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Effect of organic amendment on properties and nutrient loss of soils of selected parent material

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Abstract

Soils of Southeastern Nigeria like those of other humid tropical countries are prone to leaching due to high rainfall resulting in low fertility, nutrient status, and crop yield. Evaluating the effects of selected organic amendments on retention of nutrients in soils is of major concern and formed the purpose of the study. Soil samples were collected from Asu River Group, (ARG), Bende Ameki Group (BAG), Coastal Plain Sand (CPS) and Falsebedded Sand Stone (FBS) which were the four respective parent materials studied. Three replicates of 10 kg of prepared samples from each parent material were bagged and thereafter applied with 10 tons ha^{-1} each of poultry (PD) and goat droppings (PD, GD). The thoroughly mixed combinations laid in a completely randomized design (CRD) were allowed to blend for three months after which, samples were collected from each bag and analyzed. The remaining amended soils were subjected to a rainfall simulation which enabled the collection of sediment yield which was also analyzed to determine the nutrients in them. Generated soil data were analyzed with analyses of variance (ANOVA). Means were separated using the least significant difference (LSD) at 5% probability level. The result showed that soil organic carbon increased from 15.80 – 17.70, 6.90 - 14.20, 7.10 – 13.90 and 11.39 - 17.50 gkg^{-1} in ARG, BAG, CPS and FBS respectively before and after amendment and later decreased to 10.8, 11.30, 6.70, and 8.30 g kg^{-1} in the sediment yield following simulation. Similarly, there were significant losses of about 23.52, 60.85; 60.00 and 47.20 % of total nitrogen to detached soils in the respective lithologies. Total nitrogen and available phosphorus losses in the soils followed the order: CPS > FBS > BAG > ARG and FBS > CPS > BAG > ARG respectively.

Keywords: Erosion, Nutrient retention, Organic amendment, Runoff, Rainfall simulation, Sediment yield.

Introduction

The expanding human population and the need to meet nutritionally her food have made sustainable soil management front line issue of concern globally and in sub-Saharan Africa in particular. Igwe (2000) defined soil as non renewable vital resource whose degradation rate is rapidly high.

Most soils of sub-Saharan Africa are strongly weathered with low nutrient status thus leading to lower crop yields (Juo and Wilding, 1996; Omotayo et al., 2009). Agriculture, in particular, contributes significantly to erosion and sedimentation which are issues of concern globally. Major sediment delivered to Oceans and Rivers are generated through it (Igwe, 2000). A lot of soil nutrients namely nitrogen, phosphorous together with calcium, potassium, magnesium and organic matter are lost on an annual basis through erosion

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(Aoyama et al., 1999) to the extent that they must be replaced by fertilizer. Nutrient loss in soil takes place by various means including runoff and sedimentation (Igwe, 2000, Meena et al., 2017), volatilization, leaching, and crop removal (Enwezor et al., 1981) and can vary with climate, parent material, and land use. Nutrient losses in crop fields under cultivation contribute to degradation (Bertol et al., 2003). Runoff and sediments can be obtained through rainfall simulation processes (Sheikh et al., 2017) where rain fell with controlled duration, intensity and drop size, which are factors that make soil erosion studies difficult (Igwe, 2003).

The poor economic base of the rural farmers who need a low-cost input as an alternative to mineral fertilization to boost harvest makes the use of organic manures eminent. Several researchers (Vitosh et al., 1988; Stewart, 1991; Aoyama et al., 1999; Nyakatawa et al., 2001, Zhou et al., 2018) working under different cropping conditions globally have reported that organic manure addition to the soil improves soil condition by increasing the organic matter content.

Apart from Igwe (2000), studies on nutrient losses in eroded sediments in Nigerian soils are scarce; none is in existence on nutrient retention of the selected soils after application of amendments.

In the above connection, the principal aim of the work was to determine the effect of organic amendments on nutrient retention of soils of selected parent materials under simulated rainfall in southeastern Nigeria.

Other specific objectives include to: ascertain the effect of the amendment on the soil properties, determine the nutrient content of sediments obtained after rainfall simulation, and determine some degree of association that exists among selected soil properties.

