Physicochemical Analysis of Soil Samples from Donga, Bali and Mutum-Biyu Local Government Areas in Taraba State, Nigeria.

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Abstract: *Soil samples from Donga, Bali and Mutum-Biyu Local Government Areas were evaluated chemically for the following metals ions, K, Na, Ca, Mg, Mn, Pb, Cu, Fe, Zn, Ni and Cr. Nitrogen was also evaluated. The physical parameters were also studied: pH, colour, density, specific density, conductivity and texture. K and Na were determined by flame photometry, the rest of the 9 metals were determined using atomic absorption photometry methods. Nitrogen was determined by Kjeldal ~athod. The results showed the soil sampled to contain varying amount of element in decreasing order of K > Ca > Na > N > Fe > Mg > Mn > Ni > Gr > Pb. The pH values ranged from 4.10 to 6.90, thus presenting the soiis as acidic while the conductivity values ranged from 0.31 ps/cm to 2.20ps/cm. The density and specific gravity ranged from 1.12g/cm2 to 2 S3g/cm3 and 1.11 to 2.74, respectively. The soil samples were mostly.*

Keywords: *Physicochemical, Soil Chemistry, Heavy Metals and Soil Morphology*

I. Introduction

Soil is defined as the material that forms the physical matrix of the earth crust (Kennedy, 1992). Soil is one of the most important natural resources (Brady, 2002). St assumes this importance through its position in the landscape and dynamic, physical and biologic functions. The general concept of soil varies according to the perspective of the discipline or occupation using soil as a resource. So far, the understanding of soil is incomplete despite the duration of mankind's dependence on soil and curiosity on it exploration of its diversity and dynamics continues to yield fresh discoveries and insight (Buol, 1973).

New avenues of soil research are needed to understand soil in the context of climate change, greenhouse gases and carbon sequestration 3revik, 2002). The interest in maintaining the plants biodiversity and in exploring p<ast cultures has also stimulated renewed interest in achieving a more defined understanding of soil (Brevik, 2002).

Geologists have a particular interest in the pattern of soil on the surface of the earth (Dooley, 2006). Soil texture, colour and chemistry often reflect the underlying geological patterned material and changes of soil types at geologic unit boundaries (Pielke, 2005). Soil consists of material and. organic matters, including living organisms, comprising the pedosphere, positioned at the interface of the lithosphere with the biosphere, atmosphere and hydrosphere (Pielke, 2005). Soil formation or pedogenesis, is the combined impact of physical, chemical, biological and anthropogenic process on soil parent material resulting in the formation of soil horizons (Nikiforoff, 2006).

II. Materials and Methods

2.1 Study Setting and Design

Three different farmlands were selected for this study. This farmlands includes: Donga, Bali and Mutum-Biyu Local Government Areas, the sampling was carried out at a distance of two (2) kilometers apart from 10km in each of the four (4) cardinal directions (North, south, East West) respectively in each metropolis.

2.2 Sample Collection and Pretreatment

Most of our knowledge of soil chemistry comes from soil study. Soil study includes preliminarily soil mapping and sampling. The process was to determined the different soil types, soil elemental composition and other properties of the soil (Brady, 2002). Information were derived from physical geography and analysis of chemical elements, vegetation and land use pattern.

2.3 Sampling

In Donga, Bali and Mutum-Biyu Local Government Areas, the sampling was carried out at a distance of two (2) kilometers apart from 10km in each of the four (4) cardinal directions (North, south, East West) respectively in each metropolis. Soil sampling was dugged at about 3cm depth using a cutlass and a hoe for clearing the dried grasses and digging. Each of the soil samples in the four (4) cardinal directions was packaged in an air tight large envelope. The same method of sampling was used in the three (3) local government areas and there were a total of 60 soil samples.

2.4 List of the Soil Samples

In each metropolis and each of the four cardinal direction five (5) samples were collected and labelled N1 to N5 for the north direction, S1 to S5 for the south direction, E1 to E5 for the east direction and W1 to W5 for the west direction. The labels were contrasted by the first letters of names of the metropolis D, B and M, for Donga, Bali and Mutum-Biyu respectively. Soil samples location from Donga, Bali and Mutum -Biyu Local Government Area of Taraba State, Nigeria were denoted as;

SAMPLES

Location	North	South	East	West	Total
Donga L.G.A	DN1-DN5	DS1-DS5	DE1-DE5	DW1-DW5	20
Bali L.G. A	BN1-BN5	BS1-BS5	BE1 - BE5	BW1 - BW5	20
Mutum Biyu	MN1 -MN5	MSI-MSS	ME1 - ME5	MW1-MW5	20

2.5 Sample Analysis

The physical properties of the soils determined were colour density, and specific density and texture while chemical elements were N, K, Na, Ca, Mn, Pb, Fe, Zn, Ni, Cr and Cu.

