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Full Length Research Paper

Analysis of the Physical conditions of a contaminated typic haplustult amended with organic wastes.

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A field experiment was conducted in 2006 and 2007 cropping seasons to analyse the physical conditions of an Ultisol contaminated with spent lubricant oil alone, contaminated with spent lubricant oil and amended with organic wastes and organic waste amended soil only. The residual effect of these treatments was evaluated in 2008 cropping season. The treatments include; Spent lubricant oil (OS), OS+ burnt rice mill waste (OSBW), OS+ unburnt rice mill waste (OSUB), OS+ saw dust (OSSD), burnt rice mill waste (BW), unburnt rice mill waste (UBW) and saw dust (SD). A control (without oil or wastes) was also included. Results from the study showed that OS recorded significantly ($p<0.05$) higher bulk density (Bd) values compared to OSSD, OSBW,OSUB, BW, UBW, SD and C in the two cropping seasons of application. Results also showed that amendment of the soil with SD, BW and UB recorded higher values of total porosity (Tp), aggregate stability (As), hydraulic conductivity (Hc) and available water capacity (AWC) compared to OS, OSSD and OSBW in 2006 and 2007 cropping seasons. Amendment of soil with BW was observed to increase AS by 17%, 4%, 2%, 21%, 5%, 9% and 11% for C, UB, SD, OS, OSBW, OSUB and OSSD, respectively in 2007 cropping season. In the residual cropping season, improvement in AWC and HC were in the order BW>OSBW>UB>SD=OSSD=C=OSUB>OS and BW> UB>SD>C>OSBW>OSUB>OSSD>OS, respectively. Organic wastes were observed to improve soil physical conditions with highest improvement observed in BW amendment.

Keywords: Physical properties, organic amendments, cropping season, organic wastes.

INTRODUCTION

Soil contamination is essentially the introduction of any physical, chemical, biological or radiological substance or matter into it (Adesodun, 2004). Contaminants generally include all solutes (organics or inorganics) introduced into the soil environment as a result of human induced activities regardless of whether or not the concentrations reach levels that cause significant degradation or any harm (Adesodun, 2004). Common forms of soil contamination are spent lubricant oil, crude oil, gas flaring and grease. Once these waste materials enter the soil, they become part of a biological cycle that affect all forms of life.

According to Brady and Weil, (2002) contamination of a soil can degrade its productive capacity to provide habitat for crops. Mbah and Ezeaku, (2010) reported decreased calcium (ca), magnesium(mg) and cation exchange capacity (cec) values in automobile waste contaminated soil relative to the control. Reclamation of soil contaminated with organic chemicals coupled with enhanced awareness of their potential adverse effects on the human and environment has received increasing international attention in recent years (Susan and Kelvin, 1993). Physical and chemical methods for treatment of contaminated soil based on the use of wastes are grossly inadequate and ineffective (Abu and Ojiji, 1996) and sometimes result in further contamination of soil environment (Steven, 1991). Oil degradation is a natural process limited by temperature, pH, nitrogen, phosphorus and oxygen. Studies by Atlas *et al.,* (1991),

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Ladousse and Tramier, (1991) and Leahy and Colwell, (1990) showed that Bioremediation is commonly accepted as the most efficient, environmentally safe and cost-effective method for treatment of hydrocarbon contaminated soils.

In Abakaliki agro-ecological zone of southeastern Nigeria, large quantities of unburnt and burnt rice mills wastes and saw dusts accumulate from numerous rice mills and sawdust from timber shade respectively, located in the area. Despite the magnitude of these wastes generated daily and the possible adverse effects on the environment, no serious attempts have been made either for their effective utilization or disposal. According to Hornick and Parr, (1987) organic materials generally differ in their properties and characteristics. Those with higher levels of organic stability such as cereal straws, wood bark and sewage sludge provide distinct advantage in the initial reclamation of marginal soils This is significant in relation to the soils under study, which according to Nnabude and Mbagwu,(1999) have several structural impediments such as high bulk density, extreme consistency conditions, compaction and poor drainage .Similarly, automobile wastes accumulate in many agricultural lands in the area as a result of many automobile servicing centers.Study by Onweremadu et al. (2007) showed that accumulation of automobile wastes deteriorates farmland and cause non-point pollution. The aim of this study was to analyse the physical conditions of spent oil contaminated soil, spent oil contaminated soil amended with organic wastes and organic waste amended soil with a view of recommending these easily affordable wastes used in this study for improvement of the poor physical conditions of soils of the study area regarded as food belt of the Nigerian nation.

