www.cenresin.org

EFFECT OF TYPES OF ORGANIC WASTE ON SOIL CONTAMINATED WITH SPENT ENGINE OIL IN UMUAHIA METROPOLIS, ABIA STATE.

Onwuka, M. I. and Igwe A.C.
Department of Soil Science and Meteorology
Michael Okpara University of Agriculture, Umudike, Nigeria
E-mail: ifyonwuka2000@yahoo.com or onwuka.ifeoma@mouau.edu.ng

ABSTRACT

An incubation study was conducted at Michael Okpara University of Agriculture Umudike to evaluate the effect of types of organic waste on soil contaminated with spent engine oil in Umuahia Metropolis. The treatments were poultry manure (PM), goat dung (GD), kitchen residue ash (KRA), maize husk ash (MHA) and a control (C). The wastes were applied at 4t/ha and replicated three times in Completely Randomized Design (CRD). At the end of the incubation, the effects of the treatments were measured on soil pH, exchangeable acidity, organic carbon, available phosphorus and total nitrogen. Other parameters determined were exchangeable calcium, potassium, magnesium, lead, cadmium and chromium. All the data were subjected to the analysis of variance (ANOVA) and the differences between the treatments means separated using the least significant differences at 5% probability level. Linear correlation analyses were done using the GENSTAT package. The result obtained showed that organic wastes significantly ($p < 0.05$) increased soil pH, available phosphorus, total nitrogen, organic carbon, exchangeable calcium, potassium, magnesium and percentage base saturation over the control. The organic wastes also significantly ($p < 0.05$) reduced lead, cadmium chromium and exchangeable acidity. Among the organic wastes tested poultry manure significantly ($p < 0.05$) increased available phosphorus, total nitrogen and percentage base saturation and significantly ($p < 0.05$) reduced lead and chromium. Kitchen residue ash, on the other hand significantly ($p < 0.05$) increased soil pH and exchangeable calcium, while goat dung significantly ($p < 0.05$) increased the soil exchangeable magnesium. The soil pH significantly ($p<0.001$) and negatively correlated with lead, cadmium and chromium while the exchangeable acidity significantly ($p<0.001$) and positively correlated with lead, cadmium and chromium. Further research is recommended for the field application of the treatment.

Key words: Organic waste, spent engine oil, contaminated soil, incubation

INTRODUCTION

Soil is the key component of natural ecosystem because environmental stabilities depends largely on sustainable soil ecosystem (Adedokun and Ataga, 2007; Adenipekun, 2008). When soil is polluted, the ecosystem is altered and agricultural activities are affected. One of soil pollutant is oil and it has been reported that when the concentration of oil is beyond 3% in an environment, it becomes increasable deleterious to soil biota and crop growth (Achuba and Peretiemo-Clarke, 2008).

Spent engine oil, which is also known as used mineral based crankcase oil, is a brown to black liquid produced when new mineral based crankcase oil is subjected to high temperature and high mechanical strain (Achuba and Peretiemo-Clarke, 2008). Spent engine oil is a mixture of different chemicals including low and high molecular weight (C_{15}-C_{20}), aliphatic hydrocarbon, polychlorinated biphenyls, chlorodibenzofurans, lubricate additives and decomposition products. Others include heavy metals such as aluminum, chromium, cadmium, tin, lead, manganese, nickel and silicon that come from engine parts as they wear down (Wang *et al;* 2000). This spent oil is released into the environment by the automobile mechanic, generators, and discharge from exhaust system during use and engine leaks (Osubor and Anoliefo, 2003). This oil is toxic and contaminates the environment. In most places, they are discharged into open farms, vacant plots, water drains, gutters, streams etc.

Oil contaminated soil can be reclaim through soil extraction and land fill. This conventional method of reclaiming the soil has been found to be expensive and it is not what an ordinary farmer in the village can afford. Hence a simple and cheap method which involved the use of low-input technology such as organic waste is a viable alternative. Although organic waste is relatively slow and complex (Kasthuri, *et al.*, 1993) in natural ecosystem biodegradation of petroleum hydrocarbon, it has been widely accepted as environmental friendly as well as economic approach to the remediation of polluted soils (Akamigbo and Jidere 2003). These organic wastes are available, cost effective and naturally convert the hydrocarbons to harmless by- products such as carbon dioxide and water (Adesodun and Mbagwu, 2008). The objective of this study therefore is to determine the effect of some organic waste on spent engine oil contaminated soil.

