

# Variation in Soil Properties along a Catena in kwambai Taraba State, Nigeria

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**Abstract**—The study was carried out to determine the variation in soil properties within units and along a catena, significant of variation to soil mapping and soil management at kwambai, Takum, within latitude 7°5' N and longitude 9°5' E to 10° 10' E. Taraba State. Soil sample were collected from upland, slope and lowland areas of the catena at the depth of 0-15cm and 15-30cm at 3 composite, 18 samples were collected. Soil properties analyzed include pH, Total Acidity EC(dS/m), Ca(Meg/Kg), Mg(Meg/Kg), K(Meg/Kg), Na(Meg/Kg), Base saturation%, TEB(Meg/Kg) ECEC(Meg/Kg), P(ppm), N%, O.C%, C:N ratio. Sand has the highest fraction in the soil. The soil is predominantly sandy clay loam. Clay loam in lowland surface, loam and sandy clay are less according to textural class. Grayish brown dominate the soil, dull brown in upland subsurface, others are brown, orange, and brownish grey. In upland area EC, Ca, Mg, TEB, N and OC decrease with depth while others increase with depth. In slope area Total acidity, Ca, Mg, TEB, ECEC and P Increase with depth while others decrease with depth. In Lowland area Ca, Mg, Na, TEB, Base saturation, ECEC, and N Increase while others decrease with depth There is Significance differences in soil properties down the catena. There is no change in EC. C:N ratio has the highest coefficient of variation of 40.8% while base saturation has the lowest with 1.2% in surface down the catena, the highest in subsurface is total acidity with 55.5% and the lowest is C:N ratio with 1.0%. The following recommendations were made. More samples to be collected during Mapping, the area interval should be reduced. Management can be easily be done in the soil. Application of lime to correct soil acidity should be moderate; fertilizer application should be not be uniform because of variation in the Landscape area.

**Keywords**— Catena, Variation, depth, Mapping, management, properties.

## I. INTRODUCTION

One of the major problem of soils often ignored by soil scientists is soil variation is no stranger to a pedologist since the very essence of his profession dates back to the early recognition that soil are systematically related to landscape. The variation of soil properties affects soil Performance in that a uniform application of treatment in especially variable soil results in over-application in some parts of the field and under application in others. Cambardella, C.A & Karlen, D.L. (1999). Details characterization of soils and their variation along different topography positions has not been investigated in depth Butros I. Hatter et.al (2010). Soil as a natural body is inherently heterogeneous because of the many factors that contribute to soil formation and the complex interactions of those factors, L.M. Maniyunda, et al; (2015). Variability of soil properties may be attributed to several sources. Apart from inherent soil differences, variation in soil properties are due to soil forming factors (climate, parents materials, organisms, relief and time) and differences in weathering rates M. Mzuku, R. Khosla et.al (2005). Mapping of soil properties is an important role in the knowledge about soil properties and how it can be use sustainable, O.A. Denton et.al (2017). If the top soil pH is above 5.5 surface and subsurface is above 4.8 only maintenance level of liming is require, Bolland M. et.al (2004). Soil organic carbon accounts for less than 5% on soil layers and diminishes with depth, soil organic carbon can be greater than 10% while the poorer or heavily exploited soils level are likely to be less than 1%, R. A. Webster et.al (2014). Carbon to Nitrogen (C:N) ratio is often used as a determinant for the health of a soil, Xu et.al (2016). The bulk of soil fungi and bacteria are found to be concentrated in the surface 10cm of the soil as there is high availability of SOM and oxygen (Brady and Weil, 2002) P is medium along a catena in soil in Yola Adamawa state, Emmanuel A et.al (2018)

## II. MATERIALS AND METHODS

### 2.1 Study Area

The study area is located within latitude 7°5' N and longitude 9°5' D E to 10° 10' E Takum local government area is located in southern Taraba state. It share boundary

with Donga to the North, Ussa to the west, Benue and Cameroon to the south and Wukari to the East. Total land mass is 45km<sup>2</sup> with the population of 135,349 according to 2006 Census.