2.6 pH and Conductiivity

The pH were measured using 1:2 soil,water ratio with the the pH(Mclean 1982).

The aqueous solutions of samples used for pH were also used for the conductimetry. The electrode was cleared with distilled water and wiped with tissue paper. The electrode was dipped into the sample solution and reading taking from the digital conductimeter. The unit of the scale is microsemen/centimetres (ps/cm).

2.7 Density and Specific Gravity

Density were measured by 10cm3 cylinder weighed on an electronic weighing balance as W1 and then 5cm3 of distilled water was poured into the cylinder and subsequent weight of both water and cylinder taken as
W_2. The weight of water was obtained by deducting w_1 from W_2 i.e W_2 -

Wi. The density of water calculated as:-

Density of each soil sample (p_s) = $\frac{\text{Mass}}{\text{Volume}} = \frac{1g}{\Delta V}$

Specific gravity of each soil sample is = $\frac{(p_s)}{(p_w)}$

2.8 Colour and Texture

Soil is the first impression one has when viewing soil (Bigham etal, 1993). Striking colours and contrasting pattern are likely to be noticed about soil, but colour has little effect on the behaviour and use of soil (Brady, 2002). An important exception to this statement is the fact that dark-coloured surface soil absorbed more solar energy than lighter- coloured soil and therefore warms up fastly (Brady, 2002). The main reason for studying soil colours is that they provide valuable clues to the nature of other soil properties and conditions (Brady, 1996). Soil texture is the proportion of different sized particles in a soil (Brady, 1996). Soil texture is critical for understanding of soil behaviour and management. Soil texture in the field is not readily subjected to change, so it is considered as a basic property of soil.

III. Results

The result of the heavy metal levels from the studied farmlands in Donga, Bali and Mutum-Biyu Local Government Areas are presented as follows;
The results of the physical properties are presented in table 1, while table 2 shows the chemical parameter values of the soil samples in all the samples sites.

Samples	Colour	Notation	Texture	Density (g/cm^3)	Specific gravity	pH	Conductivity (x $10^{\sim 3}$ pis/cm)
DN_1	Dark brown	7.3 YR 3/2	Fine	1.54	1.59	6.90	1.55
DN_2	Light reddish brown	SYR 6/4	Fine	1.92	1.94	6.30	1.45
DN_3	Weak red	2.5 YR 5/4	Coarse	1.66	1.69	5.20	1.23
DN_4	Pinkish gray	7.5 YR 6/2	Coarse	1.78	1.89	5.30	2.20
DN_5	Light red	SYR 5/8	Coarse	1.16	1.22	4.10	1.39
DS_1	Black	5 YR 2.5/2	Fine	1.21	1.32	5.00	1.49
DS_2	Light reddish brown	5 YR 6/4	Fine	1.32	1.41	4.90	1.36
DSs	Dark brown	7.5 YR 4/4	Fine	1.25	1.31	5.20	1.22
DS_4	Black	5 YR 2.5/1	Fine	1.47	1.48	4.30	1.23
DS_5	Dark reddish gray	5 YR 4/2	Gravel	1.72	1.77	5.80	131
DE_1	Reddish yellow	5 YR 6/8	Coarse	1.61	1.66	5.30	1.63
DE_2	Reddish brown	5 YR 4/4	Fine	1J8	1.87	5.30	1.51
DE_3	Dark reddish brown	5 YR 3/4	Coarse	1.72	1.75	5.50	1.40
DE_4	Reddish gray	5 YR 5/2	Coarse	1.75	1.76	5.40	1.04
DW_1	Reddish brown	5 YR 4/4	Fine	1.47	1.52	5.50	1.09

