An Assessment Of Landscape Segments Suitable For Agriculture In Kerang Volcanic Area Of Jos Plateau, Nigeria

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Abstract: This study was carried out to investigate the landscape segments suitable for agricultural purpose in a volcanic land catena of Kerang Area on the Jos Plateau. A reconnaissance survey of the study area was carried out and three different slope segments were identified, a total of 41 surface soil samples were taken from the three segments using a stratified systematic sampling. These soils were then analyzed for the physical and chemical properties. The result of the analyses revealed that the organic matter, total nitrogen, soil P^H and exchangeable (Ca Mg) decline down slope, however, potassium (K) and sodium (Na) increase down slope. Co-efficient of variation of the soil properties for the three different slope segments showed low variability for the upper slope (crest and shoulder), exception being that phosphorus (43.10%) and potassium (41.10%) exhibited moderate variability. At the middle slope, the co-efficient of variation exhibited by soil properties is predominantly moderate, exception being that sodium (75%) varies at high proportion at this slope segment. At the lower slope, majority of the soil properties exhibited low variability. On the other hand, total nitrogen: available phosphorous and potassium have values of co-efficient of variation 23.10%, 65.60% and 23.10% respectively. This indicates that available phosphorus exhibited high variability while total nitrogen and exchangeable potassium have intermediate variability. The between or over all co-efficient or variation for the soil properties are predominantly moderate for most variable except P^HH_2O (11.80%) and P^H Cad_2 (10.60%) that have low variability and phosphorous (78%) has high variability. Differences in the degree of variation of soil variables from one segment to another can be attributed to soil erosion as affected by slope, nature of soil parent materials and soil management technique. The study also revealed that some of the properties determining soil fertility (total Nitrogen, Available Phosphorus, organic matter, soil P^H and exchangeable cation) decreased from the upper part to the lower part of the landscape, with the exception of potassium, (K) and sodium (Na). Recommendations were put forward on how best to use the landscape of the study for agricultural production.

Index Terms: Soil, Landscape, Segments, Soil properties, Agriculture.

1 Introduction

Agriculture being the major aspect of Nigeria's economy depends to a large extent on land quality and its availability for meaningful productivity. Among the several challenges facing mankind today is the question on how to feed the increase population and the need to improve the soil conditions. Landscape on the other hand dictates micro climate, water dynamics and material redistribution processes that critically influence the nature of soil and vegetation slope gradient and aspect strongly affected soil morphological characteristics and Geo-chemical processes, [1]. A clear understanding of the variation of soils along a typical catena gives an idea of crop suitability, within each segment of the landscape [2]. A study has shown that there is uniqueness in crops performance on a volcanic landscape on the Jos Plateau. The agricultural crop grown in the upper parts appear relatively better than those in the lower parts of the landscape [3].

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Jos Plateau is known for spectacular geomorphological features as a result it's unique geological activities of special note is the occurrence of isolated hills and rings, which was formed towards the end of tertiary period during the Miocene and Pliocene. Equally important is the fact that the Plateau has been divided into three physiological units, including hills mountains, dissected terrain and undulating landscape [4]. It is a common sight to observed steep to moderate slope along these physiographic unit as compare to other surrounding environment. The quantitative information on soil and slope relationship can be of use for planning and management of soils for improved agricultural production. The researchers also hopes that the analytical and theoretical approaches to be employed here can be of interest for future scholars. In addition, the spatial distribution and disposition along particular slope can be of use in indicating the best location for farming.

2 AIM AND OBJECTIVES

The aim of the study is to investigate the segment of landscape suitable for agricultural purposes with particular reference to Kerang volcanic area of Jos Plateau. The following objectives have been set out to achieve the aim of the study.

(i) To identify the various segments within the landscape
(ii) To determine the soil properties within each landscape segments.
(iii) To determine the extent to which each of the landscape segments can be suitable for agriculture.

