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Amelioration of Spent Oil Contaminated Ultisol with Organic Wastes and its Effect on Soil Properties and Maize (*Zea mays L*) Yield

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Abstract: Contamination of soil with toxic substances can degrade its capacity to grow plants. A Randomized Complete Block Design (RCBD) experiment was set up in 2005 and 2006 to evaluate the effect of organic wastes on the physical properties and maize (*Zea mays* L) yield of spent oil contaminated (SOC) ultisol in Abakaliki South eastern Nigeria. The wastes comprising poultry droppings (PD) and Rice husk dust (RHD) were applied at the rate of 10tha^{-1} in 2005 and their residual effect tested in 2006. The results obtained showed significant decrease (P= 0.05) in soil bulk density at 48 and 90 days after planting (DAP) in waste amended plots relative to SOC plots in both seasons. Rice husk dust (ORHD) gave highest aggregate stability value of 80.3(%) in 2005. The value was 12%, 6% and 9% higher than control ©, oil + PD (OPD) and SOC plots, respectively. Waste application increased the water retention and hydraulic conductivity of the soils relative to SOC plots in both seasons. Results also show significant decrease in crop growth and yield in SOC plots relative to the waste amended plots. Yield increase of 32%, 12% and 225% were obtained in OPD amended plots relative to C, ORHD and SOC plots, respectively in 2006. Results also showed that organic amendments can improve the physical properties and productivity of spent oil contaminated soils.

Key words: Spent oil · Contaminated soil · Organic waste · Productivity · Crop growth

INTRODUCTION

Soil is a primary recipient by design or accident of a myriad of products and chemicals used in modern society. Once these waste materials enter the soil they become part of the biological cycle that affects all forms of life. In Nigeria, increased automobile repair activities have contributed markedly to the problems of soil contamination. The automobile activities usually involve changing of lubricating oil, servicing and greasing of motor parts and replacement of worn-out parts [1]. This result in the disposal of spent lubricating oil 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 [2]. [1, 3] showed that spent oil enrich soil with heavy metals. Similarly, Agbogidi *et al*. [4] and Agbogidi and Eshegbeyi [5] showed that oil exploration activities/production and associated activities impact negatively on the Nigerian environment including the soil ecosystem, water, crop as well as tree species. Since processes used to decontaminate soil are limited in application, prohibitively expensive or may be partially expensive [6], bioremediation of organic waste is becoming an increasing important method of waste treatment [7]. This involves the introduction of nutrients in the form of organic matter to the contaminated soil to boost the activity of micro-organism that degrade the contaminants [8]. Abakaliki is a major food producing area of southern Nigeria. In the area (like many cities in Nigeria) automobile mechanics are bound and spread spent lubricating oil on agricultural lands rendering such lands uncultivable. With the teeming population of Nigeria and high demand for arable land for food production, it has become essential to investigate the effects of spent lubricating oil on agricultural land, crop growth as well as yield. Similarly, research efforts should be geared towards reclaiming such contaminated soil at minimal cost to the poor resource farmers. This study aims at evaluating the agronomic potentials of spent lubricating oil contaminated soil amended with organic wastes.

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MATERIALS AND METHODS

The Study Area: The experiment s were carried out during 2005 and 2006 growing seasons at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. Abakaliki (longitude 08°65[1]E, latitude 06° 04[1]N temperature 27°C-31°C, rainfall 1700-2000 mm, relative humidity, 60-80%) experiences bimodal patterns of rainfall (April-July) and (September-November) with short spell in August. The soil is ultisol [9] and classified as Typic Haplustult.

Materials: Maize (Var. Oba Super 11) was obtained from Ebonyi State Agricultural development programme (EBADEP). Spent lubricating oil was obtained from the mechanics village at (SITE) Abakaliki. Poultry dropping (PD) and rice husk dust (RHD) were obtained from Animal Science Department Farm and rice mill, respectively.

