Laterite Soil of Lafia, Nasarawa State, Nigeria

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Abstract: Laterites are variegated materials which are common in humid tropical area of the world, the materials when exposed to the diurnal radiation hardens and irreversible. However the terms laterites and laterite soils have different types of definitions. In fact any red coloured material rich in iron oxides has been described as laterite resulting in a lot of controversies in the literature. In order to overcome these new terms such as plinthite petroplinthite, pallid zone and iron coated materials as used by various scientists. Two types of lateritic soil are found in Lafia; autochtonous and allochtonous laterite materials. The autochtonous are laterite stone formed in-situ, and has high concentration of iron in them, mostly found at the alluvial and young plains of the study sites, the seasonal upward movement of the water table made the iron mottle called plinthite (ferrous) conglomerated with the stone contents that are later oxidized to petroplinthite (Ferric concretional stone line) to formed nonclast (sub-angular) laterites, while allochtonous laterites are clast (angular) stones found within the higher gradient between the slope of 6^0 and more than 12^0. Their formation is as a result of episodic action of fluvial activities. The stone contents of the laterites are rounded, with smooth surfaces, due to action of corrosion and abrasion of the chemical weathering.

Keywords: *Laterite, Allochtonous, Autochtonous, Plinthite, Petroplinthite, Concretional Ironstone, Oxidation, Humid Tropic, Lateralization, Shale And Regolith*

I. INTRODUCTION

Laterite can be defined as highly weathered materials that are rich in secondary forms of iron, aluminium or poor in humus and are depleted of bases and combined silica, however, with or without nondiagnostic substances such as quartz limited amounts of weatherable primary minerals or silicate clays and furthermore either hard or subjected to hardening upon exposure to alternate wetting and drying (Sivarajasingham et al, 1962, p 5). Laterite and lateritic soil have been studied by soil scientist, geographer and geologist. The soil scientists have been interested in the genesis of laterites and lateritic soil and their suitability for agriculture like-wise geographer.The geologists on the other hand are interested in these because some laterites are closely related materials that have economic values as iron ore aluminium and nickel. Different objectives of these studies on laterites or soil of laterites resulted in widely of research findings of materials being called laterite or lateritic soils (Paramananthan and Tharmarajan, 1983). The term laterite was first introduced by Buchaman (1807), a geologist as a name for a soft ferruginous material that was quarried in southern India for build blocks. According to Buchaman the rock hardened quickly to form material superior to good bricks in both strength and impermeability to water. Harrison (1910) broadened the definition of laterite to include earthy iron and aluminium rich materials that do not harden (plinthite). Today the term is also used to describe the hardened ironstone, concretions and gravels. Laterization is an important factor affecting landform development and land-use in many parts of the tropics.

A wide variety of materials have since been called laterite and lateritic soils by many researchers in many countries resulting in a great deal of disagreement about the range of materials to be covered by these terms with respect to occurrence, nature and composition in the landscape(Prescott and Pendleton, 1952; Sivasajasingham et al, 1962 Alexander and Cardy, 1962; Paramananthan and Tharmarajan, 1983).

The objective of this paper is to examine the nature and types of laterites found in Lafia region.

II. MATERIALS AND METHODS

A. The Study Area

This study is carried out in the humid tropical region of Nigeria. The study site is Lafia area, in Nasarawa State located between latitudes 8^0 35' 19"N; 8^0 35' 191"N; 8^0 32' 173"E and8^0 33' 20"E of the equator.Lafia geological formation is the youngest lithological unit in the middle Benue valleys.Obaje (1994) called it the "Upper Grits and Sandstones" and had described an unfossiliferous, non-salt-bearing, brick red grit, with white spots of felspathic materials. This is more or less flattish part of the Benue valley maintains a gentle slope, thereafter, with a gradient of about one to eight hundred meters, towards it's main geographical feature, the river Benue.The drainage is generally dendritic. The main river systems are the Guma, Ma, Asuku and Ankwe rivers. Lafia area is characterized by a tropical sub-humid climate with two distinct seasons. The wet season started from May to October and dry season from November to April. Mean annual rainfall range from 1100mm to about 1500mm. The mean monthly temperatures in the state range between 20^oC and 34^oC with the hottest months being March/April and the coolest months being December/January. Dense forests are few and far apart. Gallery forests are common along major streams and pronounced depression. The major soil units of Nasarawa state belong to the category of oxisols and tropical ferruginous soils. The soils are derived mainly from the basement complex and old sedimentary rocks (Obaje, 1994).

