubilizing bacteria and fungi, mycorrhizal and cellulolytic fungi phytohormones for plant growth.

CONCLUSION

The results of this study have shown that application of spent engine oil has deleterious effect on chemical properties of soil. All the chemical properties of soil studied indicated severity as the levels of spent engine oil application increased indicating that high disposal of hydrocarbon oil into the soil poses a great danger of soil degradation and low productivity. It was observed that available phosphorus, as well as exchangeable cations were generally depressed due to spent engine oil application.

The study concluded that improper disposal of SEO in the study area adversely affected the soil chemical properties. Therefore, indiscriminate disposal of spent engine oil should be avoided especially in cultivable areas to ensure sustainable soil productivity.

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