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Sediment yield, detachment, and runoff from soil under selected parent materials in Southeastern Nigeria.

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ABSTRACT

Soil degradation due to water erosion among other causes has been a major problem in southeastern Nigeria, therefore a study was conducted to determine sediment yield, detachment, and runoff from soil under selected parent material in southeastern Nigeria. The objective was to characterize the selected soils in terms of their physical and chemical parameters, carry out rainfall simulation, and to establish some relationships that exist among studied parameters with selected soil properties. Soil samples were collected in three replicates from twenty locations, 5 location each from 4 geologic formations namely Asu River Group, Bende Ameki Group, Coastal Plain Sand and False bedded Sandstone at a depth of 0 – 20 cm using soil auger. Standard laboratory procedures were followed for samples for routine analyses while the rest was subjected to rainfall simulation at an intensity of 190 mm / hr for a period of 30 minutes under dry and wet conditions of the soils. Result showed that significant P<0.05) differences among studied parameters. Sediment yield under wet and dry states ranged from 0.56 - 3.95 kg m^{-2} hr^{-1} and from 0.80 - 4.97 kg $m^{-2}hr^{-1}$. The highest sediment yield under both conditions was recorded at Ishiagu, Bende, Obinze and Okigwe from ARG, BAG, CPS and FBS derived parent materials, respectively. Detachment under both conditions ranged from 0.04 - 0.13 kg $m^{-2}hr^{-1}$ and from 0.03 - 0.21 kg m^{-2} hr^{-1}. Similarly, runoff ranged from 79.80 - 125.30 mm and 28.00 – 106.90 mm under wet and dry states. Result also indicated a negative relationship between clay fraction and sediment yield (r= - 0.62) under dry and (r= - 0.27) under wet condition. Conclusively, the study noted that rainfall has great impact on studied soils as higher values of sediment yield and detachment were noted mostly under dry than in wet conditions.

1. Introduction

Soil erosion as one form of soil degradation (Lal, 2009) is a global problem, impacting soil quality, health, productivity and the environment (Jakab and Szalai, 2005). Erosion has direct and indirect impacts, often directly affecting the overall quality and fertility of the soil mostly by loss of the A horizon (Gao et al. 2011; Olson et al. 1994) in the first instance and leads to increased sedimentation and turbidity, increased levels of nutrients and pollutants that diminish water quality, siltation of dams and irrigation channels (Craswell et al. 1998, Duvert et al. 2010; Hopmans et al. 1987; Pimentel et al. 1995), and a decrease in the abundance of aquatic life (Danielsen and Schumacher, 1997), eutrophication (Goldsman et al. 1986) in the later. Water erosion may be a three-phase method, consisting of the detachment of individual particles from the soil mass, their transport by erosive agents, and when sufficient energy is no longer available to transport the particles, deposition (sedimentation) of eroded particles takes place (Brady and Weil, 2009). It has been documented that the eroded soil is not only finer but more abundant in nutrients than the original soil (Menzel, 1980). Rainfall of different intensities is responsible for soil erosion and nutrient loss in humid tropical countries such as Nigeria (Igwe, 2003) and elsewhere (Blanco & Lal, 2010).

The unpredictable and infrequent nature of rain makes it difficult to study its eroding effects on soils while it is raining (Grismer and Davis, 2012). To overcome these difficulties, rainfall simulators which enable the precise application of artificial rain with controlled drop sizes, intensity, and duration, can be used to capture runoff and erosion rates both in the field and laboratory (Grismer and Davis, 2012). Rainfall simulators have been used by several authors to study erosion in Nigeria (Igwe, 2000, Osuji, 2001) and elsewhere; (Bashari *et al.* 2013). However, the advantages and disadvantages of these approaches have been the subject of some debate (Hartanto et al. 2003). One great constant concerning soil is their geographic variability in response to the factors of soil formation as climate, topography, parent materials, organism and time (Brady and Weil, 1999). The geology of the soil plays a direct and indirect influence on erosion formation. Parent materials of shale type are regarded as problematic soils. It exhibits a broad spectrum of geotechnical behavior and has often been a source of concern on the environment, are of low erodibility resulting in the absence or near absence of deep gully cut (Aghamelu *et al.* 2011). Runoff and sediment yield research (Jakab and Szalai, 2005) are essential in protecting our valuable arable lands. The analysis of soil parameters is vital for higher management practices to save lots of nutrients, soils, money, time and to shield the atmosphere (Jordan *et al.* 2005). Therefore, the study was aimed to study sediment yield, detachment and runoff from soil under selected parent materials in southeastern Nigeria. Other sub-objectives include determining some relationships that exist between studied erosion parameters and selected soil properties.