B. Sample Collection, Treatment and Preservation

The data for this research is mainly primary data which were soil samples collected from the weathered mantle of the soil profile along open or road cutting which formed the sampling point transect. However the secondary data are mainly materials from abstract and literatures of past research. In each of these areas several localities were surveyed but the actual sites were decided upon on the basis of the relative ease with which the ironstones were found, as most were exposed either on the surface along cross-sections of slopes or road cuttings. Once the general areas have been determined the actual sampling sites were then identified and demarcated. soil sampling was carried out along four transects (1 – 4) with orientation of NNW-SSE and found with the old alluvium Cretaceous Awgu formation. Sampling locations along each transect were identified as pegging points, which were 250 metres apart in length. Subsequently, the depths of topsoil, laterite and regolith (parent materials) at each site were determined as the soil samples were being taken from each point. Thirty soil samples (average of 500g per bag; spot measurement) were collected from the average depth between 45cm to One meter. Moreover, most of the laterite are found in B horizon of soil profile, in all the four sites. The soil samples were packed in polythene bags for physical and chemical analyses in the laboratory. Soil samples collected, stored at room temperature (32^{0}C), furthered air dried in the Oven at 109^{0}C ground, sieved and repacked for further laboratory analysis.

C. Mineral Analysis

All the analyses were carried out in the laboratory in accordance with American Public Health Association (1989) standard methods for examination of water. The elemental analysis was done in the water samples using Perkin Elmer and Oak Brown, atomic Spectrophotometer. The instrument setting was as described by Abiola*et al*. (2014) and Aremu*et al.* (2008). Sodium and potassium were determined by using a Flame Photometer (Model 405, Corning, UK).

D. Physico-Chemical Analyses

Physical parameters analyzed are soil colour, soil texture, moisture content and soil structure of the superficial deposits, while Temperatures were measured using a mercury thermometer while pH was done using a BNC pH meter. Conductivity measurement was done using conductivity metre model NATOP PBS while alkalinity and total hardness were done by titremetry (APHA, 1995). Chloride was measured by chloride ion water (model KRK Cl-Sz Japan). phosphate (molybdophosphoric blue colour method in H_2SO_4 system) and nitrate were estimated using a PYE UNICAM visible spectrophotometer in NAFDAC, in Lagos. Total dissolved solids were determined by gravimetry method and chemical oxygen demand (COD) by APHA method (APHA, 1995).

III. RESULTS AND DISCUSSION

The topography of the sample locations are predominantly low, with the majority of the land surface lying below 30m elevations. Moreover, Lafia has a young pediplain that runs along river channel from NW of River Amba down to the forest reservation post, with elevation above 60m. Shale is the predominant parent material in the south eastern part of the river pediplains, while alluvium deposit is predominant in upper NE of river Amba. The bedrock rock in Lafia is predominantly (90%) shale materials with continuous faults and joints, unlike site 4 where the bedrock material is alluvial deposit. Linear ridges grid of the prismatic compass strike along NNW – SSE direction at sites 1 – 4, with the major tectonic fault and erosional gullies dip along the east.