DW_2	Brown	5 YR 5/4	Coarse	1.28	1.34	5.20	1.29
DW_3	Reddish brown	5 YR 5/3	Coarse	1.32	1.38	5.40	1.22
DW_4	Dark brown	7.5 YR 4/4	Fine	1.25	1.28	4.20	1.39
DW_5	Strong brown	7.5 YR 5/6	Fine	1.28	1.29	5.60	1.39
BN_1	Strong brown	7.5 YR 5/8	Coarse	1.17	1.19	6.00	1.49
BN_2	Light red	10 R 6/6	Gravel	1.47	1.48	5.20	1.46
BN_3	Light red	10 R 6/8	Coarse	1.45	1.46	5.00	1.45
BN_4	Light reddish brown	5 YR 6/4	Coarse	1.51	1.54	5.60	1.56
BN_5	Reddish yellow	5YR6/6	Fine	1.56	1.57	4.30	1.16
BS_1	Yellow red	7.5 YR 5/8	Coarse	1.72	1.79	4.40	123
BS_2	Strong brown	7.5 YR 5/6	Coarse	1.14	1.12	4.90	1.29
BS_3	Pinkish gray	7.5 YR 6/2	Coarse	1.12	1.11	5.10	1.30

Table 2: Soil contents of N, K, Na, Ca, Mn, Pb, Fe, Zn, Ni and Cr in the study area

(mg/kg)

Sample Locations	N	K	Na	Ca	Mg	Mn	Pb	Fe	Zn	Ni	Cr
DN_1	113	510	300	390	40	2	0.9	18	4	9	2
DN_2	103	502	150	260	30	2	4	43	7	16	10
DN_3	143	10	220	70	12	3	3	14	5	7	4
DN_4	123	502	180	260	31	55	5	20	12	18	ND
DN_5	83	500	180	330	41	35	2	15	5	11	4
DS_1	109	125	240	200	28	12	0.9	12	12	3	ND
DS_2	87	500	210	330	42	21	3	14	15	14	2
DS_3	35	980	200	320	27	36	5	15	10	11	ND
DS_4	31	550	300	200	29	3	4	46	12	14	ND
DS_5	75	502	200	210	27	2	2	20	5	5	ND
DE_1	109	620	280	140	19	8	3	18	3	18	4
DE_2	186	680	ND	80	14	ND	2	14	2	5	2
DE_3	163	460	150	60	30	ND	0.9	10	1	3	ND
DE_4	143	460	250	170	18	3	8	28	12	18	ND
DE_5	107	480	180	140	16	2	0.9	11	9	11	2
DW_1	89	502	220	180	21	3	3	4	10	14	ND
DW_2	107	580	ND	300	38	5	0.9	3	8	9	2

DW_3	111	415	m	260	39	17	2	9	10	7	2
DW_4	109	320	60	130	18	2	3	39	7	5	4
DW_5	123	502	240	200	24	8	7	72	8	20	ND
BN_1	85	460	260	390	40	2	0.9	20	6	18	2
BN_2	63	502	200	210	28	3	8	44	7	29	ND
BN_3	73	680	50	170	16	ND	2	21	8	14	2
BN_4	91	574	80	200	28	ND	2	10	5	11	2
BN_5	103	502	100	260	31	2	8	24	ND	32	ND
BS_1	109	590	240	140	16	3	5	29	4	7	ND
BS_2	81	306	50	160	19	5	5	18	3	7	4
BS_3	73	304	110	470	24	3	2	4	2	5	ND
BS_4	72	240	112	280	21	ND	2	ND	6	11	2

Table 1 Continued

BS_4	Light reddish brown	5YR6/3	Fine	1.21	1.21	5.30	1.43
BSs	Brown	7.5 YR 4/4	Coarse	1.26	1.27	4.50	1.38
BE_1	Yellowish red	SYR 4/6	Coarse	1.51	1.55	5.10	1.82
BE_2	Light brown	7.5 YR 6/4	Coarse	1.47	1.50	5.20	1.28
BE_3	Strong brown	7.5 YR 5/6	Coarse	1.51	1.54	5.50	0.60
BE_4	Strong brown	7.5 YR 5/8	Coarse	1.56	1.62	4.90	0.55
BE_5	Strong brown	7.5 YR 5/6	Fine	2.50	2.60	5.20	0.56
BW_1	Reddish yellow	5 YR 6/5	Gravel	2.63	2.74	5.30	1.10
BW_2	Reddish brown	5 YR 4/4	Sandy	1.72	1.67	4.90	1.29
BW_3	Strong brown	7.5 YR 5/6	Coarse	1.66	1.63	5.00	0.36
BW_4	Strong brown	7.5 YR 5/8	Coarse	1.47	1.44	4.90	0.58
BW_5	Dark brown	7.5 YR 4/4	Fine	1.96	1.90	5.90	0.59
MN_1	Light brown	7.5 YR 6/5	Coarse	1.85	1.88	5.50	1.16
MN_2	Brown	7.5 YR 5/4	Coarse	1.81	1.88	5.10	1.23
MN_3	Pink	7.5 YR7/4	Coarse	2.08	2.12	6.80	0.42
MN_4	Light brown	7.5 YR 6/4	Coarse	1.96	2.04	5.40	1.68
MN_5	Pink	7.5 YR 8/4	Silt	1.28	1.33	5.10	1.88
MS_1	Dark brown	7.5 YR 6/3	Coarse	1.42	1.48	5.40	0.81
MS_2	Light brown	7. SYR 6/6	Coarse	1.66	1.69	5.30	0.78
MS_3	Brown	7.5 YR 5/2	Coarse	1.47	1.56	6.00	0.93
MS_4	Brown	7.5 YR 5/4	Coarse	1.72	1.79	5.80	0.64
MS_5	Strong brown	7.5 YR 5/8	Gravel	1.61	1.68	5.60	0.31
ME_1	Yellowish red	5 YR 5/6	Coarse	1.66	1.71	6.70	0.51
ME_2	Light brown	7,5 YR 6/4	Coarse	1.72	1.70	6.00	0.66