2.0 Materials and methods

2.1 Study Area

The study covered 20 locations five each from four selected geologic formations in Imo, Abia and Ebonyi States of Nigeria lying between latitudes $4^0 40'$ - $8^0 15'$N and longitudes $6^0 40'$ - $8^0 15'$ E. Individual location specific geographic positions are presented in Table 1.

Geology

The major geological materials in the area include the Asu River Group, Bende Ameki Group, Coastal Plain Sand, and False-bedded Sandstones. Others include: Upper Coal Measures, Imo Clay Shale, etc. (Orajaka, 1975, Jungerius, 1964). The area is predominantly lowlands with highlands above 200 meters above sea level (Ofomata, 1975).

Climatic conditions

The study areas like other humid tropical environment is warm all the year round (Anyadike, 2002) with dry and wet seasons. Mean annual rainfall with high intensity ranges from 2000 - 2500 mm, (Munanu, 1975a) while annual temperatures and humidity ranged from 26 - 29^{o}C and 80 % - 90 % respectively (Munanu, 1975b). The major vegetation is a tropical forest (Anyadike, 2002), which has been tampered by anthropogenic activities. There also exists forest-savanna vegetations and freshwater swamp around Afikpo, Akeze, Abakiliki, Okigwe and within the Riverine areas.

Landuse

The dominant land use is shifting cultivation or bush fallow system which has been drastically reduced due to increased population (Federal Department of Agricultural Land Resources 1990).

2.2 Sampling technique:

Random sampling technique was used to select sampling points in three replicates making a total of 60 samples used for the study. Core rings were used to collect soil samples for bulk density while soil auger was used in sample collection from 0-20 cm. Collected soil samples were put into a polythene bag, properly labeled, air-dried, crushed and sieved using 2-mm sieve. Coordinates measurement were achieved with the use of a Hand held Global Positioning System-GPS Receiver-Garmin Ltd Kansas USA

2.3 Experimental design.

The experiment was arranged in Randomized complete block design (RCBD) with two treatments or factors namely parent material and location.

2.4. Rainfall Simulation

Rainfall simulation was carried out according to the procedure of (Meyer and Harmon, 1979; Osuji, 1985; Igwe, 2000 and Osuji, 2001.) where soil samples were collected, sieved and packed in a soil bin with dimensions of 30 cm * 10cm * 12 cm. The soil bin was inclined at a slope between 1-2 % representing the slope of the area. Rainfall at intensity of 190mmhr^{-1} was allowed to fall on it for a maximum period of 30 minutes. The height of fall is 2 meters. At a every 5 minutes, runoff water was collected in a bowel placed at the opening of the soil bin. Runoff water was allowed to settle for 48 hours to enable adequate sedimentation after which runoff was decanted and measured with a measuring cylinder, while the sediments were air dried and weighed. Detached or splash soil particles were collected around the soil bin and weighed. The time was taken using a stopwatch.Percentage runoff was calculated from the formula R / Qw X 100 ……………………………(1)

2.5. Laboratory analyses

The particle size distribution was determined by the hydrometer method according to the procedure of (Gee and Or, 2002). Bulk density; was measured by core methods as Grossman and Reinsch (2002) recommended. Soil pH was determined in 1:2.5 soil liquid ratios in water using pH meter (Hendershot *et al.,* 1993). Organic carbon was determined using wet oxidation method described by (Nelson and Sommers 1982).

2.7. Data Analyses

Generated data were analyzed using ANOVA, and significant means were separated using LSD at 5 % probability level.

Table 1: Studied locations and their geographical coordinates.

