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Fertility Evaluation of Some Soils in Mabudi Langtang South Local Government Area of Plateau State, Nigeria

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Abstract
The study of soil properties in natural and man-made ecosystems is important in developing appropriate ecological sustainable management plans. In this study, the physical and chemical properties of some soils in Mabudi have been examined in relation to their fertility status. Surface (0-20cm) and sub-surface (20-40cm) soil samples were collected from Mabudi, the Headquarter of Langtang South local government of Plateau state with the aim of evaluating their fertility status. The soils were evaluated both in the field and laboratory. The textural class was found to be sandy loam in the surface and sandy clay loam at the sub-surface. Soil reaction were slightly acidic (6.3-6.9), electrical conductivity (EC) were below the critical limit of $4dSm^{-1}$to interfere with plant growth. Organic carbon (OC), total nitrogen (TN) and available phosphorus (Av.P) content were found to be low in all the soils. The exchangeable bases; calcium (Ca) content were high range from 4.51-5.95cmol(+)kg^{-1} and slightly increases with increase in depth, magnesium (Mg) (1.75-4.10cmol(+)kg-1) and sodium (Na) (1.96-3.61cmol(+)kg-^{1}) content were all medium while potassium (K) content were low. The effective cation exchange capacity (ECEC)) and percent base saturation (PBS) were all high while Exchangeable sodium percentage (ESP) were low in the soils. Highly significant positive correlation was observed between pH, electrical conductivity, total nitrogen, calcium, and total exchangeable acidity while a highly significant but negative correlation was observed between electrical conductivity, pH, total nitrogen, magnesium and organic carbon. However, a significant and positive correlation was observed between pH, potassium, magnesium, sodium, total exchangeable acidity, organic carbon and percentage base saturation. The results suggest the soils are generally of low fertility with pH close to neutral position, which suggested that the soil nutrients are optimally available to plants and could enhance root growth.

Keywords: Fertility; Evaluation; Soils; Mabudi; Langtang

Introduction

The fertility of a soil refers to the ability of the soil to sustain agricultural plant growth by providing essential plant nutrients and favorable chemical, physical and biological characteristics as a habitat for plant growth. A soil that supplies adequate essential plant nutrients with favorable soil pH can support plants of good quality and yield (Anderson, 1991). Soil is the single most important non-renewable resource for food production and livelihood to both humans and other fauna. In most rural areas, maintenance and improvement of soil quality is a primary concern. Soil nutrients vary with respect to land used and management. The general factors affecting soil quality are; parent materials, elevation aspect and land use, as well as farming system have strong influence on soil properties, such as organic matter (OM), pH and major nutrients (Anderson, 1991). Among the greatest challenges facing nations of the world today is the provision of adequate food and other basic needs of the citizenry on a sustained base. The need to produce more food and fiber to meet up the need of the world's ever teaming human population has become a matter of necessity and urgency. Soil quality may include a capacity for water retention, carbon sequestration, plant productivity, water remediation, and other functions. Continuous cultivation and indiscriminate deforestation as source of alternative energy are attributed to be the main source of declining per capita productivity of soils and fertility especially in the Nigerian savannah soils (Singh, 1997). The physical and chemical characteristic of the soil are significant indications of soil quality that can directly or indirectly influence the healthy growth of plants and the quality of their products. Several approaches have been advocated to ensure high agricultural productivity and environmental sustainability. This concept is geared towards Site Specific Crop Management (SSCM) (Soil Survey Staff, 2003).

Study of soil properties in natural and man-made ecosystems is important in developing appropriate ecological sustainable management plans (Chandra *et al.,* 2012). Soil properties could vary with land use types and management systems. In mountain areas and on hilly lands, the management of land and its uses and the production of crops demand large efforts. This is because rates of run-off and magnitudes of soil erosion are so severe and could result to depletion of nutrients alongside the soil lose. Early soil surveys were made to help farmers decide what crops and management practices were most suitable for the particular kinds of soil on their farms. The type of soil formed under a particular set of environment is a function of the parent material and time (Anderson, 1991). Soil physico-chemical properties and micronutrients vary in their contents from soil to soil and from one parent material to the other. In view of the multidimensional fertility and varied regional environmental challenges, periodic fertility evaluation is not only imperative and important but necessary if the soils are to produce crops on sustainable basis. Soil analysis allows for the grouping of soils into their various classes; low, medium and high for the purpose of fertilization as well as amendments of problem soils. In view of this, the evaluating some soils in Mabudi will add to the existing soil information in Plateau State Nigeria.