Methodology: The land (measuring 17×15 m) was mapped out, cleared with cutlass and the debris removed. The experiment was laid out as randomized complete block design (RCBD). The field was divided into five blocks with each block having four plots or experimental units, giving a total of 20 plots. Each plot (3m×3m) in a block was 0.5 m apart and 1m between blocks. The treatments were:

- No oil and amendment or control ©
- Oil + Poultry Dropping (OPD) at 10 t ha^{+}
- Oil + Rice husk dust (ORHD, at 10 t ha^{-1}
- Oil alone (SOC)

Thirty litres of spent lubricating oil was spread uniformly on OPD, ORHD and SOC designated plots every two weeks for one month (i.e. 90litres/plot). At the end of one month, 12 kg/plot (equivalent to 10 t ha^{-1}) of PD and RHD,respectively were applied on OPD and ORHD designated plots and incorporated into the soil during tillage. The control plots © were tilled without application of the spent oil or wastes. Two seeds of maize (Var Oba Super 11) were planted per hill 7 days after tillage at a spacing of 25 and 75cm. The seedlings were thinned down to leave one seedling per stand (giving a total of 53,333 stands/ha) 7 days after emergence. Lost stands were replaced. The experimental site was kept relatively weed free through out the period of the experiment. The process as described above was repeated in 2006 cropping season without application of spent lubricant oil to test its residual effect.

Data Collection and Laboratory Analysis: Three undisturbed core samples were collected from 30 cm depth in each plot and used for analysis of bulk density. The soil core samples collected using 98.2 cm^3 open faced cores were analysed separately and mean value used. Auger samples (collected at the beginning and the end of the experiment) were used to determine the soil chemical properties. The soil was air dried at room temperature and used for evaluation of chemical properties. Germination count was taken 7 days after planting (DAP). At maturity twelve (12) plants per plot were selected and tagged. The height of each tagged plant measured (with metre rule) and one cob harvested from each of them. The harvested maize cob was dehusked and air dried before shelling and grain yield adjusted to 14% moisture content. Bulk density was determined at 48 and 90 DAP using the method described by Blake and Hartge [10]. Total porosity (TP) was calculated from bulk density as follows:

$$TP = 100\ (1\text{-}bd/pd)$$

Where TP = Total porosity, bd = bulk density, pd Particle density, assumed to be 2.65 gcm^{-3}. Hydraulic conductivity was determined by the constant head soil core method [11]. The distribution of aggregates was determined by wet and dry sieving techniques [12]. Soil pH determination was carried out using 1:2.5 soil water ratio. Total nitrogen (N) was determined by Kjeldahl method [13], while available P was determined by Bray 11 method [14].

Exchangeable cations (Ca, Mg, Na and K) were extracted with ammonium acetate by Perkin Elmer atomic absorption spectrophotometer [15], while cation exchange capacity (CEC) was obtained by summation. Organic carbon (OC) was analysed by the method of Nelson and Sommers, [16]. The percentage OM was calculated by multiplying the value of OC by the conventional "Van. Bemmeller factor" of 1.724 on the assumption that soil organic matter (SOM) contains 58% c [17].

Data collected from the study was analyzed using analysis of variance (ANOVA) test based on randomized complete block design (RCBD) using FLSD (at P = 0.05) according to Steel and Torrie [18].

RESULTS

Data on chemical properties of the experiment site before the study is shown in Table 1. Data show that low concentrations of total N, organic matter (OM%), avail P and exchangeable bases (Ca, Mg, K and N) according to the ratings of Landon (1991). The texture of the soil;

Table 1: Properties of the soil before the study

Parameters	Unit	Value
Coarse sand	%	16
Fine sand	,,	39
Silt	,,	35
Clay	,,	10
Texture	,,	Sand loam
P^h(KCL)	,,	5.10
Organic matter	,,	1.09
Total N	,,	0.07
Avail. P	,,	7.0
Ca	Cmol(+)kg^{-1}	4.0
Mg	,,	3.6
Na	,,	0.15
K	,,	0.18
CEC	,,	13.0

Table 2: Properties of the amendments

		Value	
Parameters	Unit	PD	RHD
Organic matter	%	30.20	26.00
Total N	,,	3.60	0.81
Avail P	,,	2.20	3.40
Ca	Cmol (+) kg^{-1}	4.30	2.40
Mg	,,	1.96	1.20
K	,,	1.50	1.10
Na	,,	0.72	0.12

PD = Poultry droppings, RHD = Rice husk dust

Table 3: Effect on soil bulk density (gcm^{-1}) and total porosity (%)

	Bulk density				Total porosity			
	2005 DAP		2006		2005		2006	
Treatment	48	90	48	90	48	90	48	90
C	1.36	1.40	1.34	1.43	49	47	49	46
ORHD	1.40	1.46	1.34	1.42	47	45	49	46
OPD	1.38	1.42	1.32	1.40	48	46	50	49
SOC	1.50	1.57	1.52	1.48	43	41	43	40

$LSD_{0.050.07}$ 0.09 0.030.04 0.02 0.950.99 0.82, C = control = No oil and amendment, OPD = oil + poultry dropping, SOC = oil alone, ORHD = oil + Rice husk dust

which is strongly acidic (USDA-SCS 1974) is sandy loam. Data in Table 2 show that nutrient concentrating is higher in PD compared to RHD. For instance, total N in PD is 344% higher than its content in RHD. Similarity, nutrient contents of the amendments (PD and RHD) are higher than that of the soil (Table 1).