S/no	Location	Elevation (meters)	Geographical coordinates	Geologic formation	State
1	Akaeze	70	5^0 54'31"N and 7^0 38'51"E	Asu River group	Ebonyi
2	Ishiagu	89	5^0 27'11"N and 7^0 31'50.04"E	Asu River group	Ebonyi
3	Isu	129	6^0 08' 34.1" N and 7^0 48' 04.9" E	Asu Rivier group	Ebonyi
4	Onicha	76	$6^0$02'58.57"N and 7^0 46 '48.20" E	Asu River group	Ebonyi
5	Ubulu	67	6^0 01' 46.6"E and 7^0 45 '46.20" E	Asu River group	Ebonyi
6	Bende	118	$5^0$33'35.6" N and 7^0 33'16.0" E	Bende Ameki group	Abia
7	Ameki	121	$5^0$38' 33"N and $7^0$42'.09"E	Bende Ameki group	Abia
8	Uzoitem	124	$5^0$35'40"N and $7^0$38'16.6"E	Bende Ameki group	Abia
9	Uzoakoli	165	$5^0$38'10.2" E and $7^0$33'32.1" N	Bende Ameki group	Abia
10	Ndiokorie	131	$5^0$32'10.8"E and 7 ^{0} 37' 47.4"N	Bende Ameki group	Abia
11	Umualumaku	154	$5^0$37'23.3" N and $7^0$17 '57.8"E	Coastal plain sand	Imo
12	Osisioma	162	5^0 08' 23.3" N and $7^0$19' 32.10" E	Coastal plain sand	Abia
13	Umuagwo	187	$5^0$18 13.43' N and $6^0$55' 32.12 " E	Coastal plain sand	Imo
14	Awo	167	5^0 40' 33"N and 7 ^{0}56'10.8"E	Coastal plain sand	Imo
15	Obinze	180	5^0 22'23.3"N and 7^0 9'34"E	Coastal plain sand	Imo
16	Okigwe	120	5 ^{0} 50'N and 7^0 16'E	Falsebedded sand	Imo
17	Umulolo	121	$5^0$47' 38.9 "N and $7^0$17'28.61"E	Falsebedded sand	Imo
18	Akaokwa	148	5 ^{0}54' 43.06" N and 7^0 08' 34.43" E	Falsebedded sand	Imo
19	Acha	120	$5^0$49 04 N and $7^0$30' 30" E	Falsebedded sand	Abia
20	Obinaohia	110	$5^0$45 17.6N and $7^0$3207.4 E	Falsebedded sand	Abia

3. Result and Discussion

The result of selected physical and chemical properties is presented in Table 2. Result showed that the texture of the studied soil ranged from sandy clay loam (SCL) to loam in Asu River Group (ARG), loamy sand to loam in Bende Ameki Group (BAG), Sandy loam (SL) to sand in Coastal plain sand (CPS) and sandy loam to loam false-bedded sand (FBS) (Table 2). This result reflects the geologic formation and is typical of the soils of southeastern Nigeria (Igwe, 1995). The textural classification of the studied soil is in line with Smyth and Montgomery, (1962) Ashaye, (1969) in Western Nigeria and Eshett, (1985) in Eastern Nigeria who opined that the texture of surface horizon of soils of the humid tropics is dominantly loamy sand to sandy loam. Generally, bulk density ranges from 1.41 - 1.62 g cm^{-3} at Umulolo and Bende with a mean of 1.50 g cm^{-3} and C.V of 12.00%. There were no significant differences ($P \leq 0.05$) in bulk density across the different locations studied. However, with respect to the individual geologic formations, the highest and lowest values of bulk density in soils under ARG occurred at Onicha 1.56 g cm^{-3} and Akaeze 1.44 g cm^{-3}, in soils under BAG they were found at Obinze 1.59 g cm^{-3} and in Ameke 1.51 g cm^{-3} on soils under false bedded sand, bulk density was found to be highest at Okigwe 1.53 g cm^{-3} and in Obinaohia 1.48 g cm^{-3} respectively. The higher bulk density found in soil's of Bende Ameki group to that over coastal plain sand is similar to the findings of Chikezie *et al.,* (2010) under the same parent material. These values were similar to those recorded of tropical soils (Landon, 1991).

Sediment yield under wet and dry runs or conditions are presented in Table 3. The result showed that sediment yield under dry runs differed significantly ($P \leq 0.05$) with parent material and studied location while that under wet runs only differed in soils under Asu River and Bende Ameki Groups at the same level of probability. Sediment yield was generally higher in dry than in wet run Figure 1 with exception to the result of Onicha and Ubulu, Uzoakoli and Ndiokorie, Umuagwo and Awo. Igwe (2000) obtained similar results in southeastern Nigeria suggesting that soil erosion occurs more when the soil is dry and could be checked before the inception of rain. Sediment yield under wet conditions ranged from 0.56 – 3.95 kg $m^{-2}hr^{-1}$ with a mean of 2.46 kg

Table 2.0: Mean values of selected physical and Chemical properties of studied soil.