ME_3	Weak red	2.5 YR 5/2	Gravel	1.78	1.82	6.90	0.86
ME_4	Light reddish brown	5 YR 6/3	Coarse	1.69	1.72	6.40	1.04
ME_5	Dark brown	7.5 YR 4/4	Gravel	1.72	1.91	5.40	0.57
MW_1	Light reddish brown	5 YR 6/4	Coarse	1.32	1.38	5.80	0.60
Mw_2	Reddish yellow	SYR 7/4	Coarse	1.47	1.52	6.10	0.58
MW_3	Pinkish gray	7.5 YR 7/3	Coarse	1.56	1.59	4.90	0.51
MW_4	Strong brown	7.5 YR 5/8	Fine	1.92	2.00	5.20	1.29
MW_5	Light brown	7.5 YR 6/4	Coarse	1.56	1.58	6.60	1.17

IV. Discussion

This project was designed to quantify the mineral elements of soils in three local government areas namely: Donga, Bali and Mutum-Biyu, Local government area respectively of Taraba State. The physical properties of the soils determined were colour, pH, conductivity, density, and specific density and texture while chemical elements were N, K, Na, Ca, Mn, Pb, Fe, Zn, Ni, Cr and Cu.

The results of the physical properties were as present in Table 1.

The first letters in the sample codes refer to Donga (D), Bali (B) and Mutum-Biyu (M); the second letters refer to geographical direction and the number 1 to 5 sampling location along each direction

The colour results of the soil colour were as presented in Table 1. Samples DE_2, DW_2, DW_3, BS_4, BW_2 and MS_1 were found to be reddish brown which suggest the presence of iron oxides with such colour, for example, haemitite is red while magnetite is brown in colour (Brady and Weil, 2002). Samples DN_3 and ME_3 showed weak red coloration and sample BN_2, and BN_3 light red colouration which were perhaps due to the presence of haemitite. Dark reddish brown colour of samples DE_3, DE_5 may be due to organic humus.

Samples DW_2, BS_5, MN_2, MS_4, MS_3 showed brown colouration. Strong brown colouration was observed in sample DW_5, BN_7, BS_2, BE_3, BE_4, BE_5, BW_3 and BW_4. Sample DN_1 DS_3, DW_4, BW_5 and ME_5 showed dark brown colouration, DE_2, MN_4, MS_2, ME_2 and MW_4 showed light brown colour while sample BS_1, showed yellowish brown. These colours were perhaps due to the presence of brown colour of magnetite (Sakar et al., 2001).

Light reddish brown colouration was observed in samples DN_2, DS_2, BN_4, 684, ME_4 and MW_1, while samples BS_1, BE_1 and ME_1 showed, yellowish red and samples DE_1, BN_5, BW_1 and MW_2 showed reddish yellow colouration. These colours were perhaps due to the presence of haemitite and brown colour of haemitites, the yellow colour of goethite and the red colour of haemitite, and the presence of the red of magnetite and the yellow of goethite respectively. Pinkish gray colour was observed in sample DN_4 and BS_2 while samples DE_4 showed reddish gray colourations which were due to the removal of free iron under reducing conditions (Brady, 2002).

The pH values of the soil samples were as given in Table 1. It ranged from 4.10 to 6.90. Samples DN_1 and ME_3 had the highest but same pH value of 6.90, while sample DN_5 with the lowest pH value of 4.10. The ranges are within the acidic region. This shows that the soil samples from the three study area (Donga, Bali and Mutum-Biyu) were predominantly acidic in nature.