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Materials and Methods

The study area

The study area is located in Mabudi the headquarters of Langtang South LGA of Plateau State, and is located between latitude $8^0 43^1$ and $8^0$51N and longitude $9^0 47^1$ and $10^0$01E, it lies at an elevation 157m above sea level covering a land area of 1188km^2 (Figure 1). The climate is the tropical savanna type characterized by distinct dry and wet seasons. The dry season extends from November to March and the wet season from April to October. The dry season is characterized by harmattan which starts from October/November and continues until about middle of March. Rainfalls range between 1000-1200mm annually with peaks occurring between July and September. Temperature in this region is high throughout the year, because of high radiation income which is relatively evenly distributed throughout the year. April is usually the hottest month (maximum temperature being 38^{o}C) while December and January has the lowest temperature averaging 26^{o}C (Badamasi *et al.,* 2021).

The relief is composed of uplands and lowlands created by interplay of tectonic elevation and erosion now intensified by deforestation and deep differential chemical weathering of rocks. The uplands at the extreme north-west are composed of hills, mountains, and undulating terrains. The lowland is characterized by plain land with pockets of outcrops of basement complex rocks and isolated hills. Major drainages in the area are rivers Wase and Shemankar and their tributaries such as Pil-Gani, Bapkwai, Zamko etc with dendritic pattern. The original vegetation characterized by tall trees inter-spaced with tall grasses has been replaced by a grassy savannah with occasional shrubs due to man interference through land clearance and burning for farming, firewood and grazing. This resulted in regrown vegetation at various levels but the original woodland vegetation (gallery forest) is still found along major streams. Most trees are deciduous, examples include; Shea butter, locust bean, isoberlina and baobab. Land use in the area is dominated by crop cultivation in line with the occupation of over 80% of people, followed by livestock grazing and settlements.

Farming method is mainly non-mechanized, and major crops are; maize, guinea corn, millet, rice, groundnut, soya beans, yam, hot and sweet pepper (Badamasi *et al.*, 2021).

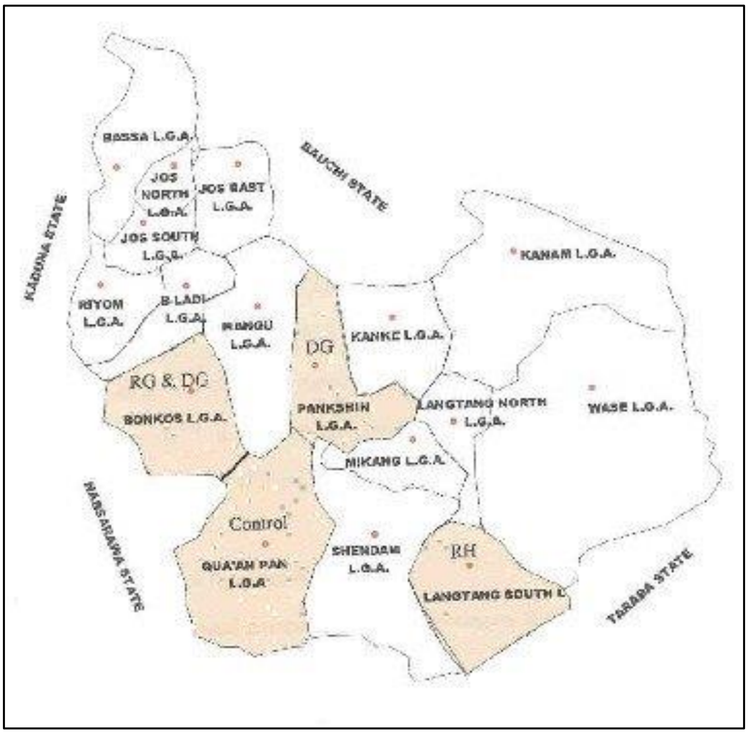

Figure 1: Map of Plateau State Showing Langtang South (Mabudi)

Field studies

Field survey was done following the steps as described by Dent and Young (1981). Five locations with substantial agricultural land in Mabudi the headquarter of Langtang south were randomly selected and sampled for the study. Ten soil samples were collected using a soil auger at a depths of 0-20cm (for surface) and 20-40cm (for subsurface) soils respectively into well lebelled polythene bags and immediately taken to the laboratory for routine analysis.