P.M	LCTN	Sand	Silt	Clay	TC	BD	pH(water)	SOC
			g/kg			g/cm^3		g/kg
ARG	Akaeze	421.33	406.13	172.54	L	1.44	4.97	1.35
	Ishiagu	505.07	348.66	146.27	L	1.47	4.93	1.58
	Isu	762.34	127.26	110.40	SL	1.54	5.63	0.73
	Onicha	760.07	117.66	122.27	SL	1.56	5.59	1.31
	Ubulu	648.80	140.00	211.20	SCL	1.45	5.71	1.24
	LSD(P≤ 0.05)	**87.73***	**NS**	**51.65***		**NS**	**0.13***	**0.79***
PM x Location		**NS**	**NS**	**NS**		**NS**	**0.09***	**0.12***
BAG	Bende	886.53	19.80	93.67	LS	1.62	5.48	1.16
	Ameke	762.39	76.17	161.44	SL	1.51	4.95	1.03
	Uzoitem	826.20	73.36	100.44	LS	1.59	5.13	1.08
	Uzoakoli	855.73	51.27	93.00	L	1.61	5.08	1.08
	Ndiokorie	852.67	30.93	116.40	SL	1.57	5.67	1.12
	LSD(P≤ 0.05)	**14.21***	**0.42***	**53.77***		**NS**	**NS**	**NS**
PM x Location		**20.22***	**NS**	**NS**		**NS**	**NS**	**NS**
CPS	Umalumaku	802.67	68.53	158.80	SL	1.52	5.24	0.97
	Osisioma	785.34	52.46	163.67	SL	1.51	5.13	1.25
	Umuagwo	805.60	49.80	144.60	SL	1.54	5.34	1.08
	Awo	805.67	17.89	149.11	SL	1.53	5.39	0.79
	Obinze	874.67	12.79	112.54	SL	1.59	5.08	0.72
	LSD(P≤ 0.05)	**64.75***	**1.37***	**NS**		**NS**	**NS**	**0.42***
PM x Location		**11.65***	**NS**	**NS**		**NS**	**NS**	**0.04***
FBS	Okigwe	654.00	225.59	120.41	SL	1.53	4.74	1.14
	Umulolo	545.06	241.90	213.04	SCL	1.41	5.11	1.72
	Akaokwa	774.5	67.23	158.27	SL	1.51	4.99	0.99
	Acha	671.73	175.20	153.07	SL	1.50	5.75	1.65
	Obinaohia	498.83	360.96	140.21	L	1.48	5.35	1.92
	LSD(P≤0.05)	**71.60***	**0.41***	**42.21***		**0.05***	**0.27***	**0.41***
	***LSD (P ≤0.05)**	**165.5***	**7.21***	**49.36***		**NS**	**0.39**	0.68
PM x Location		**22.22***	**NS**	**NS**		**NS**	**0.04***	**0.12***
	CV(%)	**14.1**	**66.5**	**20.20**		**12.00**	**4.50**	19.90

P.M=Parent material, X= Treatment interactions, ARG=Asu River group, BAG=Bende Ameke Group, CPS=Coastal plain sand, FBS=False bedded sand, LSD=Least significant difference,*LSD= Least significant difference comparing one geologic formation from another, * Significant at 5% probability level, C.V=Coefficient of variation, S.E=Standard error, ** Highly significant at 5 % probability.C.V=Coefficient of variation (CV% ranking: HV=High variation=50-100% , MV=Moderate variation =20-49%, LV=Little variation 1-19%).

Table 3. Mean values of Sediment yield, Detachment, and Runoff of studied soils.