The conductivity values of the samples presented in Table 1 ranged soil sample from 0.31 x 103 to 2.20 x 10~3 uS/cm. The highest and lowest were found value, in samples DN_4 and MS_5, respectively. The high conductivity of the DN_4 sample may be due to high concentrations of mobile ions or leached substances while the low conductivity value of sample MS_5 may be due to low concentration of conducting ions.

The results of densities and specific gravities are shown on Table

1. The range of the soil sample density is from 1.12 to 2.63g/cm3 marked by samples BS_3 and BW_1 respectively. For specific gravity, the range for the soil samples were from 1.11 to 2.74 also marked by the same samples (BS_3 and BW_1) respectively. Soils with densities and specific gravities above 1.7 may be sandy soils, in which organic matters are low or continuous tillage of land might have been experienced for longer time (Brady and Weil, 2002).

Soils with high densities have high compactibility which inhibits the easy penetration of roots to the ground and also does not permit movement of water easily on the soil (Kennedy, 1980).

The Calcium contents of the soil sample ranged from 70- 470mg/kg as compared to the magnesium range from 12-68mg/kg. The highest values for both calcium and magnesium were found in sample

BS_3 (470mg/kg) and MW_2 (68mg/kg) respectively. The sodium content ranged from 10-310mg/kg while potassium ranged from 2-415 mg/kg. The highest sodium value was obtained in sample BS_5, BE_5 and MW_5.

Sodium was not detected in samples DE_2, DW_2, DW_3, BE_2 and BE_4. Potassium was not detected in samples BW_4 and BW5 only while manganese was not-detected in samples DE_2, DE_3, BN_3, BN_5, BW_2, BW_5, MN_2, MN_3 ME_2, ME_3 and MW_5. Lead was not detected in MN_1, MN_2, MW_3 and MW_5,

Copper was not detected in any of the samples analysed. Chromium was not detected in most of the samples namely samples but found only in samples MW_5 (14 mg/kg), MW_4 (13) and BE_3, DN_5, DE, DW_4 and BS_2 (4 mg/kg). The lowest detectable concentration was 2mg/kg found in MW_3, ME_1, MS_5, DE_5, DE_2, DS_2 and DN_1

The iron concentration for Donga soil samples (DN_1-DN_5) ranged from 3 to 72mg/kg; the highest and lowest value in DW_5 and DW_2, respectively.

The value for Bali soils (BN_1-BW_5) ranged from 4 to 96mg/kg. The highest and lowest values were found in BW_5 and BS_3 but BS_4 and BW_5 samples did not show detectable amount of the metal. The Mutum-Biyu (MN_1 - MW_5) values ranged from 8 to 47uni.ts with the highest and lowest

detectable values in MN_1 and MS_2 respectively. The range values for Zn, etc are shown in Table 2.

The order of contents of the metals in the study area is Fe > Ni> Zn> Cr> Cu.

In terms of the three Local Government Areas studied, the orders are

a) Fe: Bali > Donga > Mutum-Biyu
b) Zn: Donga > Bali and Mutum-Biyu
c) Ni: Bali > Mutum-Biyu > Donga
d) Cr: Mutum-Biyu > Donga > Bali
e) N: Donga > Bali > Mutum-Biyu
f) K :Donga > Bali > Mutum-Biyu
g) Na: Donga > Bali > Mutum-Biyu
h) Mg: Mutum-Biyu > Bali > Donga
i) Mn: Donga > Bali > Mutum-Biyu
j) Pb: Bali > Donga > Mutum-Biyu

Bali study area had the highest contents of Fe, Pb and Ni but the least value of Cr.

V. Conclusion

Results of the soil sample analyses showed the presence of Fe, Zn, Ni, Cr, N, K, Na, Mg, Mn and Pb respectively. Only Cu was not detected in any of the soil samples. The results showed, a decreasing order: K > Ca > Na > N > Fe > Mg > Mn > Ni > Cr> Pb. Also, the colours of the soil samples were between brown, red and yellow suggesting high iron contents. The pH values of the soil samples ranged from 4.10 to 6.90 and indicate them to be acidic with the highest value in samples DN_1 and ME_3 while the lowest value in DN_5. pH 4.10 to 6.90 shows that soil samples from Donga, Bali and Mutum-Biyu are predominantly acidic in nature. Soil pH ranges of 5.5 to 6.5 perhaps 7.0 provide most satisfactory plant nutrients level overall (Brady, 2002). pH below 5.5 is said to be toxic to plant. By implication, it means the studied areas, with pH 4.10 to 6.90, are productive in terms of pH for the growth of crops.

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