Data in Table 3 shows that there is a significant (P= 0.05) differences in bulk density values at 48 and 90 DAP in both seasons. Observed bulk density values ranged between 1. 36 to 1.50 gcm^{-3} and 1.40 to 1, 57 gcm^{-3} at 48 and 90 DAP,respectively in the first cropping season. At 90 DAP in the second season the order of bulk density increase was SOC >C> ORHD >PD. At 48 and 90 DAP observed bulk densities were the highest in spent lubricant oil amended plots (SOC) relative to the amended plots in both seasons. Data in Table 3 also show that the lowest porosity values in SOC plots compared to other treatments at 48 and 90 DAP in both seasons. At 48 DAP in the first season the highest total porosity value of 48% was observed in the C plots. This value was 4%, 2% and 10% higher than ORHD, OPD and SOC amended plots, respectively. The order of increase in total porosity at 90 DAP in the second season is OPD >RHD=C >SOC.

Water retention of the soil (though not statistically different) was increased by 1, 2 and 5% in OPD relative to C, OPD and SOC amended plots, respectively in the first season (Table 4). Observed water retention values in the second season increased in the order OPD>ORHD,>C>SOC. Table 4 also show significant difference in hydraulic conductivity at both cropping seasons. The highest hydraulic conductivity value of 0.417 and 0.619,respectively in the first and second seasons were observed in ORHD amended plots. The value (0.417) observed in the first season was 70, 90 and 283% higher than C, OPD and SOC, amended plots respectively.

Aggregate stability was significantly different (P=0.05) in both seasons (Table 5). The highest observed value (80.3%) was obtained in ORHD plots in the first cropping season. The value was 12, 6 and 9% higher than C, OPD and SOC amended plots, respectively. In the second season, the order of increase in aggregate stability values was OPD=ORHD>C>SOC. Data in Table 6 shows that plant height was the highest in plots with no amendment and oil (C) in the first season. However, in the second season, OPD amended plots gave the highest plant height value of 185 cm. The value is 32, 12 and 225% higher than to C, ORHD and SOC amended plots respectively. In the first season, C gave the highest grain yield of 46 mg ha^{-1}. This was not similar to the result obtained in the second season where highest yield was obtained in OPD amended plots. Observed grain yield in OPD amended plots in the second season was 50 mg ha^{-1}. The value was higher than C, SOC and ORHD amended plots by 32, 213 and 16%, respectively.

Table 4: Effect on soil moisture content and hydraulic conductivity

	Moisture	Content	Hydraulic	conductivity
Treatment	2005	2006	2005	2006
C	13.5	12.4	0.246	0.053
ORHD	13.6	13.7	0.417	0.619
OPD	13.3	12.5	0.210	0.262
SOC	13.0	11.4	0.109	0.263

LSD $_{0.05}$ NS NS 0.125 0.126C = No oil and amendment, OPD = oil + poultry dropping, SOC =Oil alone, ORHD = Oil + Rice husk dust

Table 5: Effect on aggregate stability (%)

Treatment	2005	2006
C	71.9	69.8
ORHD	80.3	71.3
OPD	75.8	74.8
SOC	73.7	6.5

LSD$_{0.05}$ 1.680.98

C =No oil and amendment, OPD = Oil + poultry dropping, SOC = oil alone, ORHD = Oil + Rice husk dust

Table 6: Effect on plant growth (cm) and yield (tha^{-1})

	Plain height		yield	
Treatment	2005	2006	2005	2006
C	167	140	46	38
ORHD	114	165	38	43
OPD	159	185	40	50
SOC	68	57	20	16
FLSD$_{0.05}$	6.37	4.08	3.9	4.1

C =No oil and amendment, OPD = Oil + poultry dropping, SOC = oil alone, ORHD = Oil + Rice husk dust

DISCUSSION

Maize germination was three days earlier in C plots compared to OPD, SOC and ORHD plots in the first season. Germination count taken seven (7) DAP showed 96% in C, 96% in OPD, 86% in RHD and 70% in SOC in the first season. In the second season, it was 90% in C, OPD, ORHD and 80% in SOC. The reduction of germination % observed in spent oil contaminated plots could be attributed to the reduced moisture, hardening of the soil and soaking of some seeds by the oil in line with the observation of Udo and Fayemi [19].