Laboratory analysis

In the laboratory, soil samples collected were air-dried and grounded using wooden pestle and mortar then sieved to pass through 2mm sieve. Standard laboratory procedures were used to analyze the soils. Particle Size Distribution was determined by Hydrometer Method (Buoyoucos, 1962). Walkley Black Method (Black, 1965 as in Jaiswal, 2003) was used to analyze Organic Carbon (OC). Kjeldahl Digestion Method was used to analyze the Total Nitrogen (TN) while Bray- 1 Methods were used for the analysis of Phosphorus (Bray and Kurtz, 1945). Exchangeable bases were extracted using the ammonium acetate extraction procedure while exchangeable acidity was determined by extracting with 1N KCl. Effective cation exchange capacity (ECEC) was determined by summation method (IITA, 1979) while exchangeable sodium percentage (ESP) was calculated using standard formulas (Black, 1965 as in Jaiswal, 2003). Correlation was used to analyze the data generated.

Results and Discussion

Soil physical and chemical properties

Soils of the Mabudi were generally sandy loam in texture at the surface and sandy clay loam at the subsurface (Table 1). The soil reaction (pH) of all the samples were slightly acidic in reaction (Table 2), the electrical conductivity (EC) of all the samples collected were low and below the critical value (4dS/m) to interfere with plant growth (Brady, 1999). The organic carbon content (Table 2), according to Landon (1991) soil test results rating, all the soils were low (< 0.4%) in Organic Carbon content. The low organic carbon level could be attributed to rapid decomposition and mineralization of organic materials due high temperature and sparse vegetation in the area (Sharu *et al.,* 2013). Total Nitrogen contents of the soils were also generally low (< 0.69 gkg^{-1}) at the surface and (< 0.35 gkg^{-1}) at the subsurface. This low Total Nitrogen content could be attributed to sparse vegetation, crop removal and rapid mineralization of organic matter (Sharu *et al.,* 2013). Available phosphorus (AVP) was generally low (<7.75 $mgkg^{-1}$) in all the soils samples collected in the area. The low available phosphorus could be attributed to losses through leaching, crop removal and erosion.

Table 1: Particle size analysis of Mabudi

No	Soil Depth (Cm)	Particle Size (%) Sand	Silt	Clay	Textural Class
1	0-20	76.50	10.06	13.44	Sandy loam
	20-40	71.17	5.20	23.63	Sandy Clay loam
2	0-20	78.01	10.50	11.49	Sandy loam
	20-40	64.56	8.96	26.48	Sandy Clay loam
3	0-20	73.50	11.55	14.55	Sandy loam
	20-40	64.91	9.06	26.03	Sandy clay loam
4	0-20	71.56	15.07	13.37	Sandy loam
	20-40	65.58	8.02	26.40	Sandy clay loam
5	0-20	69.04	17.52	13.44	Sandy loam
	20-40	65.54	7.60	26.86	Sandy Clay Loam

The exchangeable bases (Table 2) calcium contents were high ranging from 4.51-5.95 cmol(+)kg^{-1} and slightly increasing with increase in depth. Magnesium (1.75-4.10 cmol(+)kg-1) and Sodium (1.96-3.61cmol(+)kg^{-1}) contents were medium while potassium contents were low and ranged from 0.21-0.38 cmol(+)kg^{-1} in the soils. Importantly also is the fact that the dominant sandy loam at the surface might have allowed for the excess leaching of bases there by making it to become slightly higher at the subsurface. Total exchangeable acidity was very high and ranged from 0.45-1.47$cmolkg^{-1}$. Effective cation exchange capacity (ECEC) were high and range 10.95-12.96$cmolkg^{-1}$, Percentage base saturation (PBS) were high and ranged from 89.01-96.01 while exchangeable sodium percentage were generally low as presented in Table 2.

