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An analysis of some soil properties along gully erosion sites under different land use areas of Gombe Metropolis, Gombe State, Nigeria

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The paper tries to analyse soil properties around three sampled gully erosion sites that cut across different land use in the study area. The aim of the study is to determine the soil physical and chemical properties of the major gully sites cutting across different land use in Gombe metropolis. Data used in this study were derived from soil samples collected from the gully sites and other secondary sources. Three sampled gully profiles were purposively selected for the study. Soil samples were collected at 0-0.30, 0.30-1.0, 1-2, 2-3, 3-4 and 4> meters respectively along the gully wall layers where there are changes in soil types based on the textural characteristics. Soil samples collected were taken to the laboratory for analysis, different soil physical and chemical properties were tested and results obtained. The difference in the soils physical and chemical properties between the three different gully erosion sites were analyzed using the analysis of (variance ANOVA) with the aid of statistical package for social sciences (SPSS) version 16.0. In all the different land use areas studied, the soil is mostly loose and very porous dominated by sandy material with low proportion of silt and clay. Atterberg limits are generally low in all the land use areas which resulted into the weakness of the soil, soil chemical properties and bulk density are low and soil particles are not consolidated, therefore, detached easily when impacted by flood water. This was what facilitates the development of deep and wide gullies found in most areas.

Key words: Soil properties, land use areas, analysis, Gombe metropolis.

INTRODUCTION

Soil erosion remains the world's biggest environmental problem, threatening sustainability of both plant and animal in the world. Over 65% of the soil on earth is said to have displayed degradation phenomena as a result of soil erosion, salinity and desertification, (Abegunde et al., 2006). In a way soil is the most vital

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earth’s natural resources. It hosts both animate and inanimate beings. Over three quarters of the world’s man-made development are on it. Gully erosion is regarded as the single most important environmental degradation problem in the developing world, (Ananda and Herath, 2003). United nation (UN) convention to combat land degradation (CCD) opines that soil erosion automatically results in reduction or loss of the biological and economic productivity and complexity of terrestrial ecosystems, (Claasssen, 2004).

Soil erosion is also seen as the removal of weathered loose soil material from ground surface with the attendant transport and deposition of sediments elsewhere. In other cases, erosion can be increased when the rate of displacement and removal of the soil from the land surface exceeds its replacement by pedological processes (Ofomata, 2007). It is also defined in terms of detachment of individual’s particles of rocks and soil and the transportation of detached particles by the erosive agents of running water and wind, (Okechukwu, 2000). Soil erosion constitutes a national hazard, on which its containment is pre-requisite to national development, (Okagbue and Uma, 1987). Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and threatens roads, fences and buildings (Bruce 2006).

Soil eroded from the Gullied area can cause siltation of fence-lines, waterways, road culverts, suspended sediments dams and reservoirs which may have attached nutrients and pesticides, which can adversely affect water quality, (Bruce 2006). To prevent soil from being detached, it has to be well aggregated so that the energy of the detaching agent does not exceed the energy of the binding between aggregates, (GECM 2003).

The most cementing material is clay. It is the clay that is most efficient in holding soil particles together. Whether this will be maintained when the soil get wet depends on many factors among which are nature of the clay, exchangeable cations, presence of stabilizing compounds and rate of wetting of the soil. Clays that are largely saturated with calcium and magnesium are generally flocculated and are more value in stabilizing soil aggregates than clays that are predominantly sodium-saturated which consequently detach. Also clays with expanding crystal lattice swell greatly on wetting and therefore have the tendency to break-up soil aggregates, (GECM 2003). In Gombe metropolis, the principal characteristic of soil that has a direct relationship to erosion is the soil texture. The top soils within the metropolis are basically coarse sandy loam. The top soils are also gritty, loose and low non plastic with low bulk density and low shear strength. Under exposed condition with little or no vegetative cover and adverse topography, long dry period and high temperature, the soils with such characteristics are highly susceptible to erosion activities. Much of the areas within the upstream region are highly eroded due to their textural characteristics under high slope.

Study area

Gombe Metropolis is located between latitude 10^0 0’N to 10^0 20’N and longitude 11^0 01’E and 11^0 19’E. It shares common boundary with Akko Local Government Area in the South and West; Yamaltu-Deba to the East and Kwami to the North. It occupied a total land area of about $40Km^2$.It is the capital of Gombe State, (Aliyu, 2002) as shown in Figure 1.

Gombe lies in the stretch of the Benue trough which, from the structural point of view is known as Zambuk Ridge area.

The study area consists of two types of soil which correspond to the two geological formations from which they are derived, (Mbaya, 2012). Sandy soil is found in the northwest of the metropolis and is underlain by keri-keri formation from which it was derived. Soil depth varies between 2.0cm as in the area where gullies originated and as deep as 15 to 20cm in some other places, (Orazulike, 1992). The soils are ferruginous which are red in color and contains nodules of ironstone; this soil is marked by deposits of iron oxide pebbles and is loose, very permeable and deficient in plant nutrients, (Mbaya 2012). Clayey soil occurs to the south and southeast of the metropolis and around the Kware River, round railway station. The soil is either derived from the Pindiga formation or clay of Gombe sandstone. The soil is grey and rich in organic matter, and possesses an appreciable shrink-swell capacity as the soils go through periods of drying and wetting.

The pattern of population growth of Gombe town was slow from 1900 to 1952 (300 to 18,500 people) while; from 1964 to 1991 the population growth has increased tremendously from 47,000 to 138,000. However, from the year 1996, when Gombe became the State capital, there was a noticeable sharp increase in population from169, 894 (1996) to 219,946 in 2000 (Tiffen, 2006) and 312,467 in the census 2006 and is projected to reachabout 400,000 in 2010 (NPC, 2006). This population explosion resulted in high demographic pressure on land and consequent developmental processes such asbuilding of houses.