The pronounced increase in soil properties and maize growth /yield in the OPD and ORHD plots relative to spent lubricant oil treated plots in the second season could be attributed to presence of organic matter (OM) which according to Atlas [20] has affect on soil properties such as water holding capacity (WHC), bulk density (BD) and mobilises nutrient for plants. Similarly, Hornick [21] reported that OM when present in sufficient quantity has beneficial effect of soil chemical and physical properties while JRB associates inclusion [22] were of the view that OM contribute N, P, S, Zn and B all of which add to the nutrient status of soils. According to Shimp and Pfaender

[23] OM from wastes can influence the ability of micro-organism to degrade pollutants.

Godbout *et al*. [24] reported that bacteria seem to be able to survive in OM which according to Kaestner and Mahra [25] appears to the essential for the degradation. It is possible from this study that OM from wastes enhanced higher microbial population which degraded the toxic compounds in spent lubricant oil amended plots making nutrients available for plants resulting in higher plant height and yield in line with the observations of Mbah *et al*. [26]. On the other hand, the significant reduction in soil properties and yield performance of maize in spent lubricant oil contaminated plots could be attributed to the adulteration structure of the soil following spent lubricant oil treatment. The spent oil increased the bulk density thereby reducing root growth and penetration leading to reduced aeration and oxygen content as a result of low porosity. The reduction in plant growth and grain yield in SOC could be attributed to the presence of spent oil in the soil environment which may have affected normal soil chemistry, reducing nutrient release and uptake. Odjegba and Sadiq [27] and Anoliefo and Vwoko [28] reported decreased plant growth and yield in oil polluted soil. Earlier studies by Agbogidi and Nweke [5] and Agbogidi *et al*. [6] showed that crude oil application to soil significantly reduced plant growth and yield. Results from the study show yield reduction in spent lubricant oil (SOC) and C amended plots in the second season relative to the first season. The observed yield reduction in C plots could be attributed to continuous cropping without addition of amendments.

Results from the study show improved soil physical properties and increased agronomic parameters on (growth and yield) spent oil contaminated soil amended with organic wastes relative to spent oil contaminated soil only. Thus organic amendments could be used to improve the physical properties and restore the productivity of spent oil contaminated soil.

REFERENCES

1. Ajayi, O.O., 2005. Heavy metal contents of soil in automobile workshop in Lagos. Nig. J. Soil Sci., 15(2): 163-164.
2. Brady, N.C. and L.T. Weil, 1999. The Nature and Properties of Soil. 12th Edn. Macmillian Pub. Co. Inc. New York.
3. Ogutemehin, L.L., K.O. Ipinmoroti and A.F. Aiyesanmi, 2005. Evaluation of heavy metal in soils at automobile workshops in Akure. Nig. J. Soil Sci., 15(2): 151-153.
4. Agbogidi, O.M., F.U. Nweke and E.M. Okechukwu, 2006. Yield performance of five cultivars of soyabean (*Glycine max* (L) Merr) as influenced by soil contaminated with crude oil. Nig. J. Trop. Agric., 8: 303-309.
5. Agboogidi, M.O. and F.U. Nweke, 2005. Effects of crude oil polluted soil on the performance of Okra (*Abelmoschus exculeutus*) Moench in Delta State. African J. Nat. Sci., 8(1): (In Press).
6. Nicholas, R.B., 1987. Biotechnology in hazardous wastes disposal an unfulfilled promise. Am. Soc. Microbial. News, 53: 138-142.
7. Atlas, R.M., Horowitz, Krichevsky and A.K. Bej, 1991. Response of microbial population to environmental disturbance. Ecol., 22: 249-256
8. Odukwuma, L.O. and A.A.A. Dickson, 2005. Bioremediation of a crude oil polluted tropical mangrove environment. Bioline International Official Site, pp: 1-6.
9. FDALR, 1985. Reconnaissance soil survey of Nigeria. Soil reports 1985. Federal Department of Agric. Land Res., (FDALR) Lagos.
10. Blake, G.H. and K.H. Hartge, 1986. Bulk Density. In Klute A. (Eds) Methods of Soil Analysis Part 1, 2nd Edn. Agronomy Monograph No. 9 ASA and SSSA. Madison W.I., pp: 365-375.
11. Reynolds, N.D., 1993. Saturated hydraulic conductivity Laboratory measurement. In: Soil sampling and method of analysis. Carter, M.R. (Edn.) Lewis Publ. Boca Raton, pp: 589-598.
12. Kemper, W.D. and R.C. Rosenau, 1986. Aggregate stability and size distribution. In: Klute A. (Edn). Methods of soil Analysis. Part 1: Physical and Mineralogical methods. 2nd Edn. ASA, SSSA Madison, W.USA, pp: 425-441.
13. Bremner, J.M., 1982. Total Nitrigen. in Page A.I. Miller R.H. Keery, D.R. (Eds) Methods of Soil Analysis. Part2 2nd Edn. Agronomy monograph No. 9 ASA and SSA, Madison WI. pp: 915-928.
14. Bray, R.H. and L.T. Kurtz, 1945. Determination of total organic and available forms of phosphorus in soils. Soil Sci., 59: 39-45.
15. Tel, D.A. and R. Rao, 1982. Automated and semi-automated method for soil plant analysis. Manual series No. 7 IITA, Ibadan.
16. Nelson, D.W. and L.E. Sommers, 1982. Total carbon, organic carbon and organic matter. In page A.C., Miller, R.H. Keeny, D.R. (Eds) methods of soil Analysis. Part 2. 2nd Edn. Agonomy Monograph No. 9. USA and SSSA Madison, 1: 539-579.