3 STUDY AREA

The Jos Plateau lies between latitude $8^0 30^1$ and 10^0N and longitude $8^0 20^1$ and 9^0 30^0E with surface area of about 8,600 square kilometer in the central part of Nigeria. It has average elevation of about 1,250 meters above sea level, and stand at height of about 600meters above surrounding plains [5]. Now with 1250 meters as the average elevation, the actual elevation of the research site at Kerang (G.P.S reading) of the highest and the lowest altitude were 1388 and 1,330 meters above sea level respectively (Filed work, 2008). Plateau is bounded in the north by the Rishi Hills to the west by the Kaduna Plain and Jere plain and on the southeast by the Benue and Gongola plains. Kerang on the other hand is bounded by the following communities to the north Panyam on the west, Pushit to the south, Mupun and Ampang to the east, Kombun. The climate of the study area exhibit qualities of the tropical climate which are marked bu the dry and raining seasons. Two well defined seasons of dry and wet conditions, corresponding to the termination of the north-east (hamartan) wind (tropical maritime air mass. The season are controlled by the position of inter-tropical convergence Zone (I.T.C.Z) the climate of the area was named tropical rainy (AW)^{0}climate.The characteristics conventional and orographic rain often occur with thunderstorms especially at the beginning of rainy season. The climate of Jos Plateau is determined by it. Altitude and position across the path of seasonal migration of the inter topical convergence zone (I.T.C.Z). As regard the accounting of its attitude, the plateau experiences lower temperature than elsewhere in Nigerian, except the Obudu Plateau and some part of eastern highland. Its position in relation to inter-tropical convergence zone(ITCZ) determines the season, the dry season is dominated by north eastern tropical continental (TC) air mass popularly known as harmatan (October to March) while we season is dominated by south western (TM) maritime air mass (May to September). The distributions of rainfall temperature relative humidity sunshine and wind flow are determined by the two seasons. The means annual rainfall of (July and August as the peak is well defined on the Jos. This month is unevenly distributed. The variability is caused by both air flow and to topography, thus on a more hilly, south west area the rainfall may be about 2000mm or more due to effect of Orographic rain, while on the eastern part of the rainfall may be as low as 1000mm. The mean annual temperature of the Jos Plateau is about 22^{0}C, but mean monthly value between 19.40^{0}C in the coolest month of December and January when the area come under the influence of cool and dry desiccating north easterly tropical continental air mass (harmatan) and 24.5^{0}C in the hottest month of April. The geology of the Jos Plateau comprise pre-cambrian basement complex rocks. The oldest recognized type being granites and migmatite, widely spread over Jos Plateau are older and younger granites. These rocks were known to form during Jurasic period. The distribution of younger granitite is such that they form hill ranges rising to an elevation between 200m and 100m above the surrounding plain. The Jos Bukuru complex is the largest, covering about 780 square kilometers in the northern part of Plateau. The quaternary and tertiary volcanic rocks (Mainly Basalt, Pumice, Lava flows and ash deposit) are recent in age. The Basalt rocks which are associated with volcanic activities can be divided into three groups, leteritised older Basalt, older Basalt and newer Basalt. The older Basalt has suffered denudational activities; where as the newer Basalt can be traced to a reasonably well preserved volcanic canoes. The Jos plateau has land surface consisting of plain, hills, depression and valleys. The Plateau surface is spotted by isolated hills and occasionally dissected by river valleys, which was formed toward the end of tertiary period during the Miocene and Pliocene and immediately after the Extrusion of order basalt probably between 5 and 2 million years ago. History has it that, initially, plateau was a swampy land, probably elevated not more than 100-200 meter above sea level with isolated rocky hills called inselberg rising up to 100mm above the plain, with river meandered between swamps leaving alluvium up to 50m thick in some places, so that at the upper part of this clayed alluvium, duricrust was found (also called laterite). The up-liftment of the Jos plateau generally was accomplished by volcanism and denudation which give rise to three principal types of isolated hills spotted on the plains.

a. Volcanic hills on older granities or pre-Cambrian metamorphic rocks from a basaltic rock the mesas which are of relief of the late tertiary depositional surface from the lateritic surface summit, a form of soft overburden capped with lateritic called duricrust located on the pre-Cambrian rocks.
b. Inselbergs and castle kopjes which are of younger and older granite complexes located on hilly areas. On the other hand the depression are mostly river valley, dissecting which was formed towards the end of tertiary period.