Material and Methods

Study location

Soil samples from four parent materials namely, Asu River group (ARG) located on Latitude $5^{0}27^{1}11^{11}$ N and Longitude $7^{0}31^{1}50.04^{11}$E, Bende Ameki Group (BAG) on Latitude $5^{0}53.3.6^{1}$N and Longitude $7^{0}33^{1}$ 16.0^{11}E, Coastal Plain Sand (CPS) or Benin formation on Latitude $5^{0}22^{1}$N and Longitude 7^{0} $9^{1}34^{11}$ E and False bedded Sandstone (FBS) on Latitude $5^{0}50^{1}$N and Longitude $7^{0}16^{1}$E respectively enabled the study to be conducted on research farm of Federal University of Technology Owerri, Nigeria. The farm has its global coordinates as $5^{0}21^{1}21^{11}$ N Latitude and $7^{0}11^{1}01^{11}$E Longitude.

Climatic conditions

The study area belongs to the humid tropical climate. The maximum and minimum temperature is 27ºC and 18ºC all through the year. The annual rainfall ranged from 1500 – 2500 mm (NIMET, 2012). The burning of bush for agriculture and other purposes such as deforestation for timber and allied products (Ibeanu and Umeji, 2003) and increased human population have distorted the natural forest vegetation. The major occupations of the people are rice, cassava; yam and oil palm production and processing, mining and hunting are also practiced.

Experimental design and field studies

Completely randomized design (CRD) was used in laying the research where the four parent material and two organic amendments served as treatments. They were replicated trice. Soil augers were used to collect soil from a depth of 0-15 cm. Collected soil samples were prepared for laboratory analyses by air-drying, and allowing it to pass through 2 mm diameter mesh.

Soil Organic Amendments application

The organic amendments were analyzed before use (Table 1). In a 10kg of soil collected from each parent material, 10 tons ha^{-1} of organic amendment viz: poultry droppings, (PD), goat dropping (GD) separately was applied and thoroughly mixed with the soil after curing. At the end of the experiment after three months, samples were respectively picked from all the pots for analyses where as the rest or remaining samples where used for rainfall simulation.

Table 1. Composition of the amendments used for the study.

Property	Units	Goat dropping	Poultry dropping
pH water		7.25	7.08
Organic carbon	g kg^{-1}	194.50	223.00
Total Nitrogen	g kg^{-1}	18.70	21.10
Available Phosphorus	mg kg^{-1}	1.87	2.10
Exchangeable calcium	$cmolkg^{-1}$	22.23	23.80
Exchangeable magnesium	$cmolkg^{-1}$	15.41	24.41
Exchangeable sodium	$cmolkg^{-1}$	2.18	1.17
Exchangeable potassium	$cmolkg^{-1}$	10.03	3.88

Rainfall simulation

This was carried out according to the procedure of (Meyer and Harmon, 1979; Igwe, 2000). Here, amended soils were packed in a soil bin with dimensions of 30 cm x 10cm x 12 cm. The soil bin was inclined at a slope between 1-2% representing the slope of the area. Rainfall at an intensity of 90 mm hr^{-1} from a height of 2m was allowed to fall on it for a maximum period of 30 minutes. Runoff water was collected in a bowel placed at the opening of the soil bin at every five (5) minutes to avoid overflow. The runoff was allowed to settle for 48 hours to enable sedimentation. Thereafter, sediment yield was air dried, weighed and analyzed.

Laboratory analyses

Grain size was determined by Gee and Or (2002) method. Bulk density was measured as Grossman and Reinsch (2002) recommended. Soil pH was determined in 1:2.5 soil liquid ratios in water and KCl, using pH meter (Hendershort et al., 1993). Organic carbon was determined using wet oxidation method described by Nelson and Sommers (1982). Total nitrogen was determined by Kjeldahl digestion method using concentrated H_2SO_4 and a sodium copper sulfate catalyst mixture (Bremner, 1996). Brady and Weil (1999) documented the method used for effective cation exchange capacity. Available phosphorus was extracted as Bray and Kurtz, (1945) documented. Exchangeable potassium and sodium were extracted with 1N neutral ammonium acetate NH4OAC and determined photometrically using flame photometer (Thomas, 1982). Exchangeable acidity was measured titrimetically (Mclean, 1982). Exchangeable magnesium and calcium were determined using ethylene diamine tetra-acetic acid (EDTA) (Thomas, 1982). Percentage losses were computed as the difference in the amount or value of a property after amendment and that in eroded sediment divided by the amount after amendment multiplied by 100.

Data analyses

Data analyses were carried out with ANOVA. The means that were significant were separated using the least significant difference (LSD) at a probability level of 5%. Correlation was computed using SPSS 15.0 for windows evaluation version (2006).