PM	Location	Sediment Yield (wet)	Sediment Yield (dry)	Detachment (wet)	Detachment (Dry)	Runoff. (Wet) Mm	Runoff Wet (%)	Runoff (dry) Mm	Runoff Dry (%)
		kg m^{-2} hr^{-1}							
ARG	Akaeze	1.52	3.23	0.03	0.08	95.80	56.52	77.50	45.62
	Ishiagu	3.02	4.97	0.09	0.10	125.30	73.85	106.90	63.01
	Isu	3.01	4.07	0.06	0.18	99.40	58.58	64.10	37.78
	Onicha	1.37	1.09	0.11	0.13	79.80	47.03	73.50	43.31
	Ubulu	3.00	1.12	0.07	0.08	99.80	58.82	82.10	48.38
LSD(P≤0.05)		**1.00***	**1.30***	**NS**	**0.06***	**NS**		**17.74***	
PM x Location		**NS**	**0.22***	**NS**	**0.09***	**1.22***		**1.67***	
BAG	Bende	3.95	3.24	0.09	0.09	91.90	54.16	39.20	23.10
	Ameke	2.39	3.00	0.08	0.12	83.32	49.10	54.70	32.24
	Uzoitem	3.16	3.37	0.05	0.10	104.10	61.34	43.40	25.58
	Uzoakoli	3.40	1.13	0.03	0.21	88.50	52.16	85.60	50.45
	Ndiokorie	3.74	3.18	0.06	0.13	103.80	61.17	67.00	39.49
LSD(P≤0.05)		**0.92***	**0.21***	**0.02***	**0.05***	**NS**		**19.21***	
PM x Location		**0.11***	**0.18***	**NS**	**NS**	**NS**		**1.54***	
CPS	Umalumaku	2.05	2.82	0.05	0.12	112.30	66.14	32.30	19.02
	Osisioma	2.68	2.72	0.10	0.10	82.50	48.59	46.10	27.15
	Umuagwo	2.63	1.08	0.09	0.11	101.30	59.66	28.00	16.48
	Awo	2.16	0.80	0.11	0.08	85.80	50.53	52.90	31.15
	Obinze	2.72	2.83	0.11	0.12	95.90	51.12	79.20	54.53
LSD(P≤0.05)		**NS**	**0.02***	**0.02***	**NS**	**NS**		**8.72***	
PM x Location		**NS**	**1.34***	**2.33***	**NS**	**NS**		**10.128**	
FBS	Okigwe	3.07	4.25	0.06	0.09	94.50	37.99	75.40	44.41
	Umulolo	1.66	2.39	0.13	0.09	87.50	51.53	72.70	42.81
	Akaokwa	0.51	4.86	0.04	0.07	105.70	62.25	87.10	51.29
	Acha	0.56	3.03	0.11	0.12	81.00	47.70	66.00	38.87
	Obinaohia	2.12	4.61	0.09	0.10	97.60	57.48	89.10	52.47
LSD(P≤0.05)		**0.76***	**1.19***	**0.01***	**0.01***	**NS**		**12.31***	
PM x Location		**1.67***	**2.16***	**NS**	**1.45***	**8.67***		**10.11***	
***LSD(P=0.05)**		**NS**	**1.77****	**NS**	**0.04****	**NS**		**16.03**	
CV (%)		23.42	36.00	45.77	23.40	24.40		14.90	
S.E		15.62	1.07	0.42	0.02	22.98		9.71	

P.M=Parent material. X= treatment interaction , ARG=Asu River group, BAG=Bende Ameke Group, CPS=Coastal plain sand, FBS=False bedded sand,LSD=Least significant difference,* Significant at 5% probability level, C.V=Coefficient of variation, S.E=Standard error, ** Highly significant at 5 % probability.(CV% ranking: HV=High variation=50-100% , MV=Moderate variation =20-49%, LV=Little variation 1-19%).

$m^{-2}hr^{-1}$ and CV of 23.42% indicating moderate variation while sediment yield under dry condition ranges from 0.80 kg $m^{-2}hr^{-1}$at Awo to 4.97 kg $m^{-2}hr^{-1}$ at Ishiagu with a mean of 2.98 and CV of 36.00% indicating high variations. The order of sediment accumulation under wet and dry conditions in ARG followed the order: Ishiagu> Isu> Ubulu>Akaeze> Onicha and Ishiagu> Isu > Akaeze > Ubulu >Onicha; Bende> Ndiokorie> Uzoakoli> Uzoitem> Ameke and Bende > Ndiokorie > Uzoitem > Ameke >Uzoakoli in Bende Ameki group respectively . In coastal plain sand, sediment yield under wet and dry conditions followed the trend Obinze> Osisoma >Umuagwo >Awo > Umualumaku and Obinze > Umualumaku Osisioma > Umuagwo> Awo respectively, while in Falsebedded sand they followed the trend; Umulolo > Obinaohia > Okigwe > Acha > Akaokwa (wet condition) and Akaokwa > Obinaohia > Umulolo> Acha > Okigwe (Table 3).