The Jos Plateau can be described as a gently undulating terrain, highest in the south west and sloping to the north east merging into Bauchi plain and gradually decending to the Kaduna Kafanchan plains north west ward, with dissected surface and escarpment to the south and south west[6]. The Jos plateau is highly noted for its drainage network, made up of streams, which constitute the source of some major river drainages in many part of Nigeria, thus Jos is referred to as the hydrographic centre of Nigeria from where rivers flowing into Lake Chad, Gongola and Benue radiate. The interaction of pedogenic factors has produced series of soil on the Jos plateau and these soils reflect the influence of parent materials. Attempt by researchers in classifying and identifying soils for the past years have been quite encouraging [7]identified two main group of soil these soils are (i) Lithisols and (ii) ferriginous tropical soils. According to Food and Agriculture Organization (FAO) classification shows that lithisols dominate over other soil on the plateau. In a similar study, Olowolafe (2001) reported that there are different soil types and changes in soil characteristics between the summit and the adjacent drainage in a typical volcanic land catena on the Jos Plateau. On the other hand similar soil major types were identified in boitite granite areas [7].

4 MATERIALS AND METHODS

The data for this study was obtained from the field, a reconnaissance survey was done to identify suitable topographic features, in the course of the survey, a careful observation along the slope profile revealed four different slopes segment and they are:

i. The crest
ii. Upper foot slope
iii. Middle foot slope and
iv. Lower foot slope

In order to obtain soil sample stratified systematic sampling was employed stratification was done to divide the landscape into crest, upper foot slope, middle foot slope and lower foot slope. Systematic (rigid grid) sampling was there after carried out, within each of the following crest middle slope and lower slope segment identified (that is the crest middle and lower slopes). A plot of 30m x 20m was chosen and divided into twelve (12) grids of 100m^2 each. Four sampling points were chosen by throwing up a coin four times, the four surface soil auger at a point where the coins landed, were dug, mixed up together to form a composite sample out of which sizeable portion was bagged for laboratory analysis. This mean that were twelve (12) sampling site for each of the slope segment, that is the crest, middle and lower slope respectively. This gives a total of thirty six samples. On the other hand, additional samples were taken from the crest, upper foot slope, middle slope and lower slope. The total soil samples along the entire slope profile under investigation then summed up to forty one (41) soil sample. Having brought the soil from the field, they were spread on the table, devoid of rain and human interference, adequate ventilation was provided. Soil samples were taken in August and well air dried, after which each soil sample was crushed using pestle and motor and then sieved within a 2mm sieve to separate gravels and other coarser materials. After the pre- treatment, soil samples were bagged and well labeled as obtained from the field before taken to the department of soil science, Ahmadu Bello University Zaria for both physical and chemical laboratory analysis. In conducting the soil analysis, importance was placed on those soil properties directly affecting soil fertility status which are: soil acidity, macro nutrients (Nitrogen, Phosphorus and Potassium) , micro nutrients (Calcium, Magnesium and Sulphur) were investigated. For the necessary analysis and interpretation of data, the following statistical techniques were adopted to explain and describe the soil data. These techniques are the mean, standard deviation, range, co-efficient of variation and bar graph, are some of the presentation tools used where appropriate.

5 RESULTS AND DISCUSSION

Table 1: Pattern of variation of soil properties along Kerang volcanic Land Catena (Selected properties)

Variables	Crest	Site slope	Upper slope	Middle slope	Lower slope
Clay (%)	70.00	150.00	230.00	240.00	270.00
Silt (%)	120.00	160.00	220.00	220.00	280.00
p^H H_2O	7.00	6.90	6.80	5.10	6.90
p^H Cad_2	5.70	5.80	5.80	4.80	5.90
Organic Matter (%)	4.35	3.43	2.47	4.15	3.10
Total Nitrogen	0.16	0.12	0.11	0.21	0.1
Available phosphorus	17.50	4.38	4.38	1.75	4.38
Exchangeable calcium meg/100g	26.00	19.00	14.00	6.00	14.00
Exchangeable magnesium meg/100g	8.95`	11.08	10.28	5.21	8.15
Exchangeable potassium meg/100g	0.46	0.84	0.44	0.56	0.72
Exchangeable sodium meg/100g	0.35	0.28	0.32	0.40	0.50