Results and Discussion

Physical properties of studies soil

The results of the physical properties of the soil before and after amendment are displayed in Tables 2 and 3 respectively. Significant (P<0.05) variations among particle size fractions were observed. Sand proportion ranged from 505.07 to 886.53 gkg^{-1} in ARG and BAG. Clay and silt fractions ranged from 93.67 to 213.04 gkg^{-1} and 12.79 – 348.66 gkg^{-1} in BAG to FBS; CPS and ARG respectively (Table 2). The soils were texturally classified as loam in ARG, loamy sand in BAG and CPS and sandy clay loam in FBS. Agim et al. (2012a), Igwe and Okebalama (2006) reported similar textures in soils of the area. Sandy texture reflects the parent material, (Enwezor et al., 1990), climate (Esser et al. 1992). Clay fraction values were low to intermediate (Ben- Hur et al. 1985) and ranged from 93.67 – 213.04 gkg^{-1} (Table 2). Silt fraction values were low (Akamigbo and Asadu, 1983). Bulk density was significantly (P <0.05) lowest in soils of Falsebedded sandstone 1.43 gcm^{-3} while the highest (1.61) gcm^{-3} occurred in soils under Bende Ameki Group. This result was in tandem with sand and sandy loam textures of the tropics (Mbah, 2006). The higher bulk density found in BAG to that over CPS which is comparable to the results of Chikezie et al. (2010) under the same parent material was due to the gravelly parent material type and their organic matter content. Evanylo and McGuinn (2000) observed that bulk density values of 1.55 to < 1.65 gcm^{-3} can critically affect or restrict root growth and development in silt loams. Low soil bulk density facilitates an increase in pore spaces, root growth, and penetration and infiltration capacities.

Table 2. Mean values of physical properties of studied soils before amendment.

PM	sand, gkg^{-1}	silt, gkg^{-1}	clay, gkg^{-1}	textural class	SCR	Dℓb, g/cm^3	TP, %
ARG	505.07	348.66	146.27	L	2.38	1.47	44.61
BAG	886.53	19.80	93.67	LS	0.21	1.61	39.33
CPS	874.67	12.79	112.54	LS	0.11	1.58	40.46
FBS	545.06	241.90	213.04	SCL	1.13	1.43	46.11
LSD (P<0.05)	23.23*	NS	11.19*		0.02*	0.21*	1.20*

ARG=Asu River Group, BAG=Bende Ameki, Group, CPS=Coastal plain sand, FBS=Falsebedded sandstone, Dℓb =Bulk density, TP=Total Porosity, L=loam, SL=Sandy loam, SCL=Sandy clay loam, LSD=Least significant difference, *=significant, NS=Not significant.

On the other hand, there were significant (P<0.05) lower sand fraction in all locations following amendment (Table 3). Silt fraction was lower in ARG (348.66 - 285.09 gkg^{-1}) and FBS (241.90 – 198.60 gkg^{-1}) compared to BAG (19.80 -94.62 gkg^{-1}) and (12.79-77.42 gkg^{-1}) in CPS after amendment Table 3 respectively. Recorded values of percentage sand, silt and clay fractions found in amended soils were in line with the finding of Ewulo et al. (2008) and Mbagwu, (1992). Bulk density had significant (P<0.05) lower values recorded in poultry than in goat droppings amended soil with exception of ARG soil were the same value was recorded. (Table 3).

Table 3.Effect of organic amendment on physical properties.

PM	O A	Sand, gkg^{-1}	Silt, gkg^{-1}	Clay, gkg^{-1}	Textural class	Dℓb, gcm^{-3}	TP, %
ARG	GD	400.20	260.03	240.17	SCL	1.41	46.87
	PD	478.00	310.16	211.84	SCL	1.41	46.87
	LSD(P<0.05)	20.33*	11.32*	3.22*		NS	NS
	Mean	439.10	285.09	226.01	SCL	1.41	46.87
BAG	GD	811.93	104.59	83.45	LS	1.61	39.34
	PD	809.15	84.65	106.20	LS	1.58	40.47
	LSD(P<0.05)	17.22*	20.34*	4.33*		0.67*	2.33*
	Mean	810.54	94.62	94.83	LS	1.59	40.00
CPS	GD	875.66	39.12	85.55	LS	1.52	42.72
	PD	717.12	115.71	167.15	SL	1.49	43.86
	LSD(P<0.05)	16.44*	23.33*	11.23*		0.03*	1.65*
	Mean	796.39	77.42	126.35	SL	1.51	48.70
FBS	GD	572.08	210.00	217.92	SCL	1.41	46.87
	PD	577.20	187.20	235.60	SCL	1.38	48.00
	LSD(P<0.05)	15.78*	24.44*	10.12*		0.32*	1.2
	Mean	574.64	198.60	226.76	SCL	1.39	47.44
*LSD (P<0.05)		23.34*	NS	7.44*		0.02*	1.23*

