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Research Article

PALYNOLOGICAL AND PHYTOECOLOGICAL STUDIES OF THE MIDDLE AND LOWER BENUE TROUGH, NIGERIA

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ABSTRACT

Palynological baseline data acquisition and analysis were carried on longitudes 6.49E and 8.33E and latitudes 4.47N and 8.35N spanning the area from middle to southern Benue Trough for the purpose of forensic studies A lithologic section was prepared using latitude from the northern to southern axis. The lithologic and palynological analysis based on field samples were tied up with the vegetation map to generate phytoecological map. The rocks were compose of shale and sandstone, therefore found to traverse within middle Benue Trough and lower Benue Trough and Niger Delta. The palynologic analysis yielded *Nympheapollis clarus*, *Fenestrites spinosus*, *Cyperaceapollis sp* and *Stereisporites sp* . *Echitricolpites spinosus, Fenetrites spinosus*; from middle Benue Trough. *Echimonocolpites rarispinosus, Cingulatisporites ornatus, Macrotyloma brevicaules, Tubistephanocolpites cylindricus, Hexaporotricolpites emelianova, Retidiporities magdalenensis, Retistephanoclpites gracillis, Elaeis guineensis, Retitriporites heterobrochati*, *Aspleniumsporites trivedii*, *Retistephanocolpites gracillis*, *Elaeis guineensis*, *Echitricolporites spinosus*, *Multiareolites formosus* and *Matonisporites sp , Multiarolites formosus*. These data were used to generate palaeogeographical distribution of pollen, spore, fungal spore, dinoflagellate, acritarch, foram test wall lining which were converted into phytoecological map which shows the comparative occurrences of the different palynomorph groups. The occurrences of environmental diagnostic palynomorphs within a specific latitude shows that the paleoecology consists of savanna, freshwater , rainforest and mangrove.

INTRODUCTION

.Pollen and spore production and dispersion are important considerations in the study of forensic palynology. First, if one knows what the expected production and dispersal patterns of spores and pollen (called the pollen rain) are for the plants in a given region, then one will know what type of "pollen fingerprint" to expect in samples that come from that area (Bryant, 1989). Therefore, the first task of the forensic palynologist is to try to find a match between the pollen in a known geographical region with the pollen in a forensic sample. Knowledge of pollen dispersal and productivity often plays a major role in solving such problems

.Plants are among the best indicators of the environment for forensic studies; floral assemblages of plants are known to be characteristic of specific ecological zones and the occurrence of the fossils of such ecological indicator species in sediment is considered a reflection of contemporary ecological conditions for forensic studies.. The reconstruction of paleo- vegetations from fossil pollen assemblages would show a reflection of the type of vegetation across the study area

Thus, with adequate evidence in the form of fossils in sedimentological data, it is possible to reconstruct and interpret past environments and biotic communities based upon processes operative today. As Davis et al. (1971) pointed out; the usefulness of fossil pollen and spores to palaeoecology is hinged on their potential for providing quantitative information on recorded ancient vegetation. Therefore, in the course of this resaecrh work, the reconstruction of these past vegetations and environments from fossil pollen assemblages, the pollen data is commonly interpreted as a reflection of the type of vegetation and climate prevalent during the period under study.

LOCATION OF THE STUDY AREA:

The coordinates of the study areas range from longitudes 6.49 ^{0}E and 8.33^{0}E and latitudes 4.47^0 N and 8.35 ^{0} N. (Table 1**).**