Table 1: Morphologic Analyses of Amba Interfluves in Lafia Study Sites

Site	Geology	Area location	Location	Slope Angles	Altitude	Site Length	Stone-Line Thickness	Characteristics
1	Middle cretaceousall uvium, Awgu formation	Amba Interfluves	Long. 08^0 33' 203";E Lat. 8^0 35' 191" N	7.5^0; 7^0; 7^0; 6.5^0; 6.5^0	87m	250m	Less than 30cm	The stonelines and saprolite horizons have lateral striation. They have a fine texture with sub angular and platy stones consist of weathered bedrock. Thick saprolite with intrusion of quartz veins and numerous ants mounds. The colours vary with the dampness of the soil profile. Some laterite and concretional ironstone sparsely distributed within the stone-line horizon.
2	Middle cretaceousall uvium, Awgu formation	Amba Interfluves	Long. 08^0 33' 112";E Lat. 8^0 35' 191" N	7.5^0; 7.5^0; 7^0; 7^0; 7.5^0	84m	250m	Less than 30cm	
3	Middle cretaceousall uvium, Awgu formation	Amba Interfluves	Long. 08^0 33' 08";E Lat. 8^0 35' 191" N	7.5^0; 7^0; 7.5^0;7.5 ^{0}; 7.5^0	85m	250m	26cm	
4	Middle cretaceousall uvium, Awgu formation	Amba Interfluves	Long. 08^0 32' 173";E Lat. 8^0 35' 191" N	4.5^0; 4.5^0; 6.5^0; 5.5^0; 6.5^0	43m	250m	26cm	

Source: Field Work,

Table 2: Texture Determination and Percentage of Soil properties in Stone line Horizon, Amba interfluves, Lafia

	T1	S1	R1	T2	S2	R2	T3	S3	R3	T4	S4	R4
Clay	2.08	0.24	0.77	2.66	0.59	0.30	1.76	0.61	0.56	1.55	0.49	2.23
Silt	12.23	0.98	5.56	8.39	3.61	1.64	13.59	4.52	4.00	10.20	4.07	7.14
Sand	35.50	12.68	29.38	27.45	10.93	19.20	32.79	27.33	29.80	35.29	17.88	26.04
Stone	49.19	86.10	64.29	61.50	84.87	78.86	48.14	67.54	65.64	52.96	77.56	64.59
Total	100	100	100	100	100	100	100	100	100	100	100	100

T: Topsoil, S: Stone line and R: Regolith Horizon Fieldwork, 2010

Figure 1.Illustrates the cross-section of the superficial deposits in Lafia. The cross section is mainly a river cross-section that leads to the south east of the river (River Amba). The total length of the transect cross-section is 1000 meters.

Table 3. Textural and Structural Analysis of Lafia Stone lines Transect point 1

Soil Sample Size	Colours	Surface Coating	Roundness	Sphericity
< 0.045mm	7.5YR 7/8	Reddish Yellow	Rounded	High
> 0.045mm	7.5YR 6/6	Reddish Yellow	Rounded	High
> 0.075mm	7.5YR 6/4	Light Brown	Rounded	High
> 0.125mm	7.5YR 6/4	Light Brown	Rounded	High and Elongated
> 0.250mm	7.5YR 6/4	Light Brown	Sub rounded	Elongated
> 0.500mm	5YR 5/6	Yellowish Red	Sub rounded	Elongated
> 1.000mm	5YR 6/4	Light Reddish Brown	Sub rounded	Elongated
> 2.000mm	2.5YR5/3; 7.5YR, 6/6	Weak Red, Reddish Yellow	Sub rounded	Elongated
> 4.000mm	2.5YR 5/2; 7.5YR, 6/6	Weak Red, Reddish Yellow	Sub rounded partially undurated.	Elongated
> 8.000mm	2.5YR, 5/2; 7.5YR, 4/2; 6/6.	Weak Red, Dark reddish grey, Reddish Yellow.	Sub rounded, partially undurated	Elongated