Dℓb =Bulk density ,TP=Total Porosity, SL=Sandy loam, SCL=Sandy clay loam, LS=Loamy sand, LSD=Least significant difference, *=significant, NS=Not significant,.*LSD=Least significant difference separating the means.

Soil chemical properties

The results of the chemical properties of studied soil before and after amendment are presented in Tables 4 and 5 respectively. Result noted significant differences (P<0.05) in soil pH. Soil in BAG had highest pH (5.48) while that under FBS had lowest pH (4.74) (Table 4). These results were rated medium which is mostly the preferred range for most crops. Lower values indicate possibility of aluminum toxicity (Landon, 1991). Soil organic carbon differed significantly (P < 0.05) with the highest value 15.80 gkg^{-1} occuring in ARG while BAG had the least 12.4 gkg^{-1} (Table 4). Effective cation exchange capacity showed significantly higher values in soils of Bende Ameki Group 8.85 $cmolkg^{-1}$ and least in CPS 3.84 $cmolkg^{-1}$. The results are similar to that of Agim, 2016. The soil organic matter which was generally very low, less than 12 gkg^{-1} except in ARG is typical of the soil of the area (Landon,1991). The low soil organic carbon was as a result of its fast mineralization rates as Stewart (1991) opined. Total nitrogen varied significantly (P< 0.05) among parent material and ranged from 0.6 – 1.40 gkg^{-1}. The values were rated very low in comparison to the value of 1.5gkg^{-1} critical and are typical of tropical soils (Landon, 1991). Effective cation exchange capacity followed the trend ARG > BAG>FBS>CPS (Table 4). Values of ECEC less than 5 and between 5-15 $cmolkg^{-1}$ are quoted by Landon (1991) as very low to low. These values are below the critical limits for soils of Southeastern Nigeria (Enwezor et al., 1990), suggesting poor fertility status of the soil.

Table 4. Mean values of the initial chemical properties of studied soils before amendment.

PM	pH	SOC	TN	AP,	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	TEB	TEA	ECEC
		gkg^{-1}		$mgkg^{-1}$	$cmolkg^{-1}$						
ARG	4.93	15.80	1.40	5.40	2.53	1.67	0.12	0.29	4.61	2.92	7.53
BAG	5.48	6.90	1.10	4.00	3.90	1.87	0.10	0.26	6.13	2.72	8.85
CPS	5.08	7.10	0.60	2.10	0.96	0.47	0.10	0.24	1.77	2.07	3.84
FBS	4.74	11.30	1.00	3.11	1.41	2.13	0.12	0.26	3.92	2.33	6.25
LSD (P<0.05)	0.33*	0.41*	0.05*	NS	0.21*	0.14*	NS	NS	0.95*	0.27*	1.75*

PM=Parent material, NS= Not significant, *=Significant at 5% probability level; *LSD=Least significant difference, TEA=Total exchangeable acidity, TEB=Total exchangeable bases, SOC=Soil organic carbon, TN=Total Nitrogen, AP=Available phosphorus.

Effect of organic amendment on chemical properties of studied soils

Soil pH was significantly (P<0.05) increased after amendment in all studied soils. The result followed the trend BAG>CPS>ARG>FBS (Table 5) respectively. The increased soil pH as a result of the applied amendments supports the findings of Egball (2002) and Mucheru (2003). The rise in soil pH could have been caused by the masking of hydrogen ion by the amendment. This has the capability of controlling the buffer characteristics as well as the ability to neutralize soil acidity (Wong et al., 1998) by increasing the basic cations in the soil. The Goat dropping increased soil pH more in soils of BAG and FBS than poultry dropping which had better performance in soils of ARG. The result is in line with (Aoyama et al., 1999; Mbah and Mbagwu, 2006, Akanni and Ojeniyi, 2008; Adeleye et al., 2010). This result could be attributed to the reduction of aluminum ions concentration in soil solution and in exchangeable sites as a result of exchangeable calcium content of the goat dropping. Increase in soil pH encourages nitrification by increasing bacterial activity and nitrification of organic matter.