MATERIALS AND METHODS

Experimental Site

The study was carried at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki-Nigeria. The site is located at latitude 06^0 4'N and longitude 08^0 65'E in the derived savannah zone of the southeast agro-ecological zone. The rainfall pattern is bimodal (April-July) and (September - November) with short dry spell in August. The total annual rainfall in the area ranges from 1500 to 2000 mm, with a mean of 1,800 mm. At the onset of rainfall, it is torrential and violent, sometimes lasting for one to two hours. The area is characterized by high temperature with minimum and maximum mean daily temperature ranges of 27°C and 31°C respectively. Humidity is high (80%) with lowest (60%) levels occurring during the dry season in April .Geologically, the area is underlain by sedimentary rocks derived from successive marine deposits from the cretaceous and tertiary periods. According to the Federal Department of Agriculture and Land Resource (FDALR, 1985) Abakaliki agricultural zone lies within Asu River group and consists of olive brown sandy shales, fine grained sandstones and mudstones.

The soil is shallow with unconsolidated parent materials (Shale residium) within 1cm of the soil surface. It belongs to the order Ultisol and classified as typic Haplustult (FDALR, 1985). Farming is the major activity of the people in this area.

Field Methods

A land area of 0.042 ha was used for the study. The experiment was laid out as spilt plot in randomized complete block design (RCBD). The main plots measured 10 m x 2 m and separated by 1 m space. Each subplot measured 2 m x 2 m with a plot alley of 0.5 m spacing while the four replicates were separated by 2 m spaces. The main plot treatments were 0% spent lubricant oil (control) and 5% spent lubricant oil equivalent to 50,000 mg kg^{-1} soil. The subplot treatments consisted of

(A) Contaminated soil as follows;

(a) spent lubricant oil (OS)

(b) OS+20 t ha^{-1} of burnt rice mill waste (OSBW) equivalent to 8kg plot^{-1},

(c) OS+20 t ha^{-1} of unburnt rice mill waste (OSUB) equivalent to 8kg plot^{-1}

(d) OS+ 20 t ha^{-1} of sawdust (OSSD) equivalent to 8 kg plot^{-1}.

(B) Uncontaminated soil as follows;

(i) 20 t ha^{-1} of unburnt rice mill waste (UB) equivalent to 8kg plot^{-1}

(ii) 20 t ha^{-1} of burnt rice mill waste (BW) equivalent to 8kg plot^{-1},

(iii) 20 t ha^{-1} of (SD) equivalent to 8 kg plot^{-1}.

(iv) Control (without oil or wastes).

The treatments spent lubricant oil, burnt rice mill waste, unburnt rice mill waste and saw dust were sourced from mechanic village, ago-rice mill industry and timber shade market, Abakaliki, respectively. Spent lubricant oil was sprayed uniformly on each main plot receiving it with a spraying machine to serve as a source of soil contamination. The wastes were spread on the subplots one week after spent lubricant oil treatment of the soil. These wastes were incorporated into the soil during seedbed preparation using traditional hoe. The beds were allowed to age for two weeks after incorporation of treatments before planting the test crop. The main plot and subplot treatments were replicated four times to give a total of thirty-two subplots in the study.

The procedure was repeated in second cropping season while the beds were re-ploughed with no application of treatments in third cropping (to determine the residual effect of the amendments).