Source: Field Work 2010

Table 4: Textural and Structural Analysis ofLafia Stone lines Transect point 2

Soil Sample Size	Colours	Surface Coating	Roundness	Sphericity
< 0.045mm	2.5YR 5/4	Weak Red	Rounded	High
> 0.045mm	2.5YR 5/4	Weak Red	Rounded	High
> 0.075mm	5YR 5/4	Reddish Brown	Rounded	High
> 0.125mm	7.5YR 4/4	Brown	Sub rounded	High and Elongated
> 0.250mm	5YR 4/3	Reddish Brown	Sub rounded	Elongated
> 0.500mm	2.5YR 4/3	Dusky Red	Sub rounded	Elongated
> 1.000mm	2.5YR 5/3	Weak Red	Sub rounded	Elongated
> 2.000mm	2.5YR 5/2; 5YR, 7/3	Weak Red, Pink	Sub rounded, partially undurated	Elongated
> 4.000mm	2.5YR, 5/2, 3/2, 6/8.	Weak Red, Light Red, Dusk Red.	Sub rounded, partially undurated	Elongated
> 8.000mm	2.5YR, 5/2, 3/2, 6/8.	Weak Red, Light Red, Dusk Red.	Sub rounded, partially undurated.	Elongated

Source: Field Work

Table 5: Texturaland Structural Analysis of Lafia Stone lines Transect point 3

Soil Sample Size	Colours	Surface Coating	Roundness	Sphericity
< 0.045mm	7.5YR 6/6	Reddish Yellow	Rounded	High
> 0.045mm	7.5YR 6/4	Light Brown	Rounded	High
> 0.075mm	7.5YR 5/4	Brown	Rounded	High
> 0.125mm	5YR 5/3	Reddish Brown	Rounded	High and Elongated
> 0.250mm	5YR 6/4	Light Reddish Brown	Sub rounded	Elongated
> 0.500mm	5YR 6/3	Light Reddish Brown	Sub rounded	Elongated
> 1.000mm	7.5YR 6/3	Light Brown	Sub rounded	Elongated
> 2.000mm	5YR 2.5/3; 5YR, 7/3	Dark Reddish Brown, Pink	Sub rounded, partially undurated	Elongated
> 4.000mm	2.5YR, 6/8;10YR 4/4	Dusk Red, Weak Red	Sub rounded, partially undurated	Elongated
> 8.000mm	2.5YR, 6/8;10YR 4/4	Dusk Red, Weak Red	Sub rounded, partially undurated	Elongated

Source: Field Work

Table 6: Textural and Structural Analysis of Lafia Stone lines Transect point 4

Soil Sample Size	Colours	Surface Coating	Roundness	Sphericity
< 0.045mm	5YR 7/8	Reddish Yellow	Rounded	High
> 0.045mm	5YR 6/8	Reddish Yellow	Rounded	High
> 0.075mm	5YR 5/8	Yellowish Red	Rounded	High
> 0.125mm	5YR 6/8	Reddish Yellow	Rounded	High and Elongated
> 0.250mm	5YR 5/8	Yellowish Red	Sub rounded	Elongated
> 0.500mm	5YR 5/6	Yellowish Red	Sub rounded	Elongated
> 1.000mm	5YR 7/8	Reddish Yellow	Sub rounded	Elongated
> 2.000mm	5YR, 6/6; 6/8	Reddish Yellow	Sub rounded nodules	Elongated
> 4.000mm	5YR 7/8; 7/3	Reddish Yellow, Pink	Sub rounded nodules	Elongated
> 8.000mm	2.5YR 6/8, 3/2, 4/2; 5YR, 7/8	Light Red, Dusk Red, Weak Red and Reddish Yellow	Sub rounded nodules and partially undurated	Elongated