MATERIALS AND METHOD

An incubation study was carried out at the Soil Science laboratory of Michael Okpara University of Agriculture Umudike (latitude 05° 29` N and on longitude 07° 33` E) for a period of eight weeks.

Soils contaminated with spent engine oil were collected from three different mechanic shops in Umuahia from a depth of 0-15cm with a soil auger. The samples were bulked together to get a composite sample. The soil samples were air dried and pass through 2mm sieve and 100g of the sieved soil were weighed into 450g capacity plastic container each.

The treatments used for the study were four organic wastes applied at 4t/ha. The treatments were poultry manure (PM), Goat dung (GD), kitchen residue ash (KRA), maize husk ash (MHA) and a control (C). The gramme equivalent of 4t/ha was calculated and it was 10.8g. It was this 10.8g of the amendment that was mixed with the 100g of soil in the containers. The organic manures were added into the soil in the containers and the containers were arranged in completely randomized design. At the end of the incubation study, the following soil chemical properties were determined; soil pH was determined in 1:2.5 soil to water suspension using the glass- electrode pH meter (Mclean 1982); exchangeable acidity was determined by the method of Black (1965) using 1N KCI and titrating with 0.05 NaOH. Organic carbon was determined by wet oxidation method of Walkley and Black as modified by Nelson and Sommer (1982). Available phosphorus was determined by Bray 1 method (Bray and Kurtz 1945). Exchangeable bases were extracted with IN NH_4OAc buffered at pH 7.0; potassium and sodium were read with flame photometer while calcium and magnesium

were determined by EDTA titration (Lanyon and Heald 1982). Total nitrogen was determined by macro Kjeldahl method as described by Bremmer and Mulverney (1982). Total lead, Cadmium and Chromium were determined by HCI digestion and the filtrates were determined using Atomic Absorption Spectrophotometer (AAS) Unicam 939 model.
The data were subjected to analysis of variance (ANOVA) for CRD and the differences between the treatments were tested using the Fisher's least significant differences at 5% probability level. Correlation relationships were done using GENSTAT package to establish relationships between the soils parameters tested.

RESULTS

The effect of the treatments on some soil chemical properties at the end of the incubation is shown in Table 1. The applied treatments significantly ($p<0.05$) increased the soil pH value over the control with the kitchen residue ash having the highest significant value. The application of the organic waste significantly ($p < 0.05$) increased the available phosphorus, total nitrogen, organic carbon, exchangeable calcium and magnesium over the control (Table 1). The result of the data obtained showed that the pots that received poultry manure gave significantly higher value for available phosphorus among the organic wasted tested. The percentage increase in available soil phosphorus due to poultry manure application over the other treatments were, 22.57%, 56.70%, 72.87% and 24.75% respectively for control, kitchen residue ash, goat dung and maize husk ash.

Table 1: Effect of organic wastes on some soil chemical properties at the incubation study.

Treatment	pH (H_2O)	Exch acidity (cmol/kg)	Available Phosphorus (mg/kg)	Total Nitrogen (%)	Organic carbon (%)	Exch Calcium (cmol/kg)	Exch Magnesium (cmol/kg)
Control	5.53	1.78	11.10	0.07	0.51	6.90	1.42
PM	7.16	0.93	49.17	0.14	1.19	19.65	2.53
KRA	7.20	0.89	27.88	0.12	1.15	27.36	2.91
GD	7.05	0.98	35.83	0.13	1.34	21.89	3.82
MHA	7.02	0.98	12.17	0.12	1.16	24.53	2.57
Lsd (0.05)	1.01	Ns	6.53	0.02	0.20	2.32	0.98

PM = Poultry manure, KRA= Kitchen residual ash, GD= Goat dung, Maize husk ash and Exch= Exchangeable

The highest significantly ($p < 0.05$) value for soil nitrogen was obtained by the application of Poultry manure, while Goat dung significantly ($p < 0.05$) increased the soil organic carbon. There was a remarkable increase in soil exchangeable calcium content with the application of kitchen residue ash over the other treatments tested. Application of goat dung gave significantly ($p < 0.05$) higher soil exchangeable magnesium value.
The effect of the treatments on lead concentration in soil contaminated with spent engine oil is shown in Fig 1. The result obtained indicated that the organic waste significantly reduced lead concentration over the control with poultry manure giving the lowest significant lead concentration value in the soil.