The order of sediment yield under wet and dry conditions was as follows: BAG > ARG > CPS > FBS and FBS > CPS > ARG > BAG respectively (Table 3). Higher sediment yield found in the soil of BAG and CPS geologic formations under both conditions is attributed to higher bulk density lower soil organic matter, higher dispersion ratio while low sediment recorded in FBS and ARG are attributed to high clay content of the soil. Feng –Ling *et al.* (2010) found that soil detachability generally decreases with rising clay content. Igwe, (2000) attributed an increase in sediment yield under dry conditions to moisture content variations and clay fraction. Cerda, (2002) found differences in sediment yield on different parent materials. He recorded high sediment yield on soils of marl in comparison to limestone, clay and sandy parent material.

Detachment or splash under wet and dry runs is shown in Table 3. Generally, like sediment yield, soil detachment was higher in dry than in wet condition in all the studied soil Figure 2. Detachment under wet runs ranged from 0.04 – 0.13 kg $m^{-2}hr^{-1}$ with a mean of 0.08 and 45.77% C.V and from 0.03 - 0.21 kg $m^{-2}hr^{-1}$ with a mean of 0.11 kg $m^{-2}hr^{-1}$ and C.V of 23.4% indicating moderate variation under dry condition. Interactions between parent material and location differed significantly ($P<0.05$) in sediment yield under dry condition and only on soils of Bande Ameki and False bedded sand stone. According to geologic formation detachment followed the order: CPS > FBS > ARG > BAG under wet runs and BAG > CPS >ARG > FBS under dry runs respectively. Igwe (2000a) obtained splash loss ranging from 0.18 - 0.82 kg $m^{-2}hr^{-1}$ under wet runs and 0.88 – 2.60 kg $m^{-2}hr^{-1}$ under dry runs in soils of central eastern Nigeria under rainfall simulation. The result suggests that splash occur more when the soil is dry than when wet suggesting that practices that reduces the exposure of soil to dryness should be discouraged. The result could also be attributed to texture, organic matter, and land use history. Dangler and El-swaify (1976) reported lower soil loss in wetter than in dry soils. In comparing all studied soils, the lowest value 0.03 kg $m^{-2}hr^{-1}$ of soil detachment under wet was found in Akaeze while the lowest 0.07 kg $m^{-2}hr^{-1}$ and highest 0.21 kg $m^{-2}hr^{-1}$ detachment under dry runs were found in Uzoakoli respectively. The interaction of rainfall and soil characteristics also contributed to soil detachment of the soil.

Runoff under wet and dry conditions is presented in Table 3. Runoff under wet condition did not differ with parent material. On the other hand, significant ($P\leq0.05$) difference was noted in runoff under dry runs. Runoff in wet and dry runs in Asu River Group ranges from 79.80 mm (47.03% of simulated rain) in Onicha to 125.30 mm (73.85 % of simulated rain) in Ishiagu and 64.10 mm (37.78 % of simulated rain) in Isu to 106.90 mm (63.01% of simulated rain) in Ishiagu. The result in Bende Ameki Group ranged from 83.32 mm (49.19 % of simulated rain) to 103.80 mm (61.17% of simulated rain) in Ndiokorie (wet runs) and from 39.20 mm (23.10% % of simulated rain) in Bende to 85.60 mm (50.54% of simulated rain) in Uzoakoli (dry runs). In Coastal Plain Sand and Falsebedded Sandstone, they ranged from 82.50mm (48.49 %) Osisioma to 101.30 mm (59.66 %) in Umuagwo, and 81.00 mm (47.70%) in Acha to 105.70 mm (62.25%) in Akaokwa (wet runs) and 28.00 (16.48 %) in Umuagwo to 92.60 mm (54.53%) in Obinze and from 66.00 mm (38.87%) to 87.10 (51.29%) still in Akaokwa dry runs. The result showed that an increase in runoff water led to an increase in sediment yield. Runoff for parent materials was significantly higher in ARG followed by CPS for wet runs and in FBS followed by ARG for dry runs respectively. This was also attributed to variation in clay content, water content and low organic matter content of the soils in question. Zhang *et al*. (2007) reported that soil type could also influence runoff. Increasing runoff volume is attributed to the reduction in infiltration rate with increasing saturation. Partial sealing by fine particles resulting from splash could also contribute to an increase in runoff.

In comparing the variability of results obtained with sediment yield and runoff, results recorded higher variation of 23.42 and 36 % for sediment yield under wet and dry runs which were higher than variation in runoff of 24.4 and 14.90% for wet and dry runs. Foltz *et al.,*(2011) obtained similar results but lower values of 8-10 % for runoff and 20-36% for sediment yield under wet and dry runs.