Source: Field Work

The parent material, shale, underlies 2.5 meters deep regolith, with shallow topsoil and stone line horizon of less than 30cm thick (Thickness of Stoneline horizon, but contains some lateritic outcrops, shale facies and layers, soils near the stone-lines contain mainly iron-coated shale materials with some concretional ironstone. Within the cross-section, some gravel can also be observed. The shale layers are either platy or rounded in nature forming pebbles within the stone line horizon. In general, the topsoil contains some organic litters and there are mudstone and siltstone. The colours of shale content in this stone line horizon vary from reddish yellow (7.5YR, 6/6), light brown (7.5YR, 6/4), light reddish brown (5YR, 6/4), light red (10YR, 4/4) to dusky red (2.5YR, 6/8). The colour of the topsoil particles range from yellowish red (5YR, 5/8) to reddish yellow (7.5YR, 6/6), the contents of the regolith are generally light red (2.5YR, 5/4) and the soil materials of the stone line horizon ranges from rounded to sub rounded and sphericity is high and elongated, as illustrated in Tables 2 – 5. In general, the superficial deposits of sites 3 and 4 in Lafia are highly weathered and those in Sites 1-2 are no exception. This is probably due to prevailing high temperatures, abundant rainfall and deep chemical weathering of the major rock formations in Lafia. The process is so intense that the depth of the regolith where sample collection was taken was more than 2.5m, which is not the same in other study areas.

The detailed surveys and analyses of the superficial deposits in Lafia explain the generic character of the landscape location.The entire landscape of the study area consists of one major alluvium deposit with no traces of other plains This area consists of low level coastal plain a ridge and valley that runs from NW of River Amba to SE of the river course. Nevertheless this area provides the stone lines horizon for study. It was probably due to large deposition and sedimentation of old alluvial materials on soft parent material (shale) as a consequence of perennial weathering (physical and chemical). The pediment gravel in the soil profile inLafia appears to be sorted out with the finer gravel on the pediment (As high as 1.3m within the pediplains, where ants, termites and earthworms are engaged in the reworking of the soil profile to build mounds and termitaria. The pebbles amount and the degree of sphericity of the gravel gradually increases down the lower-level of the pediplain in Ameri as explained in the topography of the study areas. This is probably due to the type of weathering (Physical and Chemical) that alternated each other along the slope. The slope witnesses two types of weathering between the old and the young pediplain.

The first type of weathering process was physical weathering, which probably occurred within the old pediplain at an angle above 12^0. However, chemical weathering occurs along the young plain, which is a low-level plain and also close to the water table. During the wet season there is an upward movement of water from the water table, with the concurrent deposition of metallic iron (II) oxide (Fe^{2+}) through oxidation process. Later, the sediment dries-up during the dry season by evapo-transpiration and then was cemented to form petroplinthite (Further oxidation form Iron (III) oxide). The actual amount of debris load depends on the angle of the slope and the type of slope deposits. It was observed in general that concave slope areas with slope angles between 0^0 – 18^0 contain large amounts of deposits (See detail in figure 7.2 in chapter 7). The convex slope areas, however, have acute angles with little or no deposits on them. Most importantly, various cross-sections have varying thickness of stone line horizons, with thinnest found in Lafia. The regolith materials in Sites 1-4 (Lafia) comprise shale materials with low proportions of concretional ironstone. Thus the stone line horizon in the study area of Lafia cannot be divorced from the parent material. Stone line materials found point 4 in Lafia contains iron coated shale materials with petroplinthite (Defined in Glossary), and they are further fragmented and reshaped by chemical weathering. Earthworm and ant moulds are found on the topsoil reflecting a lot of bioturbation rework going on within the soil profile.

Table 7 show the pH values of stone line samples taken from the study locations. Generally the soil samples ofLafia are acidic, with pH values varying from 3.6 on the clay materials of the topsoil in Lafia. Significant differences ($P \leq 0.05$) exist in the mean pH levels of topsoils among the sites in Lafia. The mean pH values of clay and silt in the topsoil of Lafia is low, varying from 3.6 to 3.8 respectively (Tables 7). This is probably due to high temperature, continuous erosional processes and higher leaching and eluviation of soluble salts from the topsoil to the regolith (Rahman 1992). The translocation of soluble salts resulting in increases in the exchangeable cations of the sub soil. Ferruginous soils common in the tropics are characterized by low organic matter content. The mean organic carbon of the topsoil in Lafia sites is low. The mean levels of organic carbon in the topsoil of Lafia, is 2.93%. Their corresponding stone line horizon value is 0.73%. The values in the regolith is; 0.67% for Lafia at $P < 0.05$.