The application of the organic waste significantly reduced cadmium (Fig 2) over the control. There was no statically significantly difference among the organic waste although poultry manure gave the lowest value for cadmium concentration.

Fig 3 indicated that the application of the organic waste significantly reduced chromium over the control while among the waste poultry manure significantly ($p<0.05$) reduced the chromium concentration in the soil.

The result of the effect of the organic waste on the percentage base saturation is presented in Fig 4. The result obtained showed that all the organic wastes significantly ($p < 0.05$) increased the percentage base saturation. The pots with poultry manure significantly ($p < 0.05$) increased the percentage base saturation among the other organic wastes.

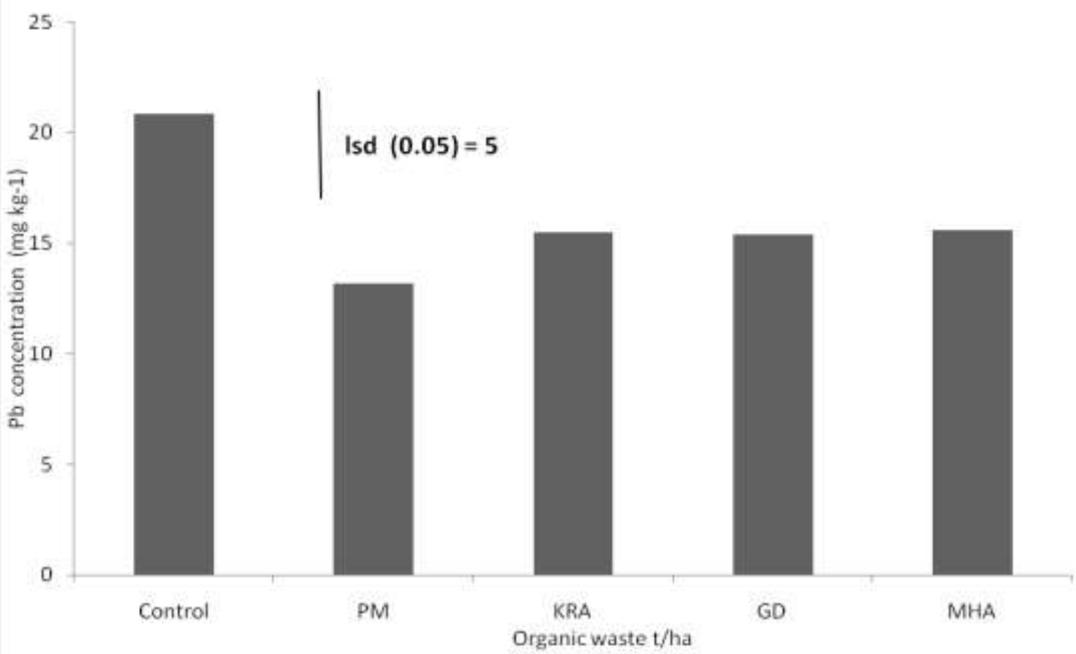

Fig 1: Effect of amendments on Lead concentration in soil contaminated with spent engine oil. Vertical bar represents lsd at 0.05