Source: *(Laboratory analysis, 2014)*

Physical properties

The data in table1 above revealed information on the general pattern of soil special distribution along Kereng volcanic catena. It is an obvious fact that there is variation in soil properties along the various slope segment identified. For clay and silt content of the soils, the pattern of distribution is such that they increase downward along the catena that is from the upper part of the catena to the lower part. For the sand, the values for crest, silt upper,, middle and lower slope are in this order 81%, 69%, 55% and 45% respectively. Perhaps the variation can be attributed the effect of transportation sorting of material of different sized [8]. The finer materials like clay are sorted and carried much more further away than the sandy particles, hence the further away from the crest the less the sand contents. However the reverse is the trend for sand content of the soil along the catena. Olowolafe (2001), observed that clay dominates at high proportion in the lower slope-foot slopes and the surface soils of the toe slope areas). This he attributed to two reasons, which have under gone much more rapid hydrolytic weathering than pyroclast to form clay and silt at both slope segments, that is foot slope and toes slopes respectively. Secondly that the clay particles eroded from the crest, site and upper slopes are deposited on the foot slope. It is equally important to note that at the crest erosional process dominates [2], hence slope process may not have pronounce effect on soil variables, consequently the pattern of soil physical properties as indicated in table 1 Similar studies was also carried out by Hashim (2003) which indicated that in soil catena in Malaysia the clay fraction decrease downslope across the entire landscape, he is of the view that its either because of the sub-surface wash or through flow. The variation in physical soil properties as shown in table 1 is equally, supported by [10]. The result gotten from investigation indicated that where composition of waste mantle result from slope processes, sand content of the soil will increase down slope, conversely where waste mantle result from pedogenesis, sand content of the soil will decrease down slope, while clay will be the reverse. It is reasonable enough at this junction to appreciate the fact that the composition of a waste mantle is a function of either slope process or pedogenesis.

Chemical Properties

Soil pH

The soil P^H as indicated by chemical analysis result shows that P^H decrease from the upper part of the catena to the lower part of the value obtained for the crest site, upper middle and lower slope are 7.00, 6.90, 6.80, 5.10 and 6.90 respectively. This in essence means that P^H decreases from the upper slope down to the lower slope. The result obtained is in line with those of Olowolafe (2001), they reported that increase in gradient angle in upper slopes is usually accompanied by increase in Soil P^H.

Organic Matter content

The case with organic matter is shown in table , it is very clear that percentage value for organic matter decrease along the catena, from the crest down the slope segments. The value obtained for the crest site upper, middle and lower slope are in this order 4.35%, 3.45%, 2.47% and 3.10%. Not withstanding the variation can be attributed vegetative decomposition deposition and different nature of parent materials at each segment (basalt rock, lava and ash) across the land scape [2]. The weathering product of these different volcanic materials may vary in their abilities to form complexes with organic matter. Rao, (1982) observed similar result for volcanic landscape in Indonesia. It therefore, stand to reason that, total nitrogen in soil along the catena at the upper part is higher than those at the lower part reflecting the effect of organic matter on total nitrogen.

Available phosphorus
The available phosphorus in the land catena also decreases down slope from the crest, shoulder site, upper, middle and lower slope. As indicated in table 1, the values are in this order, 17:50, 4.38, 4.48, 1.75 and 4.38 respectively. The variation phosphorus availability can equally be attributed to the available phosphorus nature of parent materials and slope position.

Calcium and Magnesium
It can equally be well appreciated as shown in table 3 that calcium and magnesium decrease along the slope catena from the crest, upper middle and lower slope, the value for calcium and magnesium are in the order 26.00, 18.00, 14.00, 8.00, 14.00 and 8.95, 11.08, 10.28,5.21 and 8.15 respectively. The authors' findings concur with the study of Shoji et al (1985). They observed that magnesium and calcium generally decrease from the upper (slope) part of the landscape down the slope indicating that the furthest the soil sample from the volcanic catena, the least calcium and magnesium content.