**MAP OF NIGERIA**

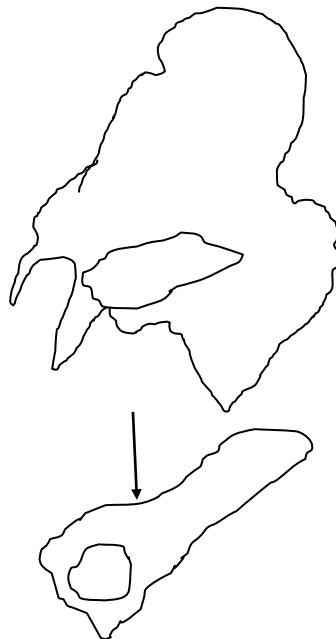


KEYS

— Boundary

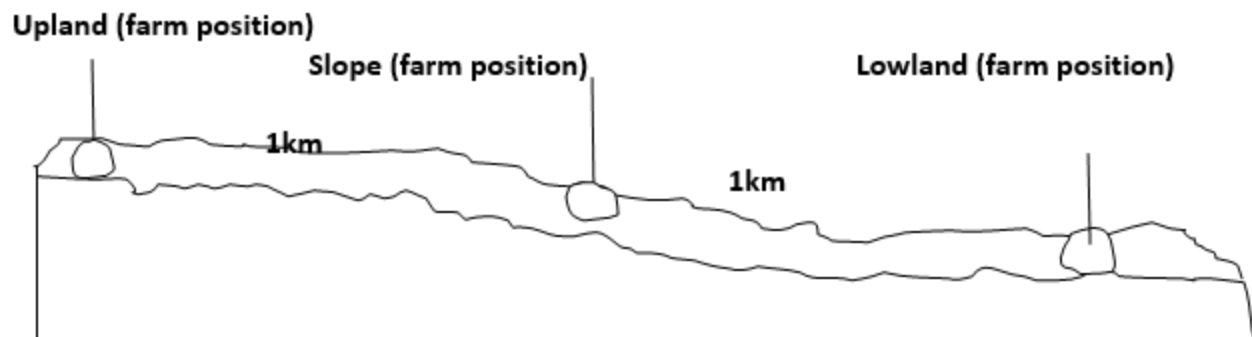
Study Area (Kwambai)

**MAP OF TARABA STATE**



**MAP SHOWING TAKUM LGA**

*Fig.1: Showing the location of the study area*



*Fig.2. Landscape, farm position of the study area*

Climate; Raining season start march and end October, dry season reach it peak in January and February when the dusty North east trade wind blow across the area. The annual temperature range from 27°C to 31°C. the climate of the study area provide conducive atmosphere for cultivation of most stable food. The area has a rainfall of 2000 to 2500mm. Vegetation of the study area is Guinea savannah which is made up of dense grasses and trees. Topography of the study area, has a gentle slope. The angle of the slope

is about 8° using abney level. The relief of the area favour rainfall and temperature.

### 2:2 Sampling Procedure

Field work reconnaissance survey was carry out to identify a representative landscape in the catena, in Kwambai area of Takum local government of Taraba state landscape position such as upland, slope and lowland were located. For the propose of this study three location or intervention sites chosen within the landscape positions with interval of

1km each. This was base on the level of farming activities. Samples were collected at two depths (0-15 cm) and (15-30 cm) 3composite was located in each landscape position. The total of 18 samples were collected in the landscape position kwambai.