Sample Number	Towns	Latitude	Longitude
01	Nassarawa, Markudi Rd.,Maraba	08° 35′22.2′′N	008°33′. 29.0′′E
02	Akunza vill,Maraba	08°30′27.9′′N	008°31′06.5′′E
03	Akunza Migili (NasarawaState)	08°20′27.3′′N	08°20′27.3′′N
04	Duduguru Junction	08° 32′14.6′′N	08°11 46.5′′E
05	Duduguru Village	08°00′ 02.9′′N	008°33′30.1′′E
06	Acaraju Road	08°44′22.4′′N	008°32′ 17.8′′E
07	Akanga Town	08°15′38.8′′N	008°32′17.8′′E
08	Kadarko	08°10′31.4′′N	008°32′17.8′′E
09	Ishere (Benue)	08°12′31.9′′N	008°19′46.8′′E
10	Markurdi-Yandev Rd (Tyo-mu Town)	07°4026.2′′N	008°19′46.8′E
11	Ikpayongo	07°33′45.8′′N	008°18′58.5′′E
12	Ikpayongo	07°40′26.2′′N	008°32′40.6′′E
13	Igbor	07°17′51.6′′N	008°29′13.0′′E
14	Howe	07°24′24.4′′N	008°34′49.9′′E
15	Oturkpo (Benue State	08°20′27.3′′N	007°40′36.1′′E
16	Oturkpo (Benue State	06°49′36.6′′N	007°40′36.1′′E
17	Ozalla (Enugu State)	Ozalla (Enugu State)	007°42′16.4′′E
18	Agbani (Enugu State)	06°25′27.3′′N	007°24′27.1′′E
19	Isi Ewaa	06°05′30.9′′N	007°28′ 14.5′′N
20	Ihe (Enugu State)	06°05′30.9′′N	007°28′14.5′′E
21	Ogugu - Stop 1(Enugu State)	05°57′33.1′′N	007°26′43.4′′E
22	Ogugu - Stop 2(Enugu State)	05°57′33.1′′N	007°26′43.4′′E
23	Agwu (Enugu State)	06°18′41.9′′N	007°29′04.0′′E
24	Agwu (Enugu State)	06°08′20.2′′N	007°31′21.1′′E
25	Lokpanta (Abia State)	05°50′31.1′′N	007°23′38.3′′E
26	Nkalagu (Ebonyi State)	06° 28 ′13.5′′N	06°28′ 13.5′′E
27	Abakaliki-Afikpo Road	06°19′58.3′′N	008°16′55.1′′E
28	Amuzu(Amuzu Ezza South L.G.A	06°10′58.1′N	008°1′4 13.8′′E
29	Abumege (12.6km to Afikpo)	06°02′28.1′′N	007°57′44.0′′E
30	Afikpo (Ebonyi State)	05°51′25.9′′N	007°46′35.8′′E
31	Afikpo-Mgbom (Ebonyi State)	05°56′26.6′′N	007°55′10.0′′E

32	Enohia- Nkalu Afikpo(Ebonyi	05°49′10.7′′N	007°47′33.8′′E
33	Macgregor College Afipko (EbonyiState)	05°50′53.9′′N	007°56′47.9′′E
34	Umualumuoke (Imo State)	05°41′00.7′′N	007°23′36.8′′E
35	Ezinachi (Imo State)	05°37′48.9′′N	007°18′43.1′′E
36	Ugwuaku	05°34′ 06.6′′N	007°18′30.0′′E
37	Umuahia (Abia State)	05°32′26.9′′N	007°19′57.2′′E
38	Boundary between Umnchia and Imo (Abia State)	05°39′38.1′′N	007°18′08.9′′E
39	Amainyi Ihitte(Imo State)	05°34′51.8′′N	006°34′51.1′′E
40	Isieke-Ibeku (Abia State)	05°38′52.1′′N	007°23′50.7′′E
41	Ohia-Abia State)	05°27′36.7′′N	007°35′40.1′′E
42	Mkpuka Junction (Abia State)	05°15′54.7′′N	007°28′24.4′′E
43	Ukpakiri (Abia State)	05°03′22.5′′N	007°23′54.3′′E
44	Ikot Ekpene (Abia State)	05°02′02.1′′N	007°12′47.7′′E
45	Ukwa-West L.G.A - Stop 1 (Abia State)	05°02′02.1′′N	007°12′26.7′′E
46	Ukwa-West L.G.A - Stop 2 (Abia State)	05°01′43.3′′N	007°19′10.1′′E
47	Ukwa-West L.G.A - Stop 3 (Abia State)	04°51′01.7′′N	007°03′41.3′′E
48	Rukpokwu (Rivers State)	04°58′46.4′′N	006°55′07.1′′E
49	Emohua - Stop 1 (Rivers State)	04°58′46.4′′N	006°55′07.1′′E
50	Emohua-Buguma road (Rivers State)	04°51′43.1′′N	006°50′21.1′′E
51	Emohua - Stop 2 (Rivers State)	04°47′36.2′′N	006°49′07.7′′E