Table 7: The mean levels of extractable nutrients in the superficial deposits of Lafia soils

	Top Soil	Sub Horizon	Regolith	Standard Error
pH	3.9	3.92	4.12	0.142
Moisture Content	0.98	0.87	0.89	0.12
Total Nitrogen	0.625	0,20	0.09	0.01 – 0.02
Organic carbon	2.93	0.73	0.67	0.04 – 0.05
CEC	9.81	35.46	7.99	0 – 0.02
Phosphorus	4.30	0.19	0.40	0.79 – 1.50
Sodium	0.275	0.283	0.275	0.00 – 0.01
Potassium	0.148	0.143	0.198	0.01 – 0.04
Calcium	0.01	0.045	0.088	0.00 – 0.01
Magnesium	0.073	0.03.	0.023	0.00 – 0.01
Iron (ppm).	3.57	23.43	5.12	0.00 – 0.01
Zn (ppm).	11.27	7.90	15.06	0.11 – 0.12
Copper (ppm).	1.20	1.235	1.203	0.32 – 0.47
Manganese (ppm).	1.785	2.553	1.898	0.25 – 0.45
Exchangeable base Content	1.85	1.85	1.85	0.00 – 0.02

Source: Field work 2010

Significance level the mean organic carbon in the topsoils differs significantly among all the transect point. Generally, stone line horizons record very low organic matter due to the instability of organic constituents in the subsoil. The higher organic carbon content in the topsoil horizons could be due to the concentration of litter, remains of bioturbation, vegetal materials and animal wastes. Low-level carbon content in the stone line and regolith indicates that considerable amount of nutrients dissolve in the rainwater and get oxidized by electronegative elements (e.g. hydroxyl (OH^-)and oxygen (O^{2-}) ions) originating in the atmosphere (Aweto and Obe, 1993). The mean value of total nitrogen in the topsoil of Lafia sites is 0.625cmol/kg. In the subsoil the mean level of total nitrogen in the laterite horizon is significantly higher ($P < 0.05$) than in the regolith. The mean total nitrogen for the three horizons at the study sites varies from 0.09% to 0.625% in Lafia (see Table 7). Comparing the values at each site and region, it was observed that the mean levels of total nitrogen in the topsoil are slightly higher at $P < 0.05$ significance level than the amount in the subsoil (stone line and regolith). Generally, the results reveal low levels of total nitrogen in the soil series of Lafia. Total nitrogen values, in both the topsoil and subsoil horizons are below 0.70%, which are closely related to the generally low levels of organic matter in the lateritic soil of tropical regions (Jones, 1973 andTolsma*et al*. 1987).The results of available phosphorus in the topsoil, stone lines and regolith from the different sample sites indicate low levels of available phosphorus characteristic of tropical soils in certain part ofLafia which agreed with work of Wells and Leamy, 1980; Jones and Wild, 1975. Stone lines and regolith have minimum amounts of available phosphorus due to the translocation of this mineral in the topsoil. The exchangeable potassium level for the horizons varies from 0.143 to 0.198cmol/kg. Most likely, there is little or negligible amount that has been leached down the laterite horizon and regolith.These results may indicate that most of the soils are derived from erosional sediments containing predominantly kaolintic clay minerals, which are inherently deficient in K-minerals (Iwuafor*et al*, 1980, Wells and Leamy, 1980). The results therefore, reflect the low-level potassium reserve in the lateritic soil and superficial deposits, which are common in the tropics as earlier observed by Debaveye and DeDapper, 1987, the mean levels of exchangeable calcium vary from 0.088 to 0.10cmol/kg. While the mean levels, of laterite horizon was 0.045cmol/kg (Table 7).The difference might be due to the rate at which the calcium ions are being oxidized in the soil profiles of Lafia. Lower values inLafia sample sites are mainly due to excessive leaching of the lateritic soil or coupled with persistent subsistence farming. In the soil profile magnesium ion vary between 0.023 and 0.073cmol/kg.The average levels of exchangeable magnesium content in the topsoil of tropical forest in West African vary between 30 to 80 percent (Jones and Wild, 1975).