Soil Sampling

At the end of the study auger and core soil samples were collected from each subplot and analysed for soil bulk density, hydraulic conductivity, aggregate stability and water retension.

Laboratory Determinations

Core samples were used to determine soil physical properties. Dry bulk density was determined by the method described by Blake and Hartge, (1986). Total porosity was calculated from bulk density values as follows;

Tp = (1-bd/pd) x 100/1

Where

Tp= Total porosity. Bd= bulk density, pd= particle density assumed to be 2.70 gCm^{-3}.Saturated hydraulic conductivity (Ks) was determined by the constant-head soil core method of Reynolds (1993) as adapted from Elrick *et al*., (1981). Auger samples used to determine moisture retained at –10 kp_a and –1500kp_a using the pressure plate extractor (Obi, 2000). Aggregate stability was determined by the wet sieving technique of Kemper and Roseau (1986).

Data Analysis

Data collected were subjected to Statistical Analysis System (SAS, 1999) and significant treatment effects separated using Duncan Multiple Range Test (DMRT).

Significant treatment effects was reported at 5% probability levels,

RESULTS AND DISCUSSION

Effect of amendments on bulk density (gCm^{-3}) and total porosity (%)

Table 1 showed that bulk density (bd) was significantly (P<0.05) higher in spent lubricant oil contaminated soil relative to other amendments in the 3- cropping seasons. Bulk density values ranged between 1.61-1.70 gcm^{-3}, 1.69-1.74gcm^{-3} and 1.68-1.77 gcm^{-3} in the 2006, 2007 and 2008 cropping seasons, respectively. The plots amended with OS recorded 4-7 %, 2-4% and 3-5% higher bulk density values than OSBW, OSUB and OSSD- amendments in 2006,2007 and 2008 cropping seasons ,respectively. Similarly, OS increased bulk density values by 5-9%, 5-12% and 7-9% respectively in 2006, 2007 and 2008 for C, BW, UB and SD amendments., Results

from the study probably suggests that contamination of soil with spent lubricant oil could cause compaction in line with the observations of Mbah *et al.,* (2009). Lower bulk density values were observed in organic waste amended spent oil contaminated and uncontaminated soil, indicating that waste application could loosen compacted soil and further demonstrated the potential of organic wastes in sustaining, physical structure as reported by Nnabude and Mbagwu, (2001). Lower bulk density is a positive productivity indicator as it helps in easing root penetration, and, therefore also encourages downward movement of water through old root channels (Obi, 2000). Total porosity values were significantly (P<0.05) lower in OS relative to C,UB,BW,OSSD,SD,OSUB and OSBW for three cropping seasons. Amendment of oil contaminated soil with burnt rice mill waste (OSBW) had 1%, 2% and 7% higher TP values compared to OS, OSUB, and OSSD, respectively, in the 2006 cropping season. Similarly, waste amendment increased soil total porosity relative to C in the uncontaminated soil. The order of increase in soil total porosity was BW>UB=SD>C, BW>UB=SD>C and BW>UB>SD>C in 2006, 2007 and 2009 cropping seasons, respectively. Generally, lower Bd and higher Tp values were recorded in uncontaminated relative to contaminated soil. In a study on amelioration of spent oil contaminated ultisol with organic wastes and its effects on soil properties and maize (*Zea mays L*.) yield, Mbah *et al.,* (2009) showed that spent lubricant oil contaminated soil reduced total porosity and attributed the reduction in total porosity to coating of oil in the pores. Lower total porosity indicates that the uncontaminated soil may be better aerated than the contaminated soil. Although waste application to contaminated and uncontaminated soil significantly (P< 0.05) decreased soil bd and increased soil total porosity relative to oil contaminated soil (OS) and control, respectively, their effect seemed to be strongly linked with the type of waste.