17. Allison, F.E., 1982. Soil organic matter and its role in crop production. Elsevier scientific publishing company. Amsterdam, pp: 637.
18. Steel, R.G. and J.H. Torrie, 1980. Principles and procedure of Statistics. A Biometrical Approach. 2nd Edn. McGraw Hill. New York, pp: 633.
19. Udo, E.J. and A.A. Fayemi, 1975. The effect of oil pollution on germination, growth and nutrient uplake of corn. Environ. Quality, 4: 573-540.
20. Atlas, M., 1973. Bioremediation of fossil fuel contaminated soils. In: In Situ Bioremediation. Application and investigations for the Hydrocarbons and contaminated site remediation. Hinchee, R.E. and Olfenbutel, R.F. (Eds.). Butter worth-Heinemann, Storeham M.A., pp: 14-33.
21. Hornick, S.B., 1983. The interaction of soil with waste constitutes. In land treatment of hazardous wastes. Parr J.F., Marshal, P.B. and Kla. J.M (Eds). Nonyes Data Corp. Park Ridge N. J., pp: 4-19.
22. J.R.B., Associates Inc, 1984. Summary report. Remedial response at hazardous wastes sites. Prepared for municipal environmental research laboratory, Cincinnati, OH., pp: 85-124.
23. Shimp, R.I. and F.K. Pfeander, 1984. Influence of naturally occurring carbon substrates on the biodegradation of Monosubstituted phenols by bacteria. Abst. Annu. Mtg. Am. Soc. Microbiol., pp: 212.
24. Godbout, G., Y. Comeau. and C.W. Greer, 1995. Soil characteristics effect on introduced bacteria survival and activity in Bioaugmentation for site remediation. Pap 3rd Int. Insitu On-site. Bioreclaim symp. Hinchee. R.E., Fredrickson J. and Allema B.C. Eds Battele press Columbus OH pp: 115-120.
25. Kaesner, M. and B. Mahra, 1996. Microbial degradation of polyclic aromatic hydrocarbons in soil affected by the organic matrix of compost. Appl. Microbial. Biotech., 44(5): 668-675.
26. Mbah, C.N., J.N. Nwite and O.E. Okporie, 2006. Effect of organic wastes on some chemical properties and productivity of spent oil polluted ultisol in Abakaliki E.E. Nigeria. Nig. J. Trop. Agric., 8: 51-56.
27. Odjegba, V.J. and A.O. Sadiq, 2002. Effect of spent engine oil on the growth parameters, chlorophyll and protein levels of *Amercintus. Hybridus L*. The Environmentalist, 22: 23-28.
28. Anoliefo, G.O. and D.E. Vwoko, 1995. Effect of spent lubricating oil on the growth of *capsium annum* and lycopersium. Pol., 88: 361-364.