METHODOLOGY

The sources of data as it relates to this study were derived from primary and secondary sources of data. The primary data includes data obtained through laboratory analysis of soil sample collected from gully sites. Secondary data includes relevant literature on the subject matter, which was extracted from published and unpublished sources, textbooks and maps. Variables used for data collection were as follows:

1. Soil physical properties- Particle size, bulk density and moisture

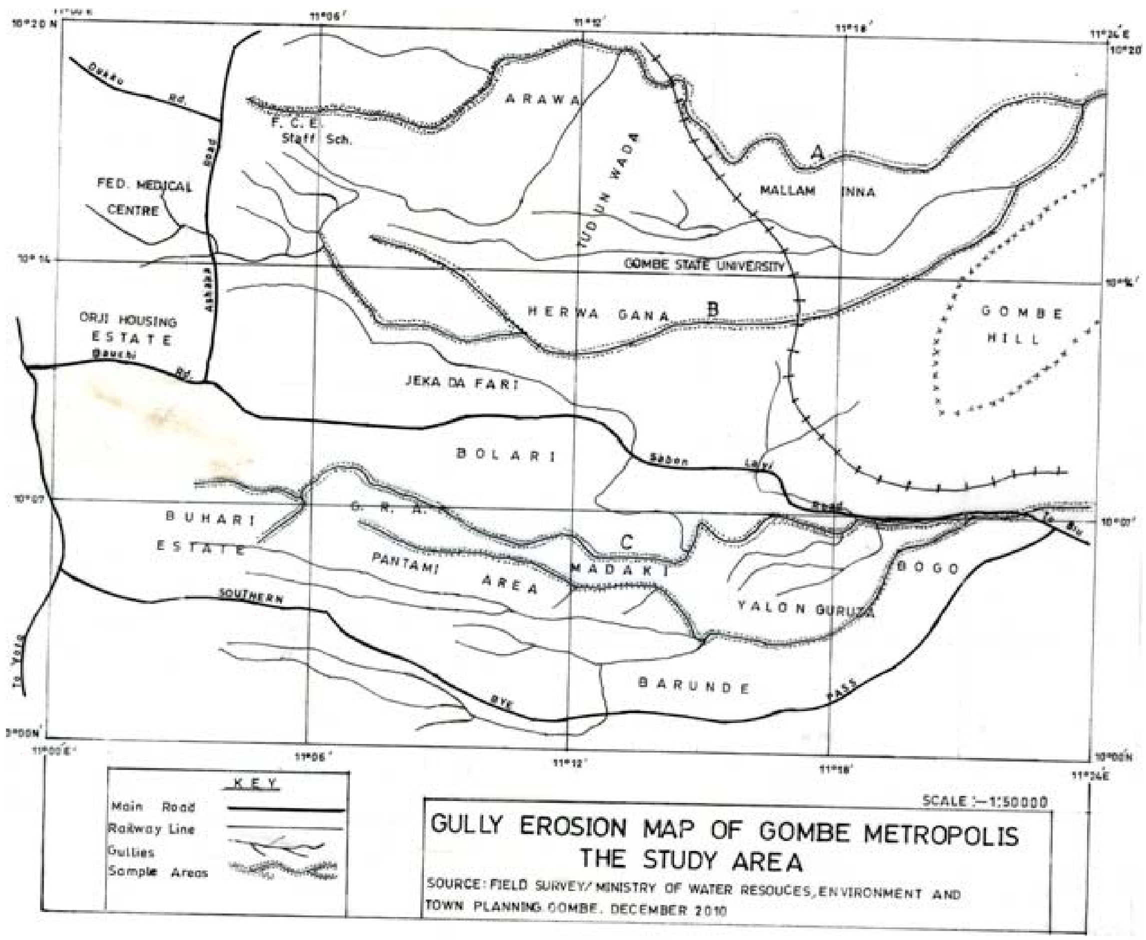

Figure 1. Gully erosion map of Gombe metropolis

content of soil.
2. Soil chemical properties - Organic matter content, soil pH, Cation exchange capacity (CEC), calcium (ca), magnesium (Mg), sodium (Na) and potassium (K),
3. Geologic- rock /porosity, permeability and Atterberg limits, etc.

Two procedures were adopted in the data collection process. These included:

1. Field work involving collection of soil samples along the selected gully erosion sites, using soil auger, handheld shovel, and polythene bags, masking tape.
2. Laboratory analysis of soil samples.

Soil sampling

Soil samples were collected at each point of gully morphological properties measured. This is to determine the susceptibility of soil to gully erosion. Soil samples were collected along gully side walls to the toe of the gully. A 30 m linen tape were stretched along gully wall layer profile to the toe of the gully, samples were collected at 0 to 0.30metre, 0.30 to1m, 1 to 2m, 2 to 3 , 3 to 4m, and > 4metres where there arechanges in soil types based on textural characteristics along the gully wall of the profile. A total of thirty six soil samples were collected and kept in polythene bags for laboratory analysis. Augur and Hand held shovel was used to collect the samples. All the collected samples were labeled and named after the gully erosion site where the samples are to be collected and will be taken to Laboratory for analysis. As shown in Figure 2.

Laboratory analyses of soil samples

Soil samples collected were taken to laboratory for analysis, soil particle distribution, chemical properties (organic matter, soil pH, exchangeable cations), bulk density, moisture content, permeability and Atterberg limits (Liquid limit, Plasticity limit and plasticity index) were tested using different measuring instrument in the laboratory and results obtained. The difference in the soils physical properties between the different gully erosions were analyzed using the analysis of variance (ANOVA) with the aid of statistical package for social sciences version 16.0.