Changes in aggregate stability (AS) and available water capacity (AWC) varied with the amendments in the contaminated and uncontaminated soil (Table 2). Higher AS values were recorded in waste amended contaminated and uncontaminated soil relative to OS and control soils, respectively. In the 3-cropping seasons amendment of contaminated and uncontaminated soil with burnt rice waste (OSBW, BW) gave highest AS value. Aggregate stability value in OSBW – amended (contaminated soil) was 8%, 2% and 6% higher than recorded values in OSSD, OSUB and OS – amendments, respectively in the 2006 cropping season. Similarly Table 2 showed that amendment of oil contaminated and uncontaminated soil with organic wastes improved the available water capacity of the soil. The order of increase in available water capacity following the addition of organic amendments in contaminated soil was: OSBW > OSUB > OSSD > OS, OSBW > OSUB > OSSD > OS and OSBW > OSUB = OSSD > OS, in 2006, 2007, and 2008 cropping seasons, respectively. Similarly, amendment of uncontaminated soil with BW, UB and SD recorded high AWC values relative to the control in the 3 – cropping seasons. Studies on soil water retention of soil

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

	Treatment	BD 2006	BD 2007	BD 2008	TP 2006	TP 2007	TP 2008
contaminated	OS	1.70^{a}	1.74^{a}	1.77^{a}	36^{a}	35^{a}	34^{a}
	OSBW	1.57^{b}	1.67^{b}	1.68^{b}	41^{b}	37^{b}	36^{b}
	OSUB	1.61^{c}	1.70^{d}	1.78^{c}	40^{b}	36^{c}	36^{b}
	OSSD	1.64^{d}	1.71^{d}	1.71^{c}	38^{c}	36^{c}	35^{ab}
uncontaminated	C	1.61^{g}	1.65^{g}	1.66^{g}	40^{g}	37^{g}	37^{g}
	BW	1.54^{h}	1.55^{h}	1.57^{h}	42^{h}	42^{h}	41^{h}
	UB	1.58^{k}	1.61^{i}	1.61^{i}	41^{i}	39^{i}	39^{i}
	SD	1.57^{k}	1.62^{k}	1.63^{i}	41^{i}	39^{i}	38^{i}

Values followed by different lettering in a column for contaminated and uncontaminated soils are statistically deferent (P< 0.05). OS=spent lubricant oil contaminated, OSBW=OS+ burnt rice mill waste, –soil not contaminated with spent lubricant oil, C-control, BRMW – burnt rice mill waste, SD-saw dust URMW – unburnt or fresh rice mill waste , OSUB= OS+ burnt rice mill waste, OSSD=OS + saw dust, BW= burnt rice mill waste, SD =saw dust , UB = unburnt rice mill waste and C = control.

Table 2: Effect of amendments on soil aggregate stability (AS) and available water capacity (AWC).

	Treatment	AS 2006	AS 2007	AS 2008	AWC 2006	AWC 2007	AWC 2008
contaminated	OS	65.4^{a}	60.7^{a}	44.4^{a}	0.16^{a}	0.14^{a}	0.16^{a}
	OSBW	77.6^{b}	73.0^{b}	55.6^{b}	0.19^{b}	0.17^{b}	0.19^{b}
	OSUB	75.8^{c}	69.9^{c}	53.8^{c}	0.18^{c}	0.17^{b}	0.18^{bc}
	OSSD	71.6^{d}	68.6^{d}	50.7^{d}	0.18^{c}	0.16^{c}	0.18^{bc}
uncontaminated	C	70.4^{e}	63.8^{e}	54.7^{c}	0.19^{e}	0.14^{e}	0.18^{e}
	BW	81.9^{f}	76.9^{f}	63.4^{f}	0.21^{f}	0.18^{f}	0.20^{f}
	UB	77.0^{g}	74.2^{g}	61.4^{g}	0.20^{d}	0.17^{d}	0.19^{g}
	SD	77.6^{g}	75.0^{h}	58.0^{h}	0.20^{d}	0.17^{d}	0.18^{e}