Relationship of clay content with erosion parameters

The relationship of clay content on sediment yield, detachment, runoff are presented in Table 4. Result indicated that clay had negative effects on sediment yield ($r = -0.62$) under wet runs and ($r= - 0.27$) under dry runs. This implies that as the clay content of the soil is increasing, the rate of sediment yield from soil decreases. This is in line with Feng–Ling *et al.,* (2010) who opined that erodibility generally decrease with rising clay content. Igwe (2000) found a negative correlation ($r = -0.25$) with clay and sediment yield under wet runs. Detachment under wet condition related negatively with clay ($r = -0.43$). Detachment under dry runs had positive relationships with clay ($r^2 =0.11$) while under wet condition it related negatively ($r = -0.43$). Igwe, (2000) obtained similar results. Clay had negative correlation with runoff under wet and dry conditions before ($r^2 = -0.14$) and ($r^2 =0.40$).

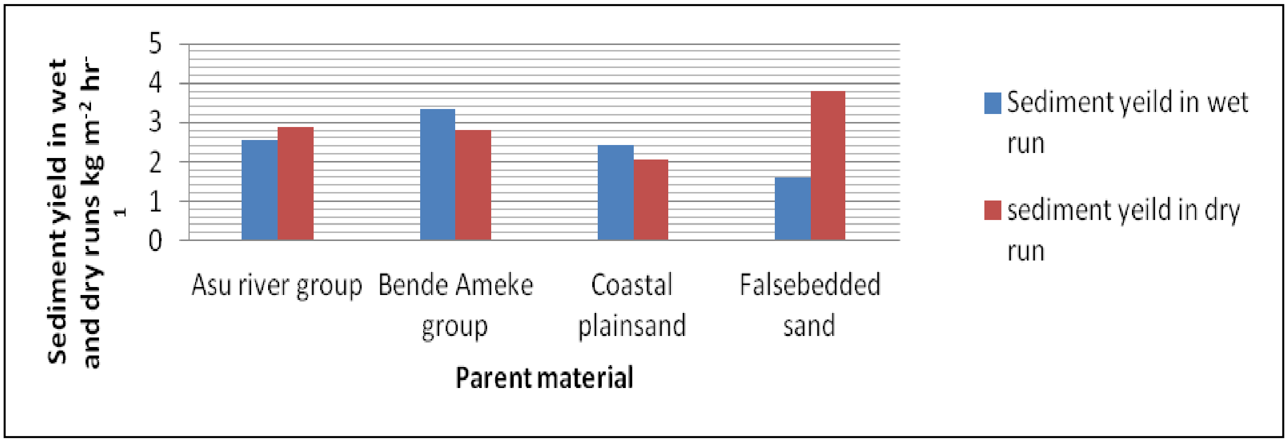

Figure 1. Sediment yield distribution in dry and wet runs according to parent material.

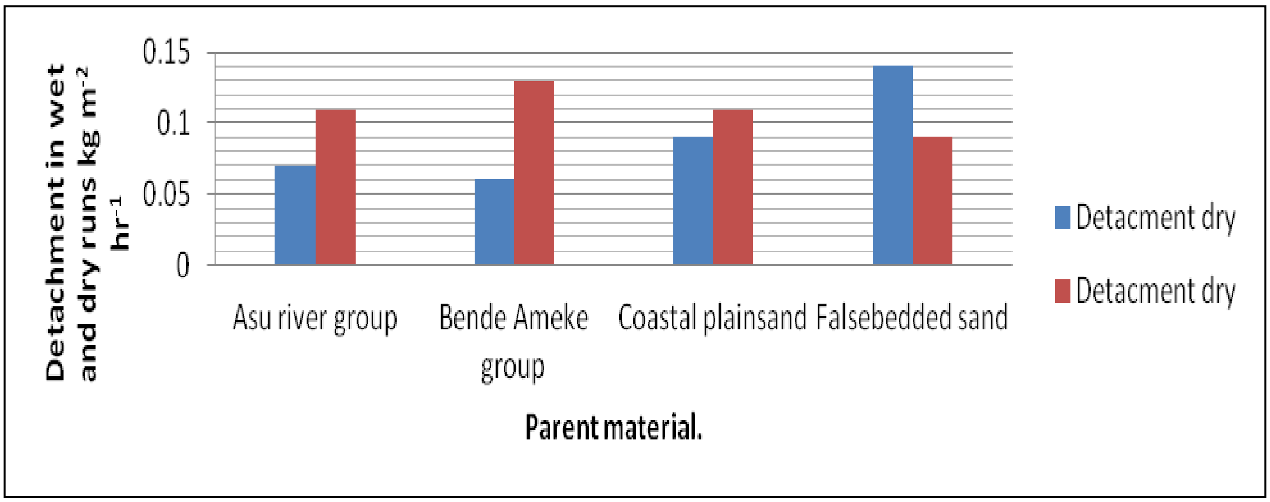

Figure 2. Detachment distribution in dry and wet runs according to parent material.