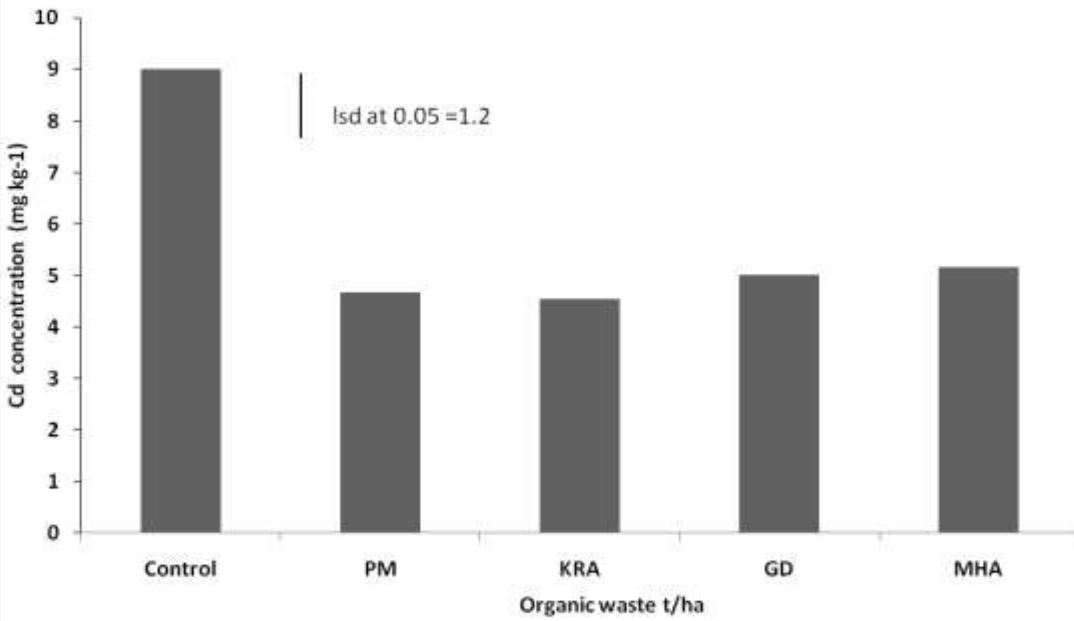

Fig 2: Effect of amendments on Cadmium concentration in soil contaminated with spent engine oil. Vertical bar represents lsd at 0.05

.

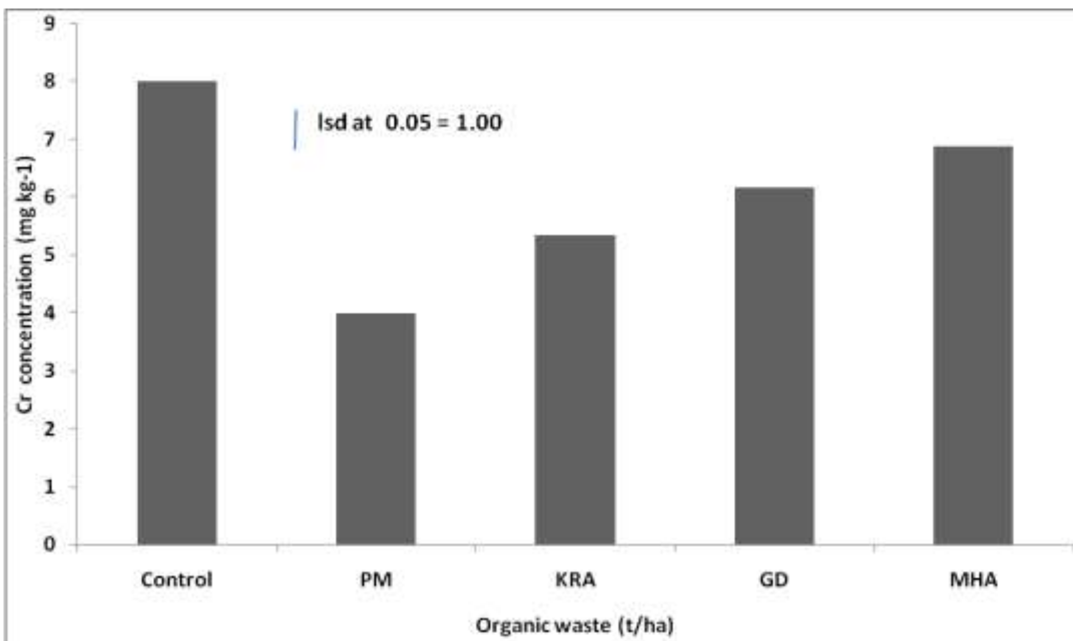

Fig 3: Effect of amendments on Chromium concentration in soil contaminated with spent engine oil. Vertical bar represents lsd at 0.05