Values followed by different lettering in a column for contaminated and uncontaminated soils are statistically deferent (P< 0.05).OS=spent lubricant oil contaminated, OSBW=OS+ burnt rice mill waste, –soil not contaminated with spent lubricant oil, C-control, BRMW – burnt rice mill waste, SD-saw dust URMW – unburnt or fresh rice mill waste , OSUB= OS+ burnt rice mill waste, OSSD=OS + saw dust, BW= burnt rice mill waste, SD =saw dust , UB = unburnt rice mill waste and C = control.

contaminated with oil (Amadi *et al.,* 1996; Vouto *et al*., 2005) showed that soil water retention, availability and transmission could be improved by oil SCUM in the soil pores. On the other hand, the significant effects of wastes on bulk density and total porosity predisposes the positive effects of wastes on soil water availability and retention since moisture characteristics is structure dependent (Nnabude and Mbagwu, 1999).

The increase in AS recorded in waste amended contaminated and uncontaminated soil relative to OS and C respectively could be as a result of positive influence of organic matter released into the soil. According to Mbagwu (1989) organic matter from wastes bound smaller aggregates into larger ones which Harries *et al.,* (1966) noted was essential for production of good tilth.

Effects of organic wastes on the saturated hydraulic conductivity of spent oil contaminated and uncontaminated soils are shown in table 3. Oil contamination (OS) decreased soil hydraulic conductivity relative to OSBW, OSUB and OSSD – amended soils in the 3 – cropping seasons. In 2006 cropping seasons OS decreased saturated hydraulic conductivity by 14%, 13%

Table 3: Effect of amendments on saturated hydraulic conductivity (HC)

		HC		
	Treatment	**2006**	**2007**	**2008**
contaminated	OS	55^{a}	54^{a}	47^{a}
	OSBW	63^{b}	62^{b}	59.7^{b}
	OSUB	62^{b}	63^{b}	59.1^{b}
	OSSD	59^{c}	58^{c}	58.4^{c}
uncontaminated	C	63^{e}	61^{e}	61^{e}
	BW	73^{f}	72^{f}	72.6^{f}
	UB	72^{g}	70^{g}	69.5^{g}
	SD	69^{h}	69^{g}	68.2^{g}

Values followed by different lettering in a column for contaminated and uncontaminated soils are statistically deferent ($P< 0.05$).OS=spent lubricant oil contaminated, OSBW=OS+ burnt rice mill waste, –soil not contaminated with spent lubricant oil, C-control, BRMW – burnt rice mill waste, SD-saw dust URMW – unburnt or fresh rice mill waste , OSUB= OS+ burnt rice mill waste, OSSD=OS + saw dust, BW= burnt rice mill waste, SD =saw dust , UB = unburnt rice mill waste and C = control.

and 7% relative to OSBW, OSUB and OSSD, amendments, respectively. The Table also showed that amendment of uncontaminated soil with SD, BW and UB, recorded higher saturated conductivity values relative to the control in all seasons. Amendment of uncontaminated soil with BW in 2007 resulted to 15%, 3% and 4% increase in saturated hydraulic conductivity relative to C, UB, and SD-amendments, respectively. Saturated hydraulic conductivity is a measure of how well the soil transmits water under saturated condition (Marshal *et al*., 1996). Higher conductivity implies that the waste amended soil transmits water better under saturated conditions when compared to the contaminated soil. Mbagwu (1989) observed that incorporation of organic wastes significantly increased soil saturated hydraulic conductivity but the magnitude of increase is dependent on the rate of waste application. The higher hydraulic conductivity values recorded in waste amended contaminated and waste amended uncontaminated soils imply lower run-off and erosion in the studied soil.

CONCLUSION

Results of this study showed that the physical conditions of spent lubricant oil contaminated and uncontaminated soils could be improved using organic wastes. Highest improvements in the physical conditions of contaminated and uncontaminated soils were recorded in BW amendment. The use of BW is recommended for improving the physical and structural impediments in the studied soil.

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