Table 5. Effect of poultry dropping and goat dropping on the studied soil after amendment

PM	O.A	pH	SOC	TN	AP	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	TEA	ECEC
			gkg^{-1}		$mgkg^{-1}$	$cmolkg^{-1}$					
ARG	GD	5.35	17.90	1.80	18.65	3.72	1.59	0.13	0.28	2.04	7.76
	PD	5.41	17.40	1.50	18.22	3.50	1.45	0.13	0.34	2.32	7.74
	LSD(P<0.05)	0.02*	NS	0.45*	NS	0.04*	0.03*	NS	NS	1.10	0.22
	Mean	5.38	17.70	1.70	18.44	3.61	1.52	0.13	0.31	2.18	7.75
BAG	GD	5.59	13.30	1.30	15.72	4.52	2.09	0.11	0.30	1.67	8.69
	PD	5.53	15.50	1.90	15.21	4.29	2.05	0.11	0.29	1.69	8.43
	LSD(P<0.05)	1.10	1.00	0.87	0.31	1.13	NS	NS	NS	NS	0.21
	Mean	5.56	14.20	1.60	15.46	4.41	2.07	0.11	0.30	1.68	8.57
CPS	GD	5.52	15.40	1.30	12.20	1.75	0.87	0.11	0.26	1.70	4.69
	PD	5.52	12.50	1.60	13.07	1.76	0.64	0.12	0.27	1.55	4.34
	LSD(P<0.05)	NS	1.11	0.31	0.76	NS	0.01	NS	NS	0.02	1.00
	Mean	5.52	13.90	1.50	12.64	1.74	0.76	0.12	0.27	1.63	4.52
FBS	GD	5.58	19.40	1.80	12.92	6.53	3.87	0.12	0.29	1.36	12.17
	PD	5.53	15.60	1.40	13.66	5.60	4.09	0.12	0.32	1.19	11.32
	LSD(P<0.05)	0.32	2.11	0.05	0.22	1.00	0.24	NS	0.43	1.55	2.76
	Mean	5.56	17.50	1.61	13.29	6.07	3.98	0.12	0.31	1.27	11.75
*LSD(P<0.05)		0.27*	0.05*	NS	NS	1.00*	NS	NS	NS	NS	1.20*

PM=Parent material, ,O.A.=Organic amendment, GD=Goat dropping, PD=Poultry dropping, NS= Not significant, *=Significant at 5% probability level; LSD=Least significant difference, TEA=Total exchangeable acidity, TEB=Total exchangeable bases, BS=Base saturation, SOC=Soil organic carbon, TN=Total Nitrogen, AP=Available phosphorus.

Similar to soil pH, organic carbon significantly (P<0.05) increased compared to their initial values in the following order: ARG (15.80 – 17.70 gkg^{-1}) > FBS (11.30 –17.50) > CPS (7.10–13.90) > Bende (6.90–14.20 gkg^{-1}) (Table 4 and 5) respectively. Agim, (2016) had a similar result. Studies of Aoyama et al. (1999), Nyakatawa et al. (2001), Ayeni et al. (2008), Mbah and Onweremadu (2009) and Uwah et al, (2014) reported increase in SOC upon the use of manure as amendment. Rise et al. (2006) ascribed the increased soil organic carbon through application of amendment to decomposition of organic manure. Organic matter plays major roles in moisture retention, nutrient availability, an increase in the exchange sites of soil. Apart from the above, it encourages aggregation and reduces erosion, etc. On the other hand, goat dropping increased soil organic carbon in soils of ARG, CPS, and FBS compared to poultry droppings. Boateng et al. (2006) observed a decrease in soil SOC following poultry manure application. Phosphorus and nitrogen were affected significantly (P<0.05) by amendments compared to their initial values before the commencement of the study. The values after amendment in some of the soils were a little above the key value of 1.5 g kg^{-1} (Senjobi and Ogunkunle, 2011; Ahukemere et al., 2012). Similarly, values of available phosphorus in soils of ARG and BAG (18.44 and 15.46 $mgkg^{-1}$) (Table 5) after the amendment were above the critical values of 15 $mgkg^{-1}$ for southeastern Nigeria soils as documented by Enwezor et al. (1990). Those of CPS and FBS (12.64 and 13.29 $mgkg^{-1}$) were below the critical limits above but better than those without amendment (Table 4). Increased total nitrogen and available phosphorus following amendment is a reflection of parent material, organic manure decomposition, land use etc. Uwah et al. (2014) attributed increased N and P following amendment to increase in microbial activities leading to the enhanced decomposition of the organic forms of N and P. Goat dropping improved total nitrogen in ARG and FBS more than poultry dropping which gave better results in CPS and BAG. Poultry dropping gave better results in ARG and BAG with respect to available phosphorous while goat dropping performed better in improving the phosphorus status of the soil in CPS and FBS (Table 5). The result is similar to Akanni and Ojeniyi (2008) who noted the highest available levels of nitrogen and phosphorus in poultry manure-amended soil compared to other animal manures. Total exchangeable bases (TEB) which were higher in amended soil ranged from 2.89 -10.48 cmolkg^{-1} in CPS and FBS (Table 4) . Higher values reflect the level of acidity of the soil.