Table 1: The Location of the study Area

AIMS AND OBJETIVES OF THE STUDY:

Aims:

The aim of the study is to systematically generate and interprete applicable Palynological data from Middle and Lower Benue Trough, and use same to delineate and assess phytoecological characteristics and palynogeographical distribution for the purpose of forensics studies

Directly deriving from the aim of the study, the specific objectives of this research are:

- To generate a comprehensive data baseline of palynomorphs.

- Attempt palaeoecological reconstruction of the study area.
- Establish a Phytoecological map for the study area

SCOPE OF THE STUDY:

Scope of Study:

i). Obtain samples from the sampled locations

ii).Prepare and analyse the samples for their palynological content

iii). Inteprete the analysed samples in line with standard palynological methods

iv). Present the results using statistical models

v). Draw up conclusions from the findings

vi). Present the report as a dissertation.

GEOLOGY AND VEGETATION OF THE STUDY AREA:

(i) The Middle Benue Trough: In the Middle Benue Trough, around the Obi/Lafia area, six Upper Cretaceous lithogenetic formations comprise the stratigraphic succession. This succession is made up of the Albian Arufu, Uomba, Gboko Formation, generally referred to as the Asu River Group (Offodile, 1976, Nwajide, 1990). These are overlain by the Cenomanian Keana and Awe Formations and the Cenomanian-Turonian Ezeaku Formation. The Ezeaku Formations is conterminous with the Konshisha River Group and the Wadata Limestone in the Makurdi area. The Late Turonian-Early Santonian coal-bearing Awgu Formation lies conformably on the Ezeaku Formation. In the Markurdi area, the Makurdi Sandstone interfingers with the Awgu Formation. The mid-Santonain was a period of folding throughout the Benue Trough. The post-folding Campano-Maastrichtian Lafia Formation ended the sedimentation in the Middle Benue Trough, after which widespread volcanic activities tool over in the Tertiary. The Asu River Group outcrops mainly in the Keana anticline east of Keana town and south of Azara; and in the area around Gboko with a typical section in the Quarry of the Benue Cement Company near Yandev. The lithologic composition of the group comprises mainly limestones, shales, micaceous siltstones, mudstones and clays (Offodile, 1976). The average thickness is estimated to be about 1,800m.

The Awe Formation was deposited as passage (transitional) beds during the Late Albian Early Cenomanian regression. Its typical sections occur around the town of Awe, where Offodile (1976) estimated

the thickness to be about 100m. The formation consists of flaggy, whitish, and medium to coarse grained calcareous sandstones, carbonaceous shales and clays. The Keana Formation resulted from the Cenomanian regression which deposited fluviodeltaic sediments. The formation consists of cross-bedded, coarse grained feldsparthic sandstones, occasional conglomerates, and bands of shales and limestones towards the top. Massive outcrops occur at Keana, Noku, Chikinye, Jangerigeri, Azara and Daudo. The deposition of the Ezeaku Formation is attributed to the beginning of marine transgression in the Late Cenomanian. The sediments are made up mainly of calcareous shales, micaceous fine to medium friable sandstones and beds of limestone which are in places shelly. The deposition took place in a presumably shallow marine coastal environment. Outcrops of the Ezeaku Formation include those at Ortesh, about 4km east of the village of Jangerigeri where the sediments are composed mainly of shaley limestone (almost entirely of oyster shells). In the bank of River Tokura, about 20km east of Keana town, on the Chikinye-Awe road, a typical section of the Ezeaku Formation occurs, consisting mainly of intercalations of shaley limestone and black shale with brownish fine to coarse grained feldsparthic sandstones at the top.