RESULT AND DISCUSSION

The results of this research work were presented and discussed below. The result obtained were discussed

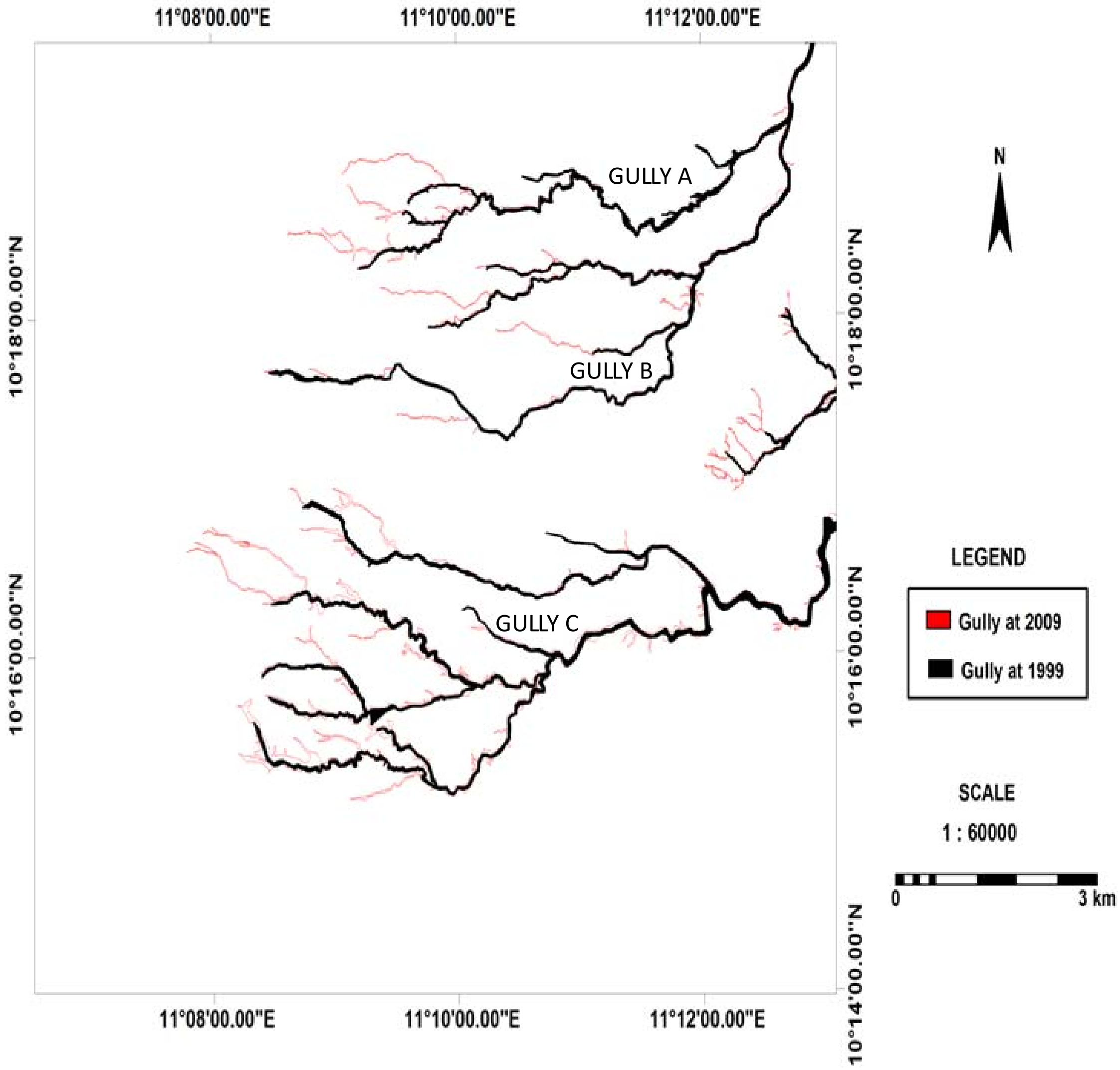

Figure 2. Classified gully density of the study area.
Source: NRSC 2013.

based on the different land use areas studied, which include residential, educational, commercial/industrial and agricultural land uses, this is in order to provide an area by area analysis.

The land use areas

The residential land use represent the largest land use in Gombe metropolis consisting of the highest number of kilometers covered by gully erosion. It consists of the build up areas occupied by residential. Majority of the gully erosion sites within the metropolis spread across the residential areas. While the educational land use on the other hand consist of schools and other educational institutions within the metropolis, the number of gullies within this land use are few, covering only a small portion of the land use area, the gullies are specifically found within the Federal College of Education Gombe as well as Gombe State University and Government Arabic College Gombe. The commercial/industrial land use area consist of different commercial and industrial areas as well as different points where commercial activities are taking place within the metropolis, it consist of gully erosion that run from Idi ground through PZ to Kagarawal. The agricultural land use consist of areas where agricultural activities are practiced, especially farming activities, this mainly exist at the outskirt of the metropolis around bypass area where the branch of Wuro-shi'e gully is found. As shown in Figure 3.