The levels of exchangeable sodium at different sample sites vary from 0.275 and 0.283cmol/kg. The mean level of exchangeable sodium for topsoil in Lafia is 0.275cmol/kg (Table 14. The lower values in sedimentary region can be attributed to the role of anion element during the oxidation reaction (metabolism) process and also due to the influence of laterilisation within the area along the river interfluves. In the B-horizons (laterite), the mean levelof exchangeable sodium is 0.283; while in the regolith, the value is 0.275cmol/kg. The variation is significant at $P <0.05$ levels. The CEC values of the topsoil, stone line and regolith horizon in the four study areas are shown in Table 7. The CEC values of the topsoil, stone lines and regolith reveal significant ($P\leq 0.05$) differences between the sites. In the topsoil, soil CEC values are however lower than in stone-lines and regolith horizon sites. Generally, the overall amounts of CEC in the tropical laterite soils of the study sites in Lafia are very small. The level of CEC determines the amount of hydroxyl or oxide ions in soil, which indirectly determines the level of soil laterilization that aids laterite nature and formation (Debeveye and DeDapper, 1987).Aweto (1985) quoted even higher CEC values for the topsoil (17.67cmol/kg) of natural evergreen forest in southwest Nigeria. The low CEC values of soils in the study areas largely reflect the general low organic matter content in the soil series. The predominant clay mineral, kaolinite in all the soil series, probably, has a low capacity to absorb nutrient cations of CEC.

The mean values of extractable zinc in the subsoil do not reveal pronounced differences among the sites at $P > 0.05$ significance level. The amount of extractable zinc is higher in the stone line than in the other horizons. This is consonant with mineral fixation in the topsoil and stone line horizon in organic matter fractions. The mean levels of iron in the sample sites vary from top soil to the Regolith 3.52 to5.12ppm, the corresponding stone lines mean values was 23.42ppm. A decrease of quartz within the stone line horizon is observed to be accompanied by an increase of sesquioxides (trace compound found in soil material containing iron) (Al_2O_3,

Fe_2O_3). This small band shows a lot of iron concretions and pisolithes obviously formed *in situ*, which are the pedogenetic effect of soil forming processes between the accumulated sediments. It must be added that some large boulders of fossil lateritic crusts were found in the broader study sites. So it is possible that bands of pisolithes might, to a certain extent, also be of erosional and accumulative origin. The results of iron level in this study correlate with the findings of Debaveye and DeDapper (1987) who worked in Kedah region of Peninsular Malaysia.

Generally, where colours are very dark, the extractable iron is sizeable in all the sites. The reddish brown nodules contain goethite (further examination of the Oxidation State in the laboratory), which is a prominent form of iron-oxide. Haematite predominates in the dusky red (almost black colour) coloured nodules. This would suggest that during the formation of the dusky red nodules, pedoclimatic conditions prevailed, favoring haematiteover goethite formation. This compares well with the results of Torrent *et al* (1982) Kampf and Schwertmann (1983). They found high amounts of iron in the soil with high temperature, low excess moisture and low relative humidity. In a similar study of lateritic soils in Kedah, Zainol (1984) recorded that the Fe in the iron nodules in the soil varies from 28.5 to 40.3ppm. However, where nodules are preponderantly dark in colour and occurring in well-drained soils, of which haematite are the dominant minerals (Zainol, 1984). Lastly, horizons at low mean sea level with well-drained soils are susceptible to constant fluctuations of water table. In the long run, the horizon will contain more geothite and brownish colour, which was similar to the findings in Lafia. Available manganese varies from 1.785 to 2.553ppm. The mean level of manganese in the topsoil was 1.785ppm. The mean values of available manganese ion in the stone line horizon at Lafia sites are moderately high (at $P< 0.05$ significance level) than in the topsoil, but still very low as compared to the values found in the Olopomewaforest reserve of Nigeria by Aweto and Obe (1993).