(ii) The lower Benue Trough/Anambra Basin: Sedimentation in the Lower Benue Trough commenced with the marine Albian Asu River Group, although some pyroclastics of Aptian-Early Albian ages have been sparingly reported (Ojoh, 1992**)**. The Asu River Group in the Lower Benue Trough comprises the shales, limestones and sandstone lenses of the Abakaliki Formation in the Abakaliki area and the Mfamosing limestone in the Calabar Flank (Petters, 1982). The marine Cenomanian Turonian Nkalagu Formation (black shale's, limestone and siltstones) and the interfingering regressive sandstones of the Agala and Agbani Formations rest on the Asu River Group. Mid-Santonian deformation in the Benue Trough displaced the major depositional axis westward which led to the formation of the Anambra basin. Post-deformational sedimentation in the Lower Benue Trough, therefore, constitutes the Anambra Basin. Sedimentation in the Anambra Basin thus commenced with the Compano-Maastrichtian marine and paralic shales of the Enugu and Nkporo Formation, overlain by the coal measures of the Mamu Formation.

(iii) Climate and vegetation The study area lies mostly within mangrove and rainforest (Figure 1)**.** The climatic condition of the country varies, with rainfall being the major controlling factor. Amount of rainfall increases southward with a marked alternation of wet and dry seasons all year round. Temperature throughout Nigeria is generally high; diurnal variations are more pronounced than seasonal ones. Highest temperature occurs during the dry season, rains and moderate afternoon highs occur during the wet season. In the study area, average highs and lows are 32^0C and 24^0C in January and 30^0C and 24^0C in June (htt://countrystudies.us/Nigeria/33.htm). The rainy season lasts for about eight months and the dry season lasts for about four months n the area. The annual rainfall within the study area is high ranging from 1400m in the north to 2500m in the south. It is heaviest between the months of June and September, and driest between November and February.

According to Olorode (2002), the study area and its environ lie within the wet rainforest belt of Nigeria with the presence of emergent tall trees like *Tarrieta utilis* and *Cyanometra ananta*. The area is rich in flora of herbaceous flowering plants like epithytic ferns (*Ptycerium sp., Trichomanes sp.*), mosses and liverworts.

The field mapping of the study area was undertaken during the dry season when undergrowths of the thick vegetation are sparse.