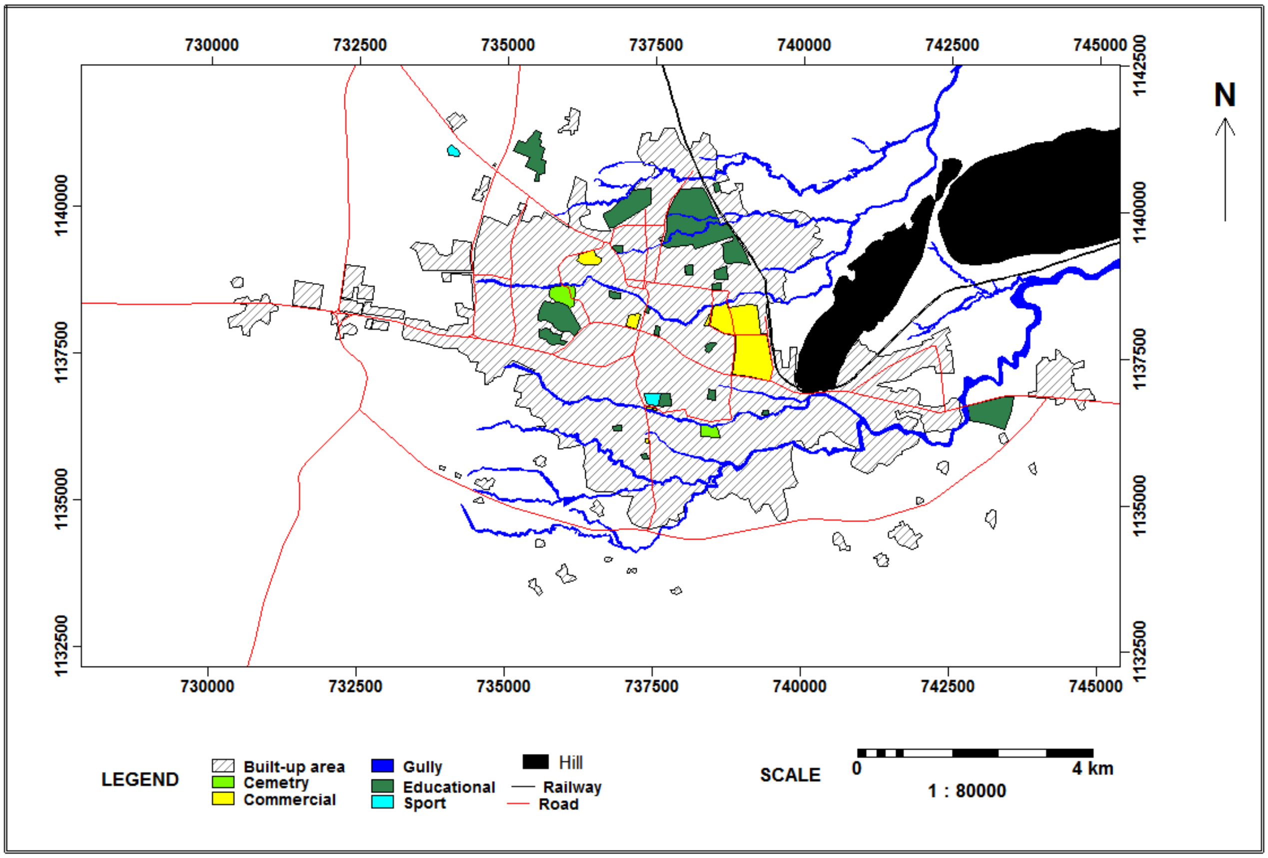

Figure 3. Classified land use image of Gombe
Source. NRSC, 2013.

Soils physical properties of the study area

The table 1 present result of some of the soil physical properties obtained in different land use areas studied. The mean particle size distributions of the soil along the three sampled gully wall layers in the residential area are presented in table 1. Gully site A, (FCE—Arawa-M/Innna-U/Uku) has the mean sand proportion of 78.5%, with coefficient of variation (C.V) of 1.14%. ; Gully site B also showed a mean sand proportion of 73.5% and gully site C further showed similar mean sand proportion of 74%. The mean proportion of silt contents for gully sites A is 5.5%, Gully B has mean silt proportions of 5.0%, and gully site C has mean silt proportions of 3.2%. The mean proportions of clay content among the three gully sites are almost similar. Gully site A, has mean clay proportion of 13%, Gully site B 17 % and gully site C 18.8% respectively. The soils particle size distribution therefore, is dominated by sand with low proportion of silt and clay in all the sampled gullies within the residential land use. Also, most of the gully floors are characterized by sandy clayey regolith.

The soil particle distributions for the gullies within the Educational land use are also presented in table 1. Gully site A has a mean sand proportion of 68.05%, B has 64.70% and C has 67.04%. The mean proportion of sand obtained from the sampled gullies under Educational land use is slightly lower than that obtained under Residential land use, this might be due to the control effort made with the use of vegetation, which may results in reducing the percentage of sand and increasing the percentage of clay and silt along the gullies. The mean proportion of silt particles within the sampled gullies A, B, and C were 5.83%, 8.0%, and 11.5% respectively. The mean values for clay particles are also presented in table 1, with gully sites A having mean proportion of 26.5%, B has 23.4% and C has the mean value of 25.8%. This suggests that, the soils within the two land use areas (Residential and Educational) have fairly pore spaces. This was supported by the Carter and Gregorich, (2008) rating of sandy surface porosity of which soils range from 35 to 50%, whereas finer textured soil ranges from 40 to 60% and compact sub soils may have as little as 25 to 30% total pore space.

The soil particle distribution for the commercial and agricultural land use were also studied and presented in