Result also showed that the values of effective cation exchange capacity were low (Landon 1991), however, improved values were recorded in amended soils compared to their initial values in the following order: ARG (7.53-7.75 cmolkg^{-1}) > FBS (6.25–11.75 cmolkg^{-1}) > BAG (8.85–8.57 cmolkg^{-1}) > CPS (3.84–4.52 cmolkg^{-1}) respectively (Table 3 and 4). The lower values of ECEC are indication of soil's poor retention of nutrients and water. Result also showed that goat dropping contributed significantly to effective cation exchange capacity than poultry dropping. Mbagwu (1992) and Agim (2016), in their study of the area found that goat dropping contributed higher CEC compared to unburned and burnt rice husks. Magnesium and calcium dominated the exchange sites as indicated by the result of ECEC.

Chemical properties of sediments following rainfall simulation

The result of the effect of organic amendment on chemical parameters of the sediments is recorded in Table 6. The result showed that soil nutrients are washed out from the farm through runoff water. Soil pH has significantly (P <0.05) lower values in detached soil particles compared to that found after amendment in all studied soil. The trend is closely related to the pH of the original soil and was attributable to rainfall which causes leaching. Soil organic carbon decreased from 17.70 gkg-1 after amendment (Table 5) to 10.80 gkg^{-1} (Table 6) translating to 38.98 % loss in eroded sediments in ARG, (14.20 to 11.30 gkg^{-1} about 22.81% loss in BAG, 13.90 – 6.70, about 51.86 % loss in CPS and 17.50 to 8.30 gkg^{-1} about 26.95 % loss in FBS respectively. The status of organic matter and nitrogen in soils is taken as an indicator of soil fertility and soil quality (Ahukaemere et al., 2012), and their loss could be detrimental to crop growth and development and high erosion. Loss of organic matter from the soil leads to low soil structure, high bulk density, low CEC, high runoff and thus high erosion. FAO (1978) reported that a decrease in soil organic matter could lead to fast biological diminution of the soil. Organic matter plays very crucial roles in the exchange complex of tropical soils which is adjudged to be very low in clay activity.