### 2.3 Laboratory Analysis

The soil samples were air-dried for 24-28 hours, crushed and passed through a 2mm sieve. Sample from sieve were collected with labeled put inside include site location, survey number and laboratory numbers. Soil sample were analyzed for pH in both water and 0.01m potassium chloride solution(1:1) using glass electrode pH meter. Total nitrogen was determined by the macro-kjeldahl digestion method, available phosphorous(Av P) was determined using Olsen's extraction method UV/visible Spectrometer. Available K is part of the exchangeable bases, the exchangeable bases( $\text{Ca}^{2+}$   $\text{Mg}^{2+}$   $\text{K}^{+}$  and  $\text{Na}^{+}$ ) were measured by atomic absorption spectrophotometer after extraction with ammonium acetate at pH 7.0C samples were titrated using 0.5N  $\text{FeSO}_4$  deep bottle green colour as end point. Hydrometer method was used to determine the particle size distribution. The cation exchange capacity (CEC) was determined by extraction with ammonium acetate .percentage base saturation was calculated by dividing the sum of the charge equivalents of the base cations by CEC of the soil and

multiplying by 100. Total acidity was determine through titration .EC was taking using EC meter. TEB is the sum of exchangeable cation in the soil.C:N This is when Organics carbon divided by nitrogen.

### III. RESULTS AND DISCUSSION

Table 1 In particle size distribution Sand is high range from (44.25-61) ,clay(19.70-36.75) and silt(6.55-34.45).it follows the same train in Slope sand(44.6-65.05), Clay(30.35-36.95) and silt(12.4-20.6) and lowland sand(38.2-53.85),clay(31.6-39.00) and silt(14.55-27.00).There is medium variation of particle size distribution down the catena.

Textural class Shows that sandy clay loam is more in the catena, leaving clay loam for lowland surface and small part of upland subsurface and slope .Sandy clay occupied little space in upland subsurface and low land subsurface .little loam in Upland surface .

Surface has more grayish brown and then light brown red, subsurface has more dull orange and then dull brown. Slope surface has brown, dull brown, and grayish brown, subsurface has more orange and then bright brown. Lowland surface has grayish brown, brownish grey and grayish grey, subsurface has more grayish brown and then brownish grey. The catena has more grayish brown

Table.1: soil texture class and color

Landscape position	Particles Size distribution%			Texture class	Soil color
	Sand	Silt	Clay		
Upland surface					
0-15cm	44.25	22.55	33.70	Sandy clay loam	7.5 YR 5/2 grayish brown
0-15cm	45.85	34.45	19.70	Loam	7.5 YR 7/2 Light brown red
0-15cm	61.85	6.55	31.6	Sandy clay loam	7.5 YR 5/2 grayish brown
Subsurface					
15-30cm	49.4	15.8	34.8	Sandy clay loam	7.5 YR 6/3 dull brown
15-30cm	45.85	17.4	36.75	Clay loam	7.5 YR 6/4 dull brown
15-30cm	49.05	14.55	36.4	Sandy clay	7.5 YR 6/4 dull brown
Slope surface					
0-15cm	46.20	20.6	33.2	Sandy clay loam	7.5YR 6/3 brown
0-15cm	65.05	16.0	33.35	Sandy clay loam	7.5YR 6/3 DULL brown
0-15cm	44.6	20.6	34.8	Clay loam	7.5 YR 4/2 grayish brown
subSurface					
15-30cm	52.25	17.4	30.35	Sandy clay loam	7.5YR 6/6 orange
15-30cm	50.65	12.4	36.95	Sandy clay loam	7.5YR 6/6 orange
15-30cm	49.05	14.53	36.95	Sandy clay loam	7.5YR 5/6 bright brown
Lowland surface					
0-15cm	41.05	19.95	36.4	Clay loam	7.5 YR 4/2 grayish brown
0-15cm	42.05	19.35	39	Clay loam	7.5 YR 5/1 brownish grey
0.15cm	42.65	27	38	Clay loam	7.5 YR 5/2 grayish grey

Subsurface					
15-30cm	38.2	18.1	36.4	Sandy clay	7.5 YR 5/1 brownish grey
15-30cm	45.5	17.75	34.8	Sandy clay loam	7.5 YR 5/1 grayish brown
15-30cm	53.85	14.55	31.6	Sandy clay loam	7.5 YR 5/1 grayish brown

Table 2 shows that pHs in upland area are slightly acidic increasing with depth, in slope and lowland area, pH are moderate and decrease with depth. Maintenance level of liming is require because the pH is above 5.5 in upland and above 4.8 in subsurface .this is with the conformation with Bolland M. et'al (2004)

Total acidity is moderate in upland, slope and lowland. Upland and slope increase with depth while lowland decrease with depth.