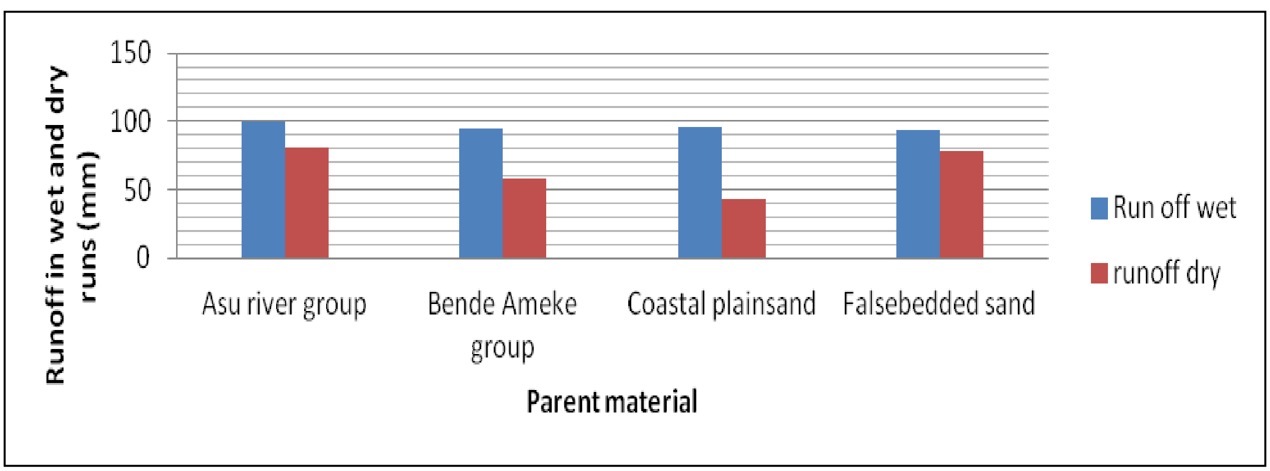

Figure 3. Runoff distribution in dry and wet runs according to parent material.

Table 4. Correlation between clay fraction and selected soil properties

Soil Property	Clay	Sediment yield dry	Sediment yield wet	Detach-ment wet	Detach-ment dry	Runoff wet	Runoff dry	Soil organic carbon
Clay (g kg^{-1})	1							
Sediment yield dry (kg m^{-2} hr^{-1})	-0.62*	1						
Sediment yield wet. (kg m^{-2} hr^{-1})	-0.27ns	0.29*	1					
Detachment wet (kg m^{-2} hr^{-1})	-0.43*	0.07 ^{ns}	-0.13 ^{ns}	1				
Detachment dry. (kg m^{-2} hr^{-1})	0.11^{ns}	-0.45 *	0.07 ^{ns}	0.34*	1			
Runoff wet (mm)	-0.14ns	0.19 ^{ns}	0.07 ^{ns}	-0.59*	-0.36*	1		
Runoff dry (mm)	-0.16 ns	0.41*	0.07 ^{ns}	-0.43*	-0.18 ^{ns}	0.27*	1	
Soil organic carbon %	0.35*	-0.34*	0.05 ^{ns}	0.46*	0.34*	-0.38*	-.0.05 ^{ns}	1

4. Conclusion

The study evaluated sediment yield, detachment and runoff from selected parent materials in Southeastern Nigeria. The result showed significant differences in the studied parameters among the parent materials. Higher values of sediment yield and detachment were noted under dry than under wet states of the soil though with few exceptions. This suggests that soil erosion might be occurring more during period of dryness than at field capacity. Result showed increase in sediment yield with increase in runoff water in both conditions. Based on the findings, we recommend that erosion could be checked just before inception of rain or at the beginning of rainy season. Soil conservation practices including mulching, afforestation, organic manure application etc that protect the soil against raindrop impact and as well prevent evaporation could be implored. The result of this study could also be extrapolated to soils of other areas and under different different intensities.

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