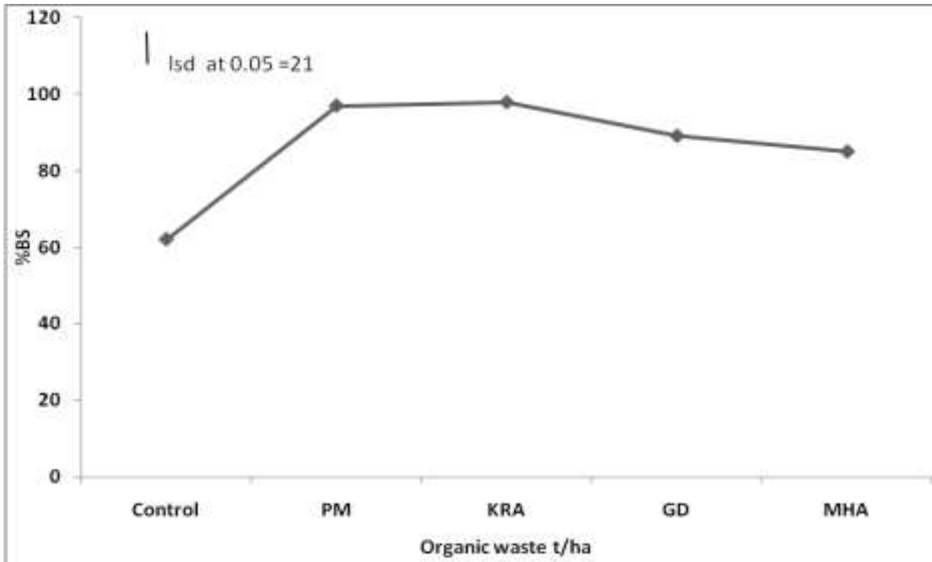

Fig 4: Effect of amendments on Percentage Base Saturation concentration in soil contaminated with spent engine oil. Vertical bar represents lsd

The correlation study between heavy metals and some chemical properties is shown in Table 2. From the result on Table 2, soil pH correlated negatively and significantly ($p < 0.01$) with lead, cadmium and chromium, while organic matter correlated negatively and significantly ($p < 0.01$) with lead and cadmium. It also correlated negatively and significantly at the probability level of 0.05 with chromium. The result obtained from Table 2 indicated that total nitrogen negatively correlated with the heavy metals but the correlation was not significant. Available phosphorus correlated negatively and significantly ($p< 0.05$, $p< 0.01$) with lead, chromium and cadmium. Also the same negative correlation and non significant relationship existed between lead and exchangeable potassium. Exchangeable calcium negatively correlated with, lead, cadmium and chromium with a significant value at probability level of 0.01 for chromium. There was a significant ($p< 0.05$) and negative correlation between exchangeable magnesium and the heavy metals. Exchangeable sodium correlated negatively and significantly ($p < 0.01$) with lead and cadmium while there was no significant value between exchangeable magnesium and chromium. Correlation analysis showed high positive correlation between exchangeable acidity and the heavy metals studied. The values were significant at $P < 0.01$ (Table 2). Total exchangeable bases, effective cation exchange capacity and percentage base saturation were negatively correlated but no significant with lead, cadmium and chromium. Percentage base saturation was highly significantly ($p<0.01$) but correlated negatively with chromium.

Table 2: Correlation between heavy metals and some soil chemical properties

Soil properties		**Heavy metals**	
	Pb	**Cd**	**Cr**
pH (H_2O)	-0.712**	-0.758**	-0.866**
Organic matter	-0.798**	-0.852**	-0.620*

Total Nitrogen	-0.142^{ns}	-0.149^{ns}	-0.054^{ns}
Available Phosphorus	-0.578*	-0.734**	-0.707*
Exch Calcium	-0.190^{ns}	-0.317^{ns}	-0.676**
Exch Magnesium	-0.612*	-0.621*	-0.568*
Exch Sodium	-0.889**	-0.776**	-0.189^{ns}
Exch Potassium	0.040^{ns}	-0.013^{ns}	-0.616*
Exch Acidity	0.733**	0.776**	0.719**
TEB	-0.082^{ns}	-0.202^{ns}	-0.570^{ns}
ECEC	-0.062^{ns}	-0.179^{ns}	-0.555^{ns}
%BS	-0.403^{ns}	-0.546^{ns}	-0.744**