EC in upland, slope and lowland are medium. Upland and slope is unsuitable with moderately leaching and slightly decrease with depth, lowland is low and remain the same with depth.

Exchangeable base, Ca is moderate in upland, slope and lowland. it may be due to plant uptake or leaching. Upland decrease with depth, while slope and lowland increase with depth. Mg is high in upland area and decrease with depth. Mg is low in slope surface and high in subsurface. It is high in lowland and increase with depth .K is moderate in upland and it increase slightly with depth .k is moderate in slope and high in lowland (it may be as a result runoff) slope and lowland decrease with depth. Na increase with depth in upland and lowland area Na is high in lowland and it decrease with depth in slope. Exchangeable base fall mostly within low and medium range. Confirmation with (Brady and Weil,2002)this may be due to low decomposition of organic

matter and slow release of chemical element into the soil. Base saturation slightly increases with depth in upland and low land. it decrease with depth in slope.

TEB and ECEC increase with depth in slope and lowland.TEB decrease while ECEC increases with depth .They are not medium. This is different with the finding of (Emmanuel A et.al 2018).P fall within medium, confirmation with (Emmanuel A et.al 2018) Who observed that P in the soil of some selected farmland located at Modibbo Adama University Adamawa State shows that P is medium., P increase with depth in upland and decrease with depth in slope and lowland .it confirm the increase in upland but contradict decrease in slope and lowland (Osujieke et.al 2016) .OC is medium (FDLAR 2012),OC decrease with depth in upland ,slope and lowland. this is confirmation with (Brady and Weil,2002) that The bulk of soil fungi and bacteria are found to be concentrated in the surface 10cm of the soil as there is high availability of SOM and oxygen. Organic carbon is high in upland and lowland. it is low in the slope, it may be due to plant uptake, rain and runoff down the catena. It is also with agreement with those observed by (Emmerson WW.1991).Nitrogen is low down the Catena l(FDLAR 2012).N decrease with depth in upland ,slope and increase with depth in lowland area. C:N ratio increase with depth in upland ,decrease with depth in slope and lowland. it may be due to leaching or plant uptake.

Table.2: Physio Chemical properties

Landscape Position	pH 1:LS H <sub>2</sub> O	Total acidity	EC (dS/m)	Exchangeable (emolekg <sup>-1</sup> )				Base Saturation (%)	TEB (Meg/kg)	ECEC (emoleKg <sup>-1</sup> )	P(MegKg )	N(%)	OC(%)	C:N	Texture Class
				Ca	mg	k	Na								
Upland															
Surface	6.25	0.30	231	5.60	3.00	0.37	0.13	96.8	9.10	9.10	18.00	0.45	1.07	2.38	SCL
0-15cm	6.36	0.30	261	3.40	6.40	0.29	0.16	94.4	10.2	10.8	15.20	0.58	1.30	2.24	L
0-15cm	6.18	0.40	280	3.20	4.60	0.32	0.20	98.3	8.12	8.52	17.90	0.48	1.11	2.31	SCL
0-15cm															
Subsurface															
15-30cm	6.40	0.60	261	3.80	4.40	0.42	0.15	93.6	8.78	9.38	16.50	0.33	0.83	2.58	SCL
15-30cm	5.93	0.30	251	4.40	4.40	0.36	0.20	96.9	9.36	9.66	17.50	0.45	1.11	2.47	CL
15-30cm	6.85	0.20	241	4.80	2.00	0.36	0.20	97.4	7.36	7.56	19.20	0.36	0.82	2.28	SC
Slope Surface															
0-15cm	6.95	0.30	281	2.40	2.40	0.43	0.16	94.7	5.59	5.69	13.15	0.25	0.75	2.20	SCL
0-15cm	5.98	0.20	230	2.80	3.80	0.47	0.24	97.1	6.84	7.04	14.2	0.28	0.66	2.36	SCL
0-15cm	5.62	0.30	245	3.80	2.60	0.39	0.20	95.9	6.99	7.29	14.5	0.53	1.13	2.13	CL
Subsurface															
15-30cm	5.10	0.30	242	2.80	3.60	0.38	0.15	95.8	6.89	7.21	13.5	0.22	0.59	2.68	SCL
15-30cm	5.95	0.40	233	5.80	5.20	0.51	0.19	96.7	11.7	12.1	20.0	0.25	0.57	2.28	SCL
15-30cm	6.93	0.70	205	2.40	5.40	0.29	0.20	92.2	8.29	8.99	12.2	0.17	0.39	2.29	SCL