The value of available copper in the soil of the superficial deposits varies between 1.20 and 1.235ppm. The mean value of copper in the topsoil was 1.20 and 1.963. Their corresponding value in the stone lines was 1.235ppm, while in regolith the mean value was 1.203 ppm.The mean value of extractable copper down the depth of the horizon (topsoil, stone line and regolith) vary significantly in both the Basement complex and Sedimentary area at $P < 0.05$ significance level. The mean levels of copper ion at the topsoil horizon are significantly higher in all the sites than in the stone line horizon, while the mean levels in the regolith are almost equivalent with the mean value at the topsoil. The micronutrient results in the superficial deposits show some variations between the Basement complex sites with those at the Sedimentary region sites. This could be attributed to the different microclimatic conditions as well as the degree of land-use activities at these study sites. The results are consistent with those of Durotoye (1970), Burke and Durotoye (1973) in Southwestern Nigeria, Dabaveye and De Dappper (1987) in Johore and Kedah area of Malaysia, Johnson (1989) in California, U.S.A. and also Runge (1995) in eastern Zaire.

CONCLUSION

This study has compared and evaluated the nature and type of lateritic soil in Lafia. It compares the superficial deposits (topsoil, lateritic and regolith horizon) of the plains in this area and examines different physical and chemical characteristics that make them related or different from one another. The outcome of the field survey and data analysis confirmed that study areas had different form of laterite and lateric soil, which are well prone to the development of superfial deposits however the type of laterites found in these strata are different due to the gradient of slope of the undulating surfaces on these sites. Moreover, the study sites in the area are more unique in the sense that the researcher found two types of laterite stones, which are autochtonouos and allochtonous in nature. The autochtonous are laterite stone formed *in-situ*, and has high concentration of iron in them, mostly found at the alluvial and young plains of the study sites, the seasonal upward movement of the water table made the iron mottle called plinthite (ferrous) conglomerated with the stone contents that are later oxidized to petroplinthite (Ferric concretional laterite) to formed nonclast (sub-angular) laterites, while allochtonous laterites are clast (angular) stones found within the higher gradient between the slope of 6^0 and more than 12^0. Their formation is as a result of episodic action of fluvial activities. The stone contents of the laterites are rounded, with smooth surfaces, due to action of corrosion and abrasion of the chemical weathering. Meanwhile Allochthonous laterites of Lafia are aggregates of different sub angular stone sizes, which are dusky red in colour and vermicular concretional ironstones. Finally, autochthonous stone lines of Lafia comprise of concretional ironstones with pebbles and cobbles of reddish brown colour and they are mostly nodular concretional ironstones.

The pedisedimental plain area of Lafia transects have the same toposequence and mopho-dynamic structure. Most superficial deposits are found within low level Old alluvial plain of Lafia. Furthermore, the physical analyses, also confirmed that most of the stone constituents within the laterite horizons at Lafia sites have high proportion of shale materials and sandstones in their laterite stone horizons. Invariably, some are vermicular and others are nodular in nature, depending on the type of weathering process, either physical or chemical weathering that affected the pedisediment at a particular time in space. The vermicular type of laterites and concretional ironstones are associated with physical weathering, while nodular laterites and concretional ironstones are aftermath of corrosional process at the lower levels of the plain surface. Above all, high contents of heavy Iron minerals are associated with the superficial deposits in Lafia.

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