Table 2: Chemical properties of Mabudi soils

NO	Soil Depth (cm)	pH 1:2	EC (dS/m)	OC (%)	N (g/kg)	AVP (mg/kg)	Ca	Mg	K	Na	TEB	TEA	ECEC	PBS (%)	ESP (%)
							cmol(+)gkg-1								
1	0-20	6.86	0.49	0.27	0.42	7.10	4.59	2.90	0.34	3.31	11.14	1.21	12.35	90.20	26.80
	20-40	6.96	0.04	0.16	0.23	6.22	5.01	1.75	0.30	2.83	9.89	1.06	10.95	90.31	25.85
2	0-20	6.80	0.31	0.21	0.46	7.75	5.30	2.96	0.29	2.82	11.37	0.99	12.36	91.90	22.81
	20-40	6.76	0.06	0.13	0.30	4.10	5.10	2.89	0.23	2.61	10.83	0.45	11.28	96.01	23.14
3	0-20	6.62	0.07	0.34	0.68	6.82	4.56	3.01	0.36	2.86	10.79	1.47	12.26	89.63	17.76
	20-40	6.71	0.16	0.24	0.30	3.30	5.95	2.82	0.26	2.14	11.17	1.17	12.34	89.01	17.34
4	0-20	6.88	0.17	0.33	0.46	7.01	5.30	4.10	0.38	2.10	11.88	0.76	12.64	93.99	16.61
	20-40	6.73	0.02	0.28	0.35	2.40	5.84	3.96	0.21	1.96	11.97	0.68	12.65	94.62	15.49
5	0-20	6.44	0.72	0.24	0.41	7.68	4.51	3.82	0.37	3.13	11.83	1.13	12.96	91.28	24.15
	20-40	6.52	0.39	0.31	0.29	6.01	4.82	3.52	0.24	2.71	11.29	0.98	12.27	92.01	22.09

Abbreviation: EC = Electrical conductivity; O.C = Organic carbon; Av.P = Available phosphorus; Ca = Calcium; Mg = Magnesium; K=Potassium; Na = Sodium; TEB= Total exchangeable bases; TEA= Total exchangeable acidity; ECEC = Effective cation exchange capacity; PBS = Percentage base saturation; ESP= Exchangeable sodium percentage

Correlation Analysis

Correlation analysis of the soils indicated that highly significant positive correlation were observed among pH (0.817**), electrical conductivity (0.710**), total nitrogen (0.711**), calcium (0.729), and total exchangeable acidity (0.829**) while highly significant but negative correlations were observed between electrical conductivity (-0.768**), pH (-0.857**), total nitrogen (-0.972**), magnesium (-0.918**) and organic carbon (-0.804**). However, a significant and positive correlations were observed between pH (0.517*), potassium (0.660*), magnesium (0.529*), sodium (0.653*), total exchangeable acidity (0.620*) organic carbon (0.564*) and percent base saturation (0.526*).

Table 3: Correlation of some chemical properties of Mabudi soils

Soil properties	EC	pH	TN	Av.P	K	Ca	Mg	Na	TEA	OC	PBS
EC											
pH	0.016										
TN	-0.019	-0.755**									
Av. P	0.377	0.517*	-0.359								
K	0.185	0.660*	-0.474	0.236							
Ca	0.027	-0.857**	0.934**	-0.274	-0.618						
Mg	0.031	0.777**	-0.972**	0.417	0.438	-0.918**					
Na	0.010	-0.119	0.303	-0.274	-0.351	0.296	-0.230				
TEA	0.394	-0.672*	0.341	0.036	-0.443	0.620*	-0.331	0.152			
OC	0.710**	0.817**	-0.491	0.564*	-0.453	0.472	-0.049	-0.049	-0.487		
PBS	-0.768**	0.437	0.711**	0.526*	0.628*	0.729**	0.592*	0.653*	0.892**	-0.804**	

* Significant
** Highly significant

Conclusion

In conclusion the results obtained from this study suggest that the soils are of low fertility status but the pH close to neutral. This implies that most nutrients are optimally available to plants and generally very compatible to plant root growth. Organic residue management, integrated nutrient management, mineral fertilizer and appropriate cropping pattern can be used to maintain the productive capacity of the soils without subjecting them to chemical degradation. Periodic soil testing is very importance to properly monitor the fertility parameters of the soils.

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