Lowland															
Surface															
0-15cm	6.31	0.30	227	2.60	7.00	0.46	0.16	97.1	10.2	10.5	17.8	0.42	1.14	2.36	CL
0-15cm	5.91	0.50	250	2.40	2.00	0.38	0.24	90.9	5.02	5.52	16.5	0.36	0.80	2.22	CL
0-15cm	5.38	0.20	235	4.00	4.40	0.59	0.20	97.8	9.19	9.39	20.3	0.19	1.09	4.41	CL
Subsurface															
15-30cm	5.83	0.40	210	2.80	4.80	0.36	0.20	95.3	8.16	8.56	14.3	0.45	1.10	2.44	SC
15-30cm	5.85	0.30	227	3.20	5.80	0.47	0.24	97.1	9.71	10.1	17.5	0.28	0.50	2.03	SCL
15-30cm	5.81	0.20	275	4.80	4.00	0.37	0.24	97.7	9.41	6.61	19.0	0.53	1.11	2.09	SCL

KEY:L=LOAM, CL=CLAY LOAM,SC=SANDY CLAY,SCL=SANDY CLAY LOAM.

### 3.1 Trend in soil properties down a catena (mean and CV%)

From table 3, pH surface (6.26>6.18>5.86) and subsurface (6.36>5.98>5.83) Aweto A.O and Enaruvbe G.O (2010) The decline in soil pH is partly due to the decline of Exchangeable cations, especially magnesium, and base saturation. Total acidity surface (0.33>0.26<0.33) and subsurface (0.36<0.46>0.30). Soil properties are not always uniform in all the segment of the catena kravchenko and Bullock (2000). EC, surface (2.57>2.52>2.32) and subsurface (2.56>2.27<2.37), Ca surface (4.06>3.00=3.00) it may be due to exploitation through farming or leaching in slope and lowland. subsurface (3.56<3.66>3.60), Mg surface (4.66>2.90<4.46) subsurface (3.16<4.73<4.86) K surface (0.32<0.43<0.47) it may be due to water runoff from the upland. Subsurface (0.38=0.38<0.40), Na surface (0.16<0.20=0.20) and subsurface (0.18=0.18<0.22), base Saturation surface (96.5<95.9<96.7) subsurface (95.9>94.9<96.7, TEB surface (9.14>6.40<8.13) and

subsurface (8.5<8.96<9.09). ECEC surface (9.57>6.60<8.47) and subsurface

(8.86<9.43<9.44), P surface (17.03>13.9>8.2) and subsurface (17.66>15.2<16.9), N surface (0.50>0.35>0.32) subsurface (0.38>0.21<0.42). The total Nitrogen shows Variation in descending in surface, but not descending or ascending order in

Subsurface According to Majawliwa et.al (2015), OC surface (1.16>0.84<1.01) subsurface (0.92>0.15<0.92) C:N (2.31>2.23<2.99) and subsurface (3.37>2.14<2.18).

Coefficient of variation in Surface C:N and N (2.9-42.8%), Ca and Mg (24-36.4%), OC and ECEC (10.3-30.8%), K, Na and TEB (9.3-21.2%) are medium, Base saturation (1.2-3.9%), Ec and pH (1.4-11%) P and Total Acidity (9.2-19.2%) are low. In subsurface Total acidity and Mg (11.5-55.5%) have high variation. K, P, N, OC, ECEC, Ca and TEB (7.8-32.6%) have Medium variation. Ec and Na (3.9-15.5%), C:N, Base Saturation and pH (1.0-9.1%) have low variation along a catena.