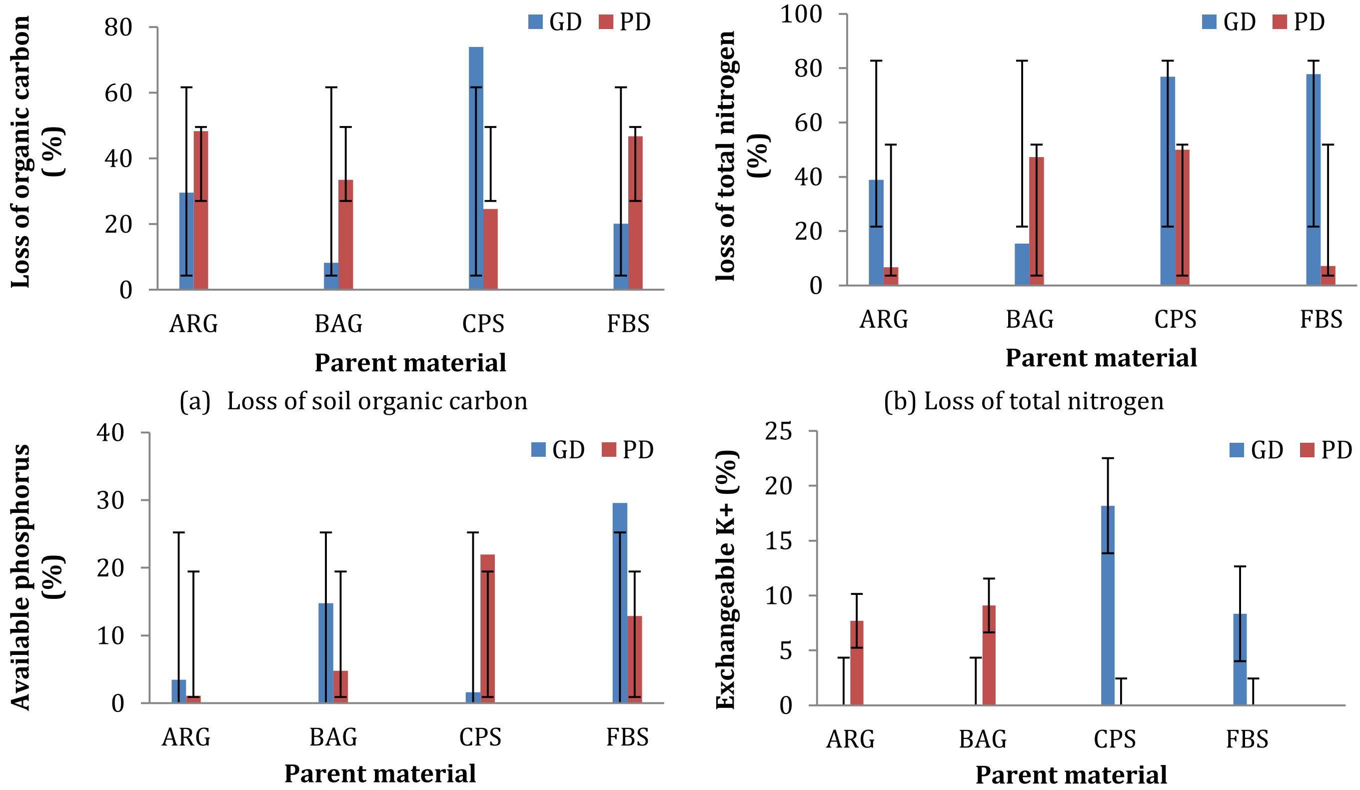
Table 6. Effect of amendment on sediment yield following rainfall simulation.

PM	O.A	pH	SOC	TN	AP	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	TEA	ECEC
			gkg^{-1}		mgkg^{-1}	cmolkg^{-1}					
ARG	GD	5.95	12.66	1.10	18.00	2.80	0.56	0.13	0.19	0.24	3.92
	PD	5.29	9.00	1.40	18.20	3.50	1.07	0.12	0.14	0.28	5.11
	LSD(P<0.05)	0.66*	2.33*	0.07*	NS	0.43*	0.06*	0.04*	0.22*	NS	1.00*
	Mean	5.62	10.80	1.30	18.10	3.15	0.82	0.12	0.17	0.26	4.52
BAG	GD	6.19	12.20	1.10	13.40	3.20	1.33	0.11	0.10	0.72	5.46
	PD	6.09	10.30	1.00	14.48	3.60	1.67	0.09	0.13	0.44	5.93
	LSD(P<0.05)	0.06*	1.34*	NS	0.06*	NS	0.23*	0.54*	NS	NS	0.05*
	Mean	6.14	11.30	1.10	14.10	3.40	1.50	0.10	0.12	0.58	5.70
CPS	GD	5.91	4.01	0.30	12.00	1.04	0.64	0.09	0.06	0.16	1.99
	PD	5.83	9.42	0.80	10.20	1.12	0.76	0.08	0.12	0.16	2.24
	LSD(P<0.05)	1.10*	0.45*	0.09*	1.32*	NS	0.03*	NS	0.04*	NS	0.45*
	Mean	5.87	6.70	0.60	11.10	1.08	0.70	0.09	0.09	0.16	2.12
FBS	GD	5.64	9.00	0.40	9.10	2.68	0.33	0.11	0.15	0.32	3.59
	PD	5.32	14.90	1.30	11.90	3.10	3.00	0.12	0.13	0.24	6.59
	LSD(P<0.05)	1.98*	2.10*	0.04*	1.15*	1.00*	2.32*	NS	0.06*	NS	2.11*
	Mean	5.48	8.30	0.85	10.50	2.89	1.67	0.12	0.14	0.28	5.10
*LSD(P<0.05)		1.2*	0.22*	NS	1.65*	NS	0.003*	NS	NS	NS	0.98*

PM=Parent material, O.A=Organic amendment, NS= Not significant, *=Significant at 5% probability level; LSD=Least significant difference,*LSD= Least significant different separating the means, AP=Available phosphorus, TEA=Total exchangeable acidity, TEB=Total exchangeable bases, BS=Base saturation,*=Significant at 5% probability level.