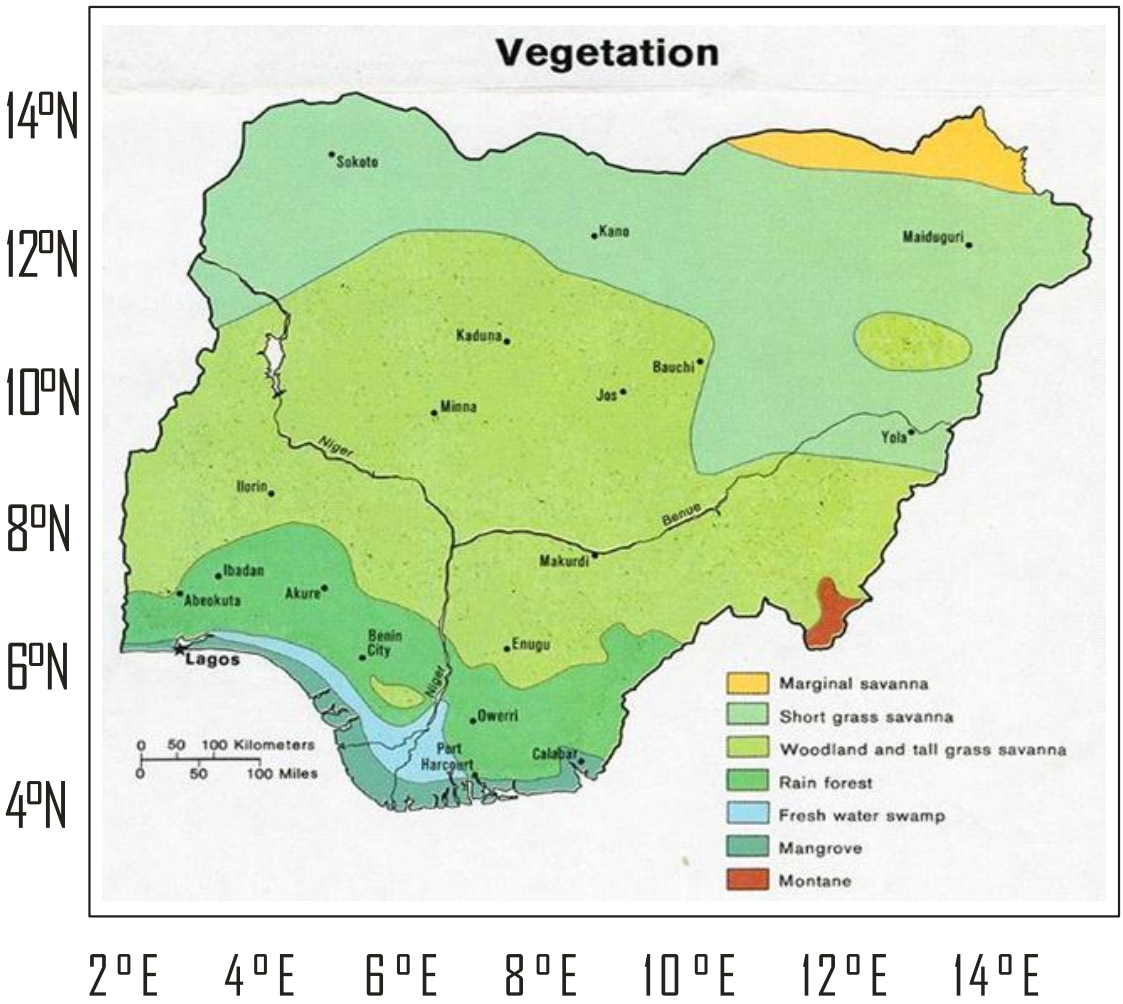


Figure 1: Vegetation Map of Nigeria showing Vegetative Types
(adapted from Iloeje, 1979)

METHODOLOGY

Palynological samples and slides preparation: Samples were prepared for palynological studies. About 5 gram of each sample was placed in a labeled cup in which 100ml of 70% hydrofluoric acid (HF) was added with the aim of separating the palynomorphs from the other rock debris by digesting the silica in sample. The samples were then washed and the slides prepared. A portion of the kerogen was mixed with 0.1% PVA solution, pipette onto a cover slip and allowed to dry. The remainder of the kerogen was sieved at 20µ. A portion of the sieved material was mixed with PVA solution pipette onto a cover slip and allowed to dry. The cover slips were mounted upon a microscope slide using norland adhesive. The slides were properly labeled and observed under research microscope through which snapshot was taken.

RESULTS AND DISCUSSION

Palynological Baseline data acquisition of surfacial rocks from the Middle and Lower Benue Trough were carried out. Samples were obtained from 51 Locations covering several States of Nigeria (See Table 1 for co-ordinate). Samples from Location 1 to 8 covered **Nasarawa State**. The places covered within the state were Maraba, Akunza village, Akunza Migili , Duduguru Junction, Duduguru Village, Acaraju Road, Akanga Town, Kadarko.

Location 9 to 16 are in **Benue State.** The places covered within the state are; Ishere , Tyo-mu Town, Ikpayongo, Igbor, Howe, Oturkpo,.

Enugu State comprises locations 17 to 24. The places covered are Ozalla, Agbani, Isi Ewaa, Ihe, Ogugu , Agwu.

Abia state is made up of locations 25, 37,38, 40-47 Lokpanta, Ugwuaku, Umuahia, Boundary between Umnchia and Imo, Isieke-Ibeku , Ohia-Abia, Mkpuka Junction , Ukpakiri, Ikot Ekpene, Ukwa-West L.G.A - Stop 1, Ukwa-West L.G.A - Stop 2 , Ukwa-West L.G.A - Stop 3 .

Locations 26-33 are in **Ebonyi State** and comprises Nkalagu , Abakaliki-Afikpo Road, Amuzu, Abumege , Afikpo.