Table 1. Soil physical properties

Land use area	Soil Property	Gully site A (FCE-Arawa-M/Inna-U/Uku)			Gully site B (Fed.lowcost-B/Yero-herwagana-idi-u/uku)			Gully site C (Old GRA- Gabukka-Barunde-Madaki-Bogo-Doma)		
		Mean	SD	C.V	Mean	SD	C.V	Mean	SD	C.V
Residential	Sand	78.5	9.2	1.14	73.5	7.7	1.23	74.0	4.5	1.27
	Silt	5.5	1.2	14.9	5.0	2.2	13.9	3.2	2.2	18.5
	Clay	13.0	7.3	4.93	17.0	6.7	4.21	18.8	6.9	3.89
	Bulk Density	2.0	0.2	49.5	1.8	0.2	50.0	1.6	0.3	52.6
	Moisture Content	10.5	0.6	9.01	10.6	0.6	8.92	9.8	0.6	9.6
Educational	Sand	68.05	9.1	1.16	64.70	4.6	1.32	67.04	5.0	1.16
	Silt	5.83	1.0	2.25	8.0	2.1	9.90	11.5	3.8	6.5
	Clay	36.5	7.8	2.25	33.4	6.6	3.0	35.8	4.9	1.90
	Bulk density	2.2	0.3	40.0	1.9	0.2	47.6	2.0	0.2	49.5
	Moisture content	10.9	0.7	8.62	10.7	0.6	8.92	9.8	0.6	9.6
Commercial	Sand	Gully site A IS absent within commercial land use , therefore no data obtained.			78.05	9.0	1.11	Gully site C IS absent within commercial land use , therefore no data obtained.		
	Silt				5.8	1.3	14.7			
	Clay				14.0	7.3	4.90			
	Bulk density				1.1	0.5	39.5			
	Moisture content				8.0	0.4	9.0			
Agricultural	Sand	Gully site A and B are absent within agricultural land use land use , therefore no data obtained						63.21	8.0	1.13
	Silt							14.5	4.2	6.9
	Clay							12.0	6.7	4.0
	Bulk density							2.0	0.2	51.0
	Moisture content							10.8	0.6	8.75

table 1.

However, the commercial and agricultural land use areas are not affected by all the three major gullies sampled for this study. Commercial land use is only affected by gully site B which passes through it, while agricultural land use is affected only by gully site C at Wuro-shi'e. Table 1 also revealed that the mean sandy value obtained in the Idi-kagarawal gully site under the commercial land use was 78.05%, and a mean value of 63.21% was obtained from the Wuro-shi'e gully under Agricultural land use. The mean values for silt and clay particles obtained under commercial and Industrial land use are 5.8 and 14.0% respectively. Another value was obtained for the mean values of silt and clay under agricultural land use as indicated by table 1 is 12.0 and 14.5% respectively. The percentage silt and clay are higher in the agricultural land use than that of the commercial land use due to the presence of different species of plants grown in the area.

Textural classification of soil in the study area

The major textural classes of soil are defined by the percentage of sand, silt and clay obtained from the soil particle analysis. A mixture of sand, silt and clays particles that exhibit the properties of those separate in about equal proportions are considered as loamy, Brady and Ray (1999). However, a loam in which sand is dominant is classified sandy loam, sand and loamy sands are dominated by the properties of sand which comprises at least 70% of the material by weight and less than 15% of the material is clay, Brady and Ray (1999).

The soil particle suggested sandy loam soil as the dominance soil of the study area thereby agreed with Nyle C. Brady's above statement, this is because the soils in the area have about an average of 70% sand proportion in the different land use areas studied. The soil texture in the area appears to be similar to that obtained in Mubi and environs which has sandy loam as textural class. The textural classification of the study area as shown in table 1 indicates the dominance of sand in the soil with an average of 70% in proportion. This indicate the soil erosion in the area may be as a result of the function of soil erodability, this is supported by Gosh and Maji (2011), which shows that the medium and coarse particle that are more easily detached from the soil mass, therefore more erodible.

Soil bulk density

The mean soil bulk density for the three sampled gullies within the residential land use revealed 2.0%, 1.8g/cm^3, and 1.6g/cm^3 for gully sites A, B and C respectively. This may be attributed to the different areas that they exist within the residential areas. The mean values for bulk density are also obtained from the gullies under Educational land use which has 2.2g/cm^3, 1.9g/cm^3 and 2.0g/cm^3 for gully A, B and C respectively. The bulk density mean values obtained in both the commercial and agricultural land use are 1.1g/cm^3 and 2.0g/cm^3 respectively, with 0.5, 39.5 and 0.2, 51.0 as standard deviation and cumulative values for commercial/industrial and that of agricultural land uses respectively. This low bulk density could be attributed to soil compaction and soil structural degradation. Again the alternate increases of the bulk density within the gully depth with the associated compaction may lead to overburdening of the soil materials on the top which may slide upon horizontal pressure.

Soil moisture content

Moisture content values for the three sampled gully sites within Residential and Educational land use are also shown in table 1. The table showed gully site A, has a mean value of 10.5 g/cm^3; Gully site B has 10.6 g/cm^3 and gully site C has 10.3 g/cm^3 for Residential land use and 10.9g/cm^3, 10.7g/cm^3 and 9.8g/cm^3 for Educational land use respectively.

The moisture content means values for the commercial/ industrial land use is 8.0g/cm^3 with 0.4 and 9.0 as standard deviation and cumulative value respectively. Other values were also obtained for agricultural land use with the mean moisture content value found to be 10.8g/cm^3 with standard deviation and cumulative value of 0.6 and 8.75 respectively, table 1.

The high values of moisture content in all the sample gullies are probably as a result of urban waste water that flow into some of these gullies, (Mbaya et al 2012) and presence of vegetation used in some gullies for control effort especially within educational land use. The descriptive data in table 1 was further subjected to ANOVA test to establish whether there is significance difference in the soils physical properties between the gully sites selected. The result showed no differences (P>0.05).This implies that the proportions of sand, silt, clay, bulk density and moisture content for the sites under the four land use areas studied are almost similar. The possible reasons for this might be attributed to the nature of the soil, geology and land use of the study area.

The result indicates that gully erosion is more severe in the residential land use and commercial land use areas of Gombe metropolis because the soils are dominated by sandy materials, which makes it more susceptible and consequent increase in gully erosion more especially the depths. This findings agreed with those of others studied by Yakubu, (2004), Ofomata, (2007) and Rahab, (2008) and Mbaya (2012) who indicate that the dominance of sand proportion in the Nigeria savanna soils has accelerate gully erosion.