Comparison of nutrient loss from studied soil to effect of organic amendment applied

In comparison to the level of nutrients loss following rainfall simulation, between the two organic amendments used, higher losses of organic carbon were noted in poultry dropping amended soil under ARG, BAG, and in FBS respectively while the reverse was the case for CPS (Figure 1a). Boateng et al., (2006) observed lower levels of SOC in soil amended with poultry dropping. On the other hand, Kibet et al. (2014) found a similar trend in soil detached from Central Southeast Nigeria though not in amended soil. The level of organic matter retention in these soils is very important owing to its function on aggregate stability, water retention, maintenance of soil tilth and minimizing erosion. Result also showed loss of total nitrogen though not significant in detached soil particles following simulation (Figures 1c). Poultry dropping trapped more of total nitrogen on ARG, CPS, and FBS than that of goat dropping in soil under BAG (Figure 1b). Kibet et al. (2014) attributed high loss of nitrogen in eroded sediments to their high dissolution in water which mobilizes it irrespective of the quantity in the soil. They found a mean value of 0.071 kg ha^{-1} after 120 minutes of continuous dry and wet runs of high-intensity rainfall. Awodum et al. (2007) found increased nitrogen, phosphorus potassium, calcium and pH, in soil amended with goat dropping compared to NPK fertilizer. Available phosphorus loss followed the trend: ARG, BAG, and FBS under goat dropping amended and CPS under poultry dropping amended soil (Figure 1c). Loss of phosphorus in the eroded sediments is attributed to its absorption to the soil complex and poses a greater risk because of euthrophication if deposited in rivers. Phosphorus is an essential plant nutrient necessary for higher plant yield, therefore the application of P fertilizer to the soil especially when tilled during high rainfall should be minimized to avoid washing away through runoff to rivers and oceans thus causing pollution lowering their quality.



(a) Loss of soil organic carbon (b) Loss of total nitrogen (c) Loss of available phosphorus (d) Loss of exchangeable K^+

Figure 1. Loss of soil nutrients from amended soil following simulation.

Correlation of organic carbon with selected soil properties.

In Table 7, the relationship or correlation between organic carbon and selected soil properties are shown. Significant ($P<0.05$) positive relationships of soil organic carbon with total nitrogen (r^2 = 0.35), available phosphorus (r^2 = 0.39) clay fraction (r^2 = 0.55) and effective cation exchange capacity (r^2 = 0.23) respectively and negatively related to bulk density (r^2 = -0.55). The negative value obtained between soil organic carbon and bulk density is an indication of dissociation that exists between them. The other results showed that about 35%, 39%, 55% and 23 % of the value of total nitrogen, phosphorus, clay, and effective cation exchange capacity are contributed by organic matter all things being equal (Agim et al., 2012a,b) found a similar relationship between soil organic carbon and other properties.

Table 7.Correlation of soil organic carbon with selected soil properties.

Soil property	Correlation coefficient. (r^2)	Level of Significance 5%
pH H_2O	0.21	Significant
Organic carbon	0.99	Highly significant
Total Nitrogen	0.35	Significant
Available Phosphorus	0.39	Significant
Effective cation exchange capacity	0.23	Significant
Clay fraction	0.55	Significant
Bulk density	-0.55	Highly significant
Total porosity	0.30	Significant

Conclusion

The study showed significant improvement in soil properties following organic amendments. There were significant losses of in eroded sediments which followed the order: CPS>ARG>FBS>BAG. With respect to soil nutrient retention by organic amendments, goat dropping prevented more of the soil nutrients from washing away from the studied soil than that of poultry dropping. We recommend that organic amendments especially goat dropping be applied in our soils, practices such as contour bonds that will trap sediment on site be adopted in the farm. Afforestation and mulching should be practiced in order to reduce the direct impact of rainfall on the soil be carried out.

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