Potassium and Sodium
As revealed in table 1 potassium (K) and sodium (Na) don't have significant variation along the catena the fact could be that leaching translocation and redistribution of mobile chemical constituents the low potassium (K) and sodium (Na) nature of parent material and the topographic position may not have much effect on these soil parameters. It can then be concluded that along Kareng land catena, some of the properties determining soil fertility decrease from the upper parts down slope to the lower part of the slope. This is equally supported by Hashim (2003) that lower slope is characterized by much greater variability with low slope distance appear to have greater variability influence on soil character. He concluded that the combine effect of slope and distance down slope is responsible for much of the variation observed in soil properties along a given land catena.

6 CONCLUSION AND RECOMMENDATION

Observations
Generally, there is variation in soil properties as revealed by laboratory particles size distribution and chemical analysis. The case with clay and silt, they increased down ward along the volcanic land catena. That is from upper part to the lower part of the slope. However, it was observed that the finer materials like clay particles are sorted and carried much further away than the sandy particles. Hence the further away from the crest, the more the clay content of the soils reverse is the trend for sand. On the other hand, chemical analysis revealed that, some of the properties determining soil fertility (total Nitrogen, Available Phosphorus, organic matter, soil P^H and exchangeable cation) decreased from the upper part to the lower part of the landscape, with the exception of potassium, (K) and sodium (Na). Line within co-efficient of variation revealed that, most of the soil variables exhibited low to moderate variability. However, for the crest and shoulder soil properties exhibited low variability except for phosphorus (45.10% and potassium (41.10%) with moderate variability. The low variability can be attributed to the uniformity in parent materials (Basalt). The co-efficient of variation exhibited by soil properties at the middle foot slope is pre-dominantly moderate. However, sodium (Na) (75.5%) has high variability. The dominant moderate variability at the middle foot slope can be attributed to relative stability in slope and uniform soil management. The case with lower slope, almost all the soil properties exhibited low variability except that total nitrogen, available phosphorus and potassium have 23.10%, 65.60% and 23.20% respectively which are moderate and high variability. The between soil properties exhibited moderate variability and this can be traced to the fact that parent materials at each slope segment differ. As for crest there is Basalt, middle slope has lava while lower slope is made up of ash. At each of these slope segments, the nature of parent materials determines soil properties. The process of slope in redistributing weathered materials and relative stability in pedogenic process at the middle and lower slope have made it possible for moderate variability along the entire landscape catena. By comparison for the within and between variation, it can be concluded that, while the within slope segment shows low to moderate variability, the between slope can be regarded as showing moderate variability, except for sodium, with high co-efficient of variability.

CONCLUSION

The following conclusion can be drawn from the observations. The variation in the pattern of soil properties can be regarded as moderate for the between slope segments and low variability for the within slope segments. Slope process, hydrolytic weathering and gradual transportation and deposition of materials are also contributing factors to variability in soil properties along the Kerang volcanic land catena. It is also important to note that the prediction of soil response to environmental hazard and adequate estimate of crop yield given that weather condition is favourable, can be some extent ascertain.

RECOMMENDATIONS

From the observations and conclusion made with respect to volcanic land catena, the authors recommend proper land use planning for the various slope segments of the Kerang volcanic land catena need to be given attention. Government and research organization should intensify effort toward volcanic land catena inventory at the local national and international level so as to maximize the potential fertility of the landscape for agricultural purpose. The internal soil property of the volcanic materials vary, hence the need for farmers to be enlighten as to which manure (organic or inorganic) can be appropriate for the catena landscape. Observation has also revealed that most of the soil properties essential for maintaining soil fertility decreases from the upper part of the slope (summit) to the lower part, hence the authors recommend that upper slope need to be explore for farming purposes instead of grazing. The co-efficient of variation of the soil properties have been largely due to nature of parent materials, hence the authors are of the opinion that intensive further studies either by government, agencies, researchers or non-governmental organizations should be geared toward understanding detail nature of parent materials in relation to any crop to be grown at any of the slope segment.

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