Soil atterberg limit, shear strength and aggregate stability

Table 2 presents the result of soil analysis foratterberg limit, shear strength, and aggregate stability of all the different land use areas studied, the result is presented and discussed to show the level of these variables in the area. Table 2 presents the results of Atterberg limits (liquid limit, plasticity limit and plasticity index) obtained in the study area. Liquid and plasticity limits were measured and were used to obtain the plasticity index, which is a measure of the plasticity of the soil.

The mean liquid limits (LL) for gully site A, B, and C, are 27.4, 26.5, and 27.0% respectively in the residential land use, and 28.9, 27.0, and 27.1 for the three sampled gullies under educational land use. Different values were also obtained for the commercial and agricultural land use with the mean values for LL as 27.0 and 28.0% respectively. The analysis further revealed no significance difference in LL (P>0.05) among the sampled gullies. The mean plasticity limits (PL) for gully site A, is 22.4%, gully site B have mean values of 21.5% and gully site C have mean values of 27.0 % for all the three sampled gullies in the residential area. The mean values for plasticity limits of the sampled gullies in the educational land use are 22.7, 22.5 and 22.9% for gully A, B and C respectively. The mean PL values as presented in table 2 for commercial and agricultural land use areas obtained were 24.0 and 21.5% respectively.

The mean values for plasticity index (PI) as shown in table 2 for residential land use are 3.5, 4.0 and 4.1% for the sampled gullies A, B and C respectively. Separate values were obtained for the sampled gullies under educational land use with gully A having 5.9, B has 4.5 and C has 4.2%. While the mean values for PI are 5.0 and 4.5 for the commercial/industrial and agricultural land use respectively. The results in table 2 show low values for atterberg limit in all the land use areas under studied; this explained the weakness of the soils and frequent removal of the gully surfaces.

The results of permeability test in table 2 revealed that the mean values for gully site A, B and C in the residential area are 3.8x10^{-3}, 2.4x 10-^{3} and 1.9x10^{-3} respectively, and the mean values for sampled gullies A,B and C in the educational land use are 3.0x10^{-3}, 2.5x10^{-3}2.1x10^{-3} respectively, the mean values obtained for commercial/industrial and agricultural land use areas as presented in table 8 are 3.6 x 10^{-3}cm/sec and 2.0 x 10^{-3}cm/sec respectively. No significance difference (P>0.05) among the sampled gullies were observed. The result of porosity test for gully site A, B and C for the residential

Table 2. Soil Atterberg limits and aggregate stability test

Land use area	Soil Property	Gully site A (FCE-Arawa-M/Inna-U/Uku)			Gully site B (Fed.Lowcost-Bubayero-Herwagana-Idi-Uku)			Gully site C (OldGRA-Gabukka-Barunde-Madaki-Bogo-Doma)		
		Mean	SD	C.V%	Mean	SD	C.V%	Mean	SD	C.V
Residential	LL %	27.4	0.8	3.5	26.5	1.1	3.6	27.0	1.0	0.3
	PL%	22.4	1.4	3.8	21.5	0.6	3.5	22.9	0.8	0.2
	PI%	4.9	1.1	16.6	4.5	0.5	20	4.1	0.6	0.03
	PM (Cm/sec)	$3.8x10^{-3}$	2.2	20	$2.4x10^{-3}$	1.4	26.3	$1.9x10^{-3}$	1.2	0.02
	AS	6.0	0.6	15.2	6.5	0.8	13.6	6	0.7	0.04
	Porosity (%)	45.5	0.0	2.2	44	0.00	2.2	43.0	1.28	0.5
Educational	LL %	28.9	0.7	3.4	27.0	1.0	3.7	27.1	1.0	0.3
	PL %	22.7	1.3	4.0	22.5	0.5	4.3	22.9	0.7	0.2
	PI %	5.9	1.2	14.0	4.5	0.5	2.0	4.2	0.6	0.03
	PM (Cm/sec)	$6.0x10^{-3}$	2.2	2.0	$2.4x10^{-3}$	1.4	26.3	$1.9x10^{-3}$	1.2	0.02
	AS	6.55	0.6	14	5.5	0.6	15.6	5	0.7	0.03
	Porosity (%)	46.5	0.0	2.2	43	0.00	2.3	51.0	1.26	0.7
Commercial	LL%	Gully site A IS absent within commercial land use , therefore no data obtained			27.0	1.8	2.5	Gully site C IS absent within commercial land use , therefore no data obtained		
	PL%				24.0	1.4	3.3			
	PI%				5.0	1.1	15.8			
	PM cm/sec				$3.6x10^{-3}$	2.2	15			
	AS				5.0	0.8	15.0			
	Porosity				47.0	0.3	2.4			
Agricultural	LL%	Gully site A and B are absent within agricultural land use , therefore no data obtained						28.0	1.1	2.6
	PL%							21.5	0.6	3.0
	PI%							4.5	1.0	20.2
	PMcm/sec							$2.0x10^{-3}$	1.4	26.0
	AS							6.5	1.0	14.0
	Porosity %							40	0.4	2.2

LL- Liquid limit, PL – Plasticity limit PI - Plasticity index, AS- Aggregate Stability PM- Permeability, AIF- Angle of internal friction.

land use are 45.5, 44.0 and 43.0% respectively as shown in table 2, the educational land use has mean porosity values of 46.5, 43.0 and 51.0% for gully A, B and C respectively. While that of commercial/industrial and agricultural land uses were 47.0 and 40.0% respectively.The degree of porosity shows the ease to which water can percolate and disintegrate the structure of the soils.