* = Significant at $P < 0.05$ ** = Significant at $P < 0.01$
ns = Not significant

DISCUSSION

The reason for the general increase of the soil pH and the reduction in the soil exchangeable acidity, by the application of the organic wastes especially kitchen residue ash could be attributed to the high levels of basic cation which they contained. According to some researchers like Ano and Ubochi (2007) and Onwuka and Ogbonna (2009) animal manure and kitchen residue ash on analysis contain 17 - 27.60 cmol/kg of calcium and with a pH (H_2O) of 6.7 - 11.9. The cations contained in these materials displaced the acidic cations like aluminum and hydrogen from the soil exchangeable complex by neutralization and precipitation. Thereby increasing the soil pH and reducing the exchangeable acidity. The improvements recorded in soil available phosphorus, exchangeable calcium, exchangeable potassium, exchangeable magnesium, organic matter, total nitrogen and percentage base saturation could be attributed to the organic wastes added to the soil which on decomposition and mineralization released the different nutrients in the soil. The reductions recorded in the amount of lead, chromium and cadmium in the soil was a result of the added amendments.

In the correlation study it was observed that most of the chemical properties correlated negatively with the heavy metals tested. This means that as the soil chemical properties like pH, organic matter, available phosphorus, exchangeable calcium and exchangeable magnesium are increasing, lead, chromium and cadmium were decreasing. The decrease in the amount of the heavy metals by the increase in soil pH could be as the result of the fixation or precipitation of these metal ions at high pH. According to Walker *et al.,* (2003) heavy metals are bioavailable between pH 3.5-6.0 beyond which they will become less bioavailable under alkaline condition. This may be one of the reasons why there was negatively correlation between the heavy metals and the pH as the pH recorded in this present study was above 7. Barrow (1997) said that increase in soil pH leads to an increase in the negative charge on variable charge surface in soil, which will result to the precipitation of the heavy metals as sparingly soluble compounds of phosphate, carbonate and hydroxide. The organic waste added into the soil increased the organic carbon and organic matter level of the soil. The organic matter correlated negatively and significantly with the heavy metals, this is because organic matter compounds like fulvic acid contain a large proportion of hydroxyl and carboxylic groups which have been found to be very effective in forming bonds with metals (Basta *et al.*, 2005) these bonds formed are called chelate. The formation of metal chelate reduces solubility of metals in soil (Pulford and Flowers, 2006). Exchangeable acidity correlated positively and significantly with the heavy metals indicates that acidity favour the availability of the heavy metals. Heavy metals like lead, cadmium and chromium has been found by McLaughlin *et al.,* (1996) and Kobaz *et al.,* (2001) to be most mobile in acidic soil within the pH of 4.5-5.5.

CONCLUSION

The results of the study showed that the application of the organic wastes increased soil pH, available phosphorus, exchangeable calcium, potassium, magnesium, and sodium and percentage base saturation. In the same vein, the wastes also reduced the soil exchangeable acidity, lead, chromium and chromium. Among the organic wastes tested poultry manure and kitchen residue ash applied at 4t/ha showed an overall best performance in ameliorating soil contaminated with spent engine oil in Umuahia metropolis in Abia State. Further research is recommended for the field application of the treatments.

REFERENCE

Achuba, F .I. and Peretiemo-Clark, B. O. (2008). Effect of spent engine oil on soil catalase dehydrgenase activities. Int. agro physics, 22: pp4

Adedokun, O. M, and Ataga, A. E. (2007). Effect of amendment and Bioaugumentation of soil polluted with crude oil, automotive gasoline and spent engine oil on the growth of cowpea (*Vigna ungiculata L. Walp*). Scientific Research Eassy , Vol 2 (5) 147-149

Adenipekun, C .O. (2008). Bioremediation of engine oil polluted soil by Pleurotus- tuber-regium singer, a Nigeria whole- rot fungus. African Journal of Biotechnology 7: (1) 55-58

Akamigbo , F. O. R and Jidere, C. M. (2003). Carbon nitrogen dynamics in organic waste amended crude oil polluted wetland soil. Proceedings of the 28th Annual Conference of the Soil Science Society of Nigeria held at Umudike, Abia State. Ojeniyi et al (ed). Pp 256-261.