Table.3: Variation of soil properties across the catena (Mean and CV%)

Variables	Properties	Upland		Slope		Lowland	
		Mean	CV %	Mean	CV %	Mean	CV %
Surface(0-15cm)	Ph	6.26	1.4	6.18	11	5.86	7.8
	Total Acidity	0.33	15.2	0.26	19.2	0.33	19.2
	EC(dS/m)	2.57	9.3	2.52	10.3	2.37	4.6
	Ca(Meg/Kg)	4.06	29.0	3.00	32.7	3.00	24
	Mg(Meg/Kg)	4.66	25.6	2.90	29.0	4.46	36.4
	K(Meg/Kg)	0.32	12.5	0.43	9.3	0.47	21.2
	Na(Meg/Kg)	0.16	16.6	0.20	2.0	0.20	20.0
	Base saturation%	96.5	2.0	95.9	1.2	95.2	3.9
	TEB(Meg/Kg)	9.14	11.3	6.40	13.7	8.13	33.7
	ECEC(Meg/Kg)	9.57	11.9	6.60	12.8	8.47	30.8
	P(ppm)	17.03	9.2	13.9	5.0	18.2	10.6
	N%	0.50	12.0	0.35	42.8	0.32	36.3
	O.C%	1.16	10.3	0.84	28.5	1.01	17.8
Subsurface(15-30)	C:N ratio	2.31	2.9	2.23	4.9	2.99	40.8
	Ph	6.36	7.1	5.98	3.8	5.83	3.4
	Total Acidity	0.36	55.5	0.46	43.4	0.30	38.3
	EC(dS/m)	2.56	3.9	2.27	8.4	2.37	13.9
	Ca(Meg/Kg)	3.56	29.1	3.66	11.5	3.60	10.1
	Mg(Meg/Kg)	3.66	50.5	4.73	11.1	4.86	38.3

K(Meg/Kg)	0.38	7.8	0.38	28.9	0.40	15.0
Na(Meg/Kg)	0.18	15.5	0.18	11.1	0.22	9.0
Base saturation%	95.9	2.1	94.9	2.5	96.7	1.3
TEB(Meg/Kg)	8.5	12.0	8.96	27.4	9.09	9.0
ECEC(Meg/Kg)	8.86	12.8	9.43	26.1	9.44	8.2
P(ppm)	17.66	8.2	15.2	27.1	16.9	14.2
N%	0.38	15.7	0.21	19.0	0.42	28.5
O.C%	0.92	17.3	0.51	21.5	0.92	32.6
C:N ratio	3.37	6.1	2.14	9.1	2.18	1.0

### 3.2 Significance Of Soil Variation To Soil Mapping

There is high and moderate variation of soil properties across the landscape position (catena). The soil change with some meters in confirmation of (Aweto A.O and Enaruvbe G.O 2010) from their finding soil properties are not always uniform in all slope segment of the catena. Soil thickness was observed it may be due to heavy implement on the farm or grazing by ruminant animals. In case of sampling more samples should be collected. Sample interval should be reduced preferably small scale.

### 3.3 Significant of Soil Variation to Soil Management.

From table 1 The dominant soil is sandy clay loam then; clay loam, sandy clay and loam. Management can be easily done in the above soil. Application of lime to correct acidity should be moderate. Fertilizer application should not be uniform due to the variation of properties of some landscape area Cambardella, C.A & Karlen, D.L. (1999). Zero or no tillage should be practice to reduce compaction.

## IV. CONCLUSIONS

Generally the variation in soil properties is moderate within the landscape position of the catena excluding Base saturation, EC, pH, P, Total acidity are low in surface while Total acidity and Mg are high, EC, Na, C:N, Base Saturation, pH are low in subsurface. The results indicate that the density of observations for those soil properties exhibiting high and medium variation should be increase during sampling, soil mapping and for soil management purpose.

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