Soil chemical properties of the study area

Table 3 presented results of some of the soils chemical properties analyzed for the four different land use areas studied, (pH, organic matter content and exchangeable cations). These are some of the important chemical properties of soil when assessing gully erosion. Soil pH value indicates whether the soil is acidic or alkaline. The average pH values for the three gully sites in the residential land use are 6.2, 5.7 and 5.6 for gully site A, B, and C respectively; the mean values for the gullies in the educational land use are 5.7, 6.0, and 5.2 for A, B, and C respectively. Another mean values of soil pH were obtained under the gully wall layers of commercial/ industrial and agricultural land use with 5.2 and 5.5 respectively. This implied that the soil in the study area is moderately acidic. However, there was no significance difference (P> 0.05) between the different gullies site studied. The implication of this finding is that the soil of the study area may not be affected by micro-organisms that work on organic matter which might enhance the binding of soils to resists erosivity of rainfall and runoff impact.

The overall pattern of exchangeable Ca, Mg and K for all gully site A, B and C in the residential land use were shown. The mean values for Ca are 5.3 (gully site A), 8.3(gully site B) and 7.5 (gully site C); K has mean values of 4.7 (gully site A), 2.2 (gully site B) and 2.1(gully site C); and Mg mean values are between 2.5, 2.8 and 2.6 for gully site A, B and C respectively. They showed a general

Table 3. Soils chemical properties

Land use area	Soil Property	Gully site A (FCE-Arawa-M/Inna-U/Uku)			Gully site B (Fed.lowcost-Bubayero-Herwagana-Idi-Uku)			Gully site C (OldGRA-Gabukka-Barunde-Madaki-Bogo-Doma)		
		Mean	SD	C.V	Mean	SD	C.V	Mean	SD	C.V
Residential	pH	6.2	0.36	60.5	5.7	0.65	15.7	5.6	0.41	16.6
	%OM	0.8	0.01	123.4	0.8	0.32	89.3	1.3	0.00	76.9
	Ca	5.3	0.34	39.3	8.2	0.20	11.9	9.5	0.21	10.3
	Na	0.8	0.01	123.4	0.8	0.00	125.0	1.0	0.01	99.0
	K	4.7	0.35	19.8	2.2	0.01	45.2	1.4	0.01	71.3
	Mg	2.5	0.24	36.5	2.8	0.25	32.7	2.6	0.22	35.5
	P	19	1.70	4.80	32	5.99	2.60	20.5	1.2	4.6
Educational	pH	4.5	0.32	20.8	5.3	0.61	16.9	4.2	0.40	22.6
	%OM	0.8	0.01	123.4	0.7	0.01	140.8	0.6	0.00	166.6
	Ca	5.5	0.32	17.2	9.5	0.44	10.1	10.5	0.40	0.17
	Na	1.0	0.01	99.0	0.9	0.00	111.1	0.9	0.00	111
	K	2.6	0.20	35.7	1.0	0.01	99.0	1.5	0.00	66.6
	Mg	3.0	0.31	30.2	3.8	0.24	24.8	3.4	0.31	3.5
	P	12	1.67	7.30	20	5.98	3.87	18.5	1.2	3.9
Commercial	pH	Gully site A IS absent within commercial land use , therefore no data obtained			5.2	0.36	60.5	Gully site C IS absent within commercial land use , therefore no data obtained		
	%OM				0.81	0.01	123.4			
	Ca				4.9	0.34	39.3			
	Na				0.8	0.03	121.0			
	K				2.7	0.35	19.8			
	Mg				2.2	0.24	36.5			
	P				16.0	1.82	4.83			
Agricultural	pH	Gully site A and B are absent within agricultural land use , therefore no data obtained						5.5	0.65	15.7
	%OM							1.9	0.32	89.3
	Ca							9.52	0.20	11.9
	Na							0.94	0.01	125.0
	K							3.2	0.01	45.2
	Mg							3.8	0.33	32.7
	P							32	24.42	5.72

OM- Organic matter ,Na – Sodium K – Potassium Mg – Magnesium, P- Phosphorus

increase in mean values for both soil layers. However, ANOVA, revealed significant differences in soil layers among the sample gully sites (P>0.05). This is with respect to Ca, K, and Mg. table 4.4 also presented the result of the exchangeable Ca, Mg and K, with the mean values of 4.9, 2.2, and 2.7 respectively for commercial/ industrial land use and 9.52, 3.8 and 3.2 for agricultural land use respectively.

The pattern of exchangeable Ca, Mg and K for all gully site A, B and C in the educational land use are almost similar to that of residential land use . The mean values for Ca as presented by table 9 are 5.5, 9.5, and 10.5for gully A, B, and C respectively. K has mean values of 2.6 (gully site A), 1.0, (gully site B) and 1.5 (gully site C); and Mg mean values are 3.0, 3.8 and 3.4 also for gully site A, B and C respectively. On the whole the valley bottom soils were more enriched with the basic elements, while the top or middle layer recorded the lowest mean values. This may be explained in terms of the relative steepness of the gully walls and hence downward of the basic elements and subsequent accumulation at the valley floor.

Exchangeable Na on the other hand showed an irregular increase and decreased in mean values of the gully walls. The mean values for gully site A, B and C in the residential area are 0.8, 0.8, and 1.0 respectively. On the other hand, the mean values for the gullies in the educational land use are 1.0 for Gully A, 0.9 for Gully B, and 0.9 also for Gully C. different mean values were also obtained in the gullies under commercial/industrial and agricultural land use. The mean value of 0.8 with standard deviation of 0.03 and commulative value of 121.0 were obtained under commercial/industrial, while the mean values of 0.94 with SD of 0.01 and CV of 125.0 were obtained under agricultural land use. Analysis of variance showed significant differences (P>0.05) among the sampled gully site. The possible variations might be due to mineral constituent of urban waste disposal and the sewage that are washed away into these gully sites.