Ano, A.O and Ubochi, C.I. (2007). Neutralization of soil acidity by animal manures: mechanism of reaction. *African Journal of Biotechnology* Vol 6 (4) pp 364-368.

Barrow, N. J. (1997). Reaction with variable charge soils; Martinus Nijhoff: Dordrecht. The Netherlands, pp 191.

Basta, N.T., Ryan, J .A. and Chaney, R. L. (2005). Trace element chemistry in residual treated soil: Key concepts and metal bioavailability. Journal of Environmental Quality 34, 49-63.

Black C. A. (ed). 1965. Methods of Soil Analysis, Part 2. *ASA Madison USA.* Pp 1149 – 1378

Bray R.H and Kurtz, L. T. (1945). Determination of total and available forms of phosphorus in soils. *Soil Science 59: 39-45*

Bremmer, J. M. and Mulverney, G. S. (1982). Nitrogen Total: In Page et al (ed) Methods of soil analysis. American Society of Agronomy No 9, Madison, W. pp 595-624.

Kasthuri, V. Tanaka, H., Komukai, S., Toki, H., Iwabuchi, T. and Miyachi, S. (1993). Ecodymanic of Oil Degrading Bacteria and Significance of Marine mixed Population: In the Degradation of Petroleum compound. Marine Inst., Kamaishi Laboratory, Iwate 026, Japan pp 427- 432.

Kobza, J., Hansen, H. C. B., Makovnikova, J., Matuskova, L. Styk, J., and Schmidt, R (2001). Soil Pollution, In Hansen, H.C.B (ed.) Environmental Soil Chemistry, Matej Bel University, Banska Bystrica, Slovakia, pp 97-135.

Lanyob, L. E and Heald, W. R. (1982). Magnesium, calcium, strontium and barium. In A.L.Page (ed). *Methods of Soil Analysis*, part 2. Agronomy NO 9 Madison Wisconsin. USA. Pp 247-262.

McLaughlin, M. J., Tiller, K. G., Naidu, R. and Stevens, D.P. (1996). Review: The behavior and environmental impact of contaminants in fertilizer. Australian Journal of Soil Research 34, 1-54.

Mclean, E. O., (1982). Soil pH and lime requirement. In Pager AL, editor. *Methods of Soil Analysis*, part 2. 2nd ed Agron. Monog Vol. 9, Madison, WI: ASA and SSSA. pp 199-224.

Nelson, R. E. and Sommer, L.E (1982). Total carbon, organic carbon and organic matter. In Page (ed) *Methods of Soil Analysis*, part 2. Agronomy NO 9 Madison Wisconsin. USA. Pp 539-579

Onwuka, M. I and Ogbonna, E. A. G. (2009). Effect of different kitchen residue ash sizes on acidity amelioration in an Ultisol soil. Proceeding of the 33rd Annual Conference of Soil Science Society of Nigeria. Held at University of Ado – Ekiti. Pp184- 189.

Osubor, C. C. and Anoliefo, G.O. (2003). Inhibitory effect of spent lubricating oil on the growth and respiratory function of Arachis Hypogea l. Benin Sci Dig 1: 73-79

Pulford, I. and Flowers, H. (2006). Environmental Chemistry at a Glance, 1st edn: Blackwell Publishing.

Walker, D. J., Clemente, R., Roig, A. and Bernal, M. P. (2003). The effects of soil amendments on heavy metal bioavailability in two contaminated Mediterranean soils. Environmental Pollution 122, 303-312

Wang, Q. R., Cui, Y. S., Liu, X. M., Dong, Y.T. and Christie, P. (2003). Soil contamination and plant uptake of heavy metals at polluted sites in China. Journal of Environmental Science and Health Part a- Toxic/ Hazardous Substances and Environmental Engineering 8, 823-838.