The implication of this findings to biological control of gully erosion, is that increased in Na can have negative effects on the soil fertility and hence retard the growth of plants such as vertiver grass and paniculatu/ Pitadeniastrumafricanum which are regarded as the most effective method of controlling gully erosion because of its affordability, accessibility and adaptability. The results of soil organic matter content (OMC) in table 3 showed that the mean values of gully site A, B and C was low in both residential and educational land use s. The overall pattern of variation of organic matter content, revealed a downward increases in the organic contents. However, there was significant differences at the top and bottom layers of the gully walls (P>0.05). The possible causes of these differences might be attributed to leaching of the organic matter down the valley floors of the gully sites. Table 3 also shows the mean values for organic matter content with 0.81% for gully under commercial/industrial land use and 1.94% for agricultural land use.

The results of soil phosphorus test (Table 3) showed mean values from Gully A to C. Gully site A, B and C in the residential land use have mean values of 19, 32ppm and 20.5ppm, respectively; and the mean values for Gullies A, B and C in the educational and use as 12, 20, and 18.5 respectively. Another mean values were obtained for gully layers under commercial and agricultural land use , the mean values as presented by table 12 is 16.0 ppm with SD of 1.82 and CV of 4.83, the table also shows the value for agricultural land use with 32ppm, and the SD of 24.2 and CV of 5.72. However, analysis of variance showed significant differences between the sampled gully walls. This value is low, and translates low phosphorus in the soil. These findings agreed with Ayuba (1992), who observed that, the Nigerian savanna is characterized by low phosphorus. In general, the amount of mineral cement expressed as the oxides of Ca, Mg, Na and K shows low correlations with rate of gully growth: the smaller the amount of cement, the greater the rate of gully advance.

CONCLUSION

Gully erosion menace has been on increase and advancing at alarming rates over the past few decades in Gombe metropolis, causing untold hardships, misery and loss of houses, lives and other properties worth millions of naira.

In all the three sampled gullies studied cutting across different land use areas the soil is mostly loose and very porous. Atterberg limits, soil chemical properties, bulk density are low and the soil particles are not consolidated, therefore this detached easily when impacted by flood water. This was what facilitates the development of deep and wide gullies found in most areas. This explain why some of the gully control effort by government fail, because of their in ability to properly study the soil around the gullies before controlling it. Solving erosion problem must be based on scientific and engineering data of associated variables such as soil, rainfall data, runoff etc.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

ABEGUNDE AA, ADEYINKA SA, OLAWUNI PO, OLUODO OA (2006). An Assessment of the Socio Economic Impacts of Soil Erosion in South-Eastern Nigeria. Shaping the Change XXIII FIG Congress Munich, Germany https://www.fig.net/pub/fig2006/papers/ts56/ts56_02_abegunde_etal_0787.pdf

Aliyu D (2002). A comparative Study of Soil Fertility Status under Different Agricultural Practice in Gombe Local Government Area. An unpublished B.Sc. Dissertation, Geography Department Bayero University Kano, Nigeria.

Ananda J1, Herath G.J (2003). Soil erosion in developing countries: a socio-economic appraisal. Environ Manage. 68(4):343-53.http://www.ncbi.nlm.nih.gov/pubmed/12877868

Brady NC, Ray RW (1999). The Nature and Properties of Soils, 12th Edition, Prentice-Hall Publishing inc. New Jersey, USA.

Bruce Carey (2006) Gully erosion. Natural Resources and Water Managing Queensland's natural resources.http://www.qld.gov.au/dsitia/assets/soil/gully-erosion.pdf

Claassen R (2004). Have conservation Compliance Incentives Reduced Soil Erosion? Amber Waves. The Economic of Food, Farming, Natural Resources and Rural America, http://webarchives.cdlib.org/sw1vh5dg3r/http://ers.usda.gov/AmberWaves/June04/Features/HaveConservation.htm

Gosh S, Maji T (2011). Pedo-Geomorphic Analysis of Soil in the Lateritic Region of Rampurhat I Block of Birbhum district, West Bengal and Shikaripara Block of Dumka district, Jharkhand. Int. J Environ. Sci. 1:7.

Mbaya LA (2012). A Study of Inter-relationships among Gully Variables in Gombe Town, Gombe State, Nigeria. Woodpecker J Geogr. And Regional Planning 1(1):001-006, june 2013.

NPC (2006). Census Results. National population commission, Gombe office. http://june12post.com/national-population-commissions-population-figures-for-nigeria-states-for-2006-population-and-housing-census-real-or-imagined/

Okagbue CO, Uma KO (1987). Performance of gully erosion control measures in management. Vancouver, Canada, IAHS Publ. (167):1634-172.

Okechukwu GC (2000). Gully Erosion, Conservation and Management in the Tin Mining Region of the Jos Plateau. A paper delivered at inaugural lecture, University of Jos.

Ofomata GEK, Phil-Eze PO (2007). Introduction. In G. E. K. Ofomata & P. O. Phil-Eze (Eds.), Geographical perspectives on environmental problems and management in Nigeria (pp. 1-10). Enugu: Jamoe Publishers.

Orazulike DM (1992). X-ray diffraction study of Uranium minerals in

selected hard specimen of ore from Midnite mine, Spokare, Washington State. J. Mining Geol. 28(2):195-202.
Rahab NO (2008). Effects of Soil Physical Properties on Gully Morphology in Zaria, Northern Nigeria. A paper presented at the 48th Annual Conference of Association of Nigerian Geographers, held at the Department of Geography, University of Calabar, October 2008.
Tiffen M (2006). Gombe Emirate, 1900-68: Urban and commercial development. A public lecture held in Gombe State University 12thFebruary.
Yakubu S (2004). Assessment of Soil Changes under different Land use in Zaria area, Northern Nigeria. Unpublished M.Sc thesis, Department of Geography, AhmaduBello University, Zaria, Nigeria.