Locations 34-36 and 39 are in **Imo State** and comprises Umualumuoke, Ezinachi, Amainyi Ihitte. Locations 48 to 51 are in **Rivers State** and comprises; Rukpokwu , Emohua, Emohua-Buguma road.

(A) PALYNOMORPHS:

Palynological Analysisiof the samples from the various locations yielded pollen, spores, dinoflagellate e.t.c Photographs of some of palynomorphs encountered are presented in Plate 1 . Location map are

superimposed on the vegetational map to establish relationship with vegetational zones and as a result phytoecological map was generated. Interpretation are based on the Scheme of Sowunmi 1981 Germeraad et al 1968, Ige 2009 and Hutchinson and Dalziel (1968).

Cingulatisporites sp

Leiotriletes sp,

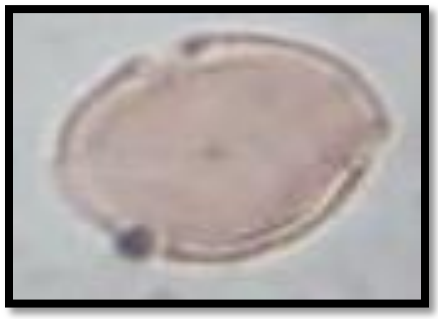
Fungal spore

Zonocostites ramonae,

Verrucattosporites alienus

Laevigatosporites discordatus

Rugulatisporites caperatus



Psilatriporites sp

Broken pollen



Cingulatisporites sp Tricellate fungal spore Retitricolporites sp

(B) PALYNOMORPHS/PALYNOECOLOGICAL GROUPING:

The recovered sporomorphs were differentiated into paleoecological groups based on the main source area (vegetation zones) of the extant parent plants or the Nearest Living Relatives (NLR). The grouping follows the order of the present positioning of the vegetation zones. This method of grouping pioneered by Poumot (1989) was based on the fact that the nature, quantity and quality of recovered pollen and spores are functions of their proximity to ecology. The paleoecological deduction in this study is guided by the work of Poumot (1989) and other workers such as Keay (1959), Sowunmi (1973, 1981a and b, and 1995), Dupont and Awgu (1991), Morley (1995), Mosbrugger and Utescher (1997), Dupont (1999), Adeonipekun (2007), Tekleva and Krassilov (2008) and Kujau *et al.*, (2013).

However, it has to be recognized that, because of the degree of taxonomic precision possible with sporomorph identifications, the palynoecological groupings in this study only include the taxa with known botanical affinities.This is a reasonable thing to do since it has been recognized that extant cogenerics often vary widely in their modern climatic envelopes. Inferences about palaeoclimates using palaeobotanical evidence is, therefore, better based on a taxonomically broad range of fossil taxa and their nearest living relatives, and ideally taxa that are entirely distributed within narrow climatic boundaries (Mosbrugger and Utescher 1997, Uhl et al. 2003, The palyno-ecological grouping which was used to generate phytoecological map (figure 2) is as follows

Mangrove *Foveotricolporites crassiexinous*, *Psilatricolporites crassus Spinizonocolpites baculatus* and *S.echinatus* (*Nypa fruticans*). *Psilatricolporites operculatus, Cycadocolpites sp, . Psilatricolporites sp, Psilatricolporites crassus, Psilatricolporites annuliporis, Psilatricolporites sp*

Freshwater Swamp *(FS) Retibrevitricolporites obodoensis ,nympheapollis clarus, rettricolporites irregularis, psilatricolporites operculatus, striatricolpites catatumbus, laevigatosporites sp, verrucatosporites sp,rettricolporites obdoensis,Proteacidites longispinosus, Retibrevitricolporites obodoensis, Retitricolpites sp*

Rainforest *Elaeis guineensis, psilatricolporites crassus, echitriporites triangulisformis, podoceiporites sp, stereisporites sp, . Echipriporites spinosus*

Savana *Polyadopollenites* spp, *Striatricolpites catatumbus*, *Retistephanocolporites gracilis,monoporites annulatus, multiareolites formosus, cyperceaepollis sp, echitricollporites spinosus, fenestrites spinosus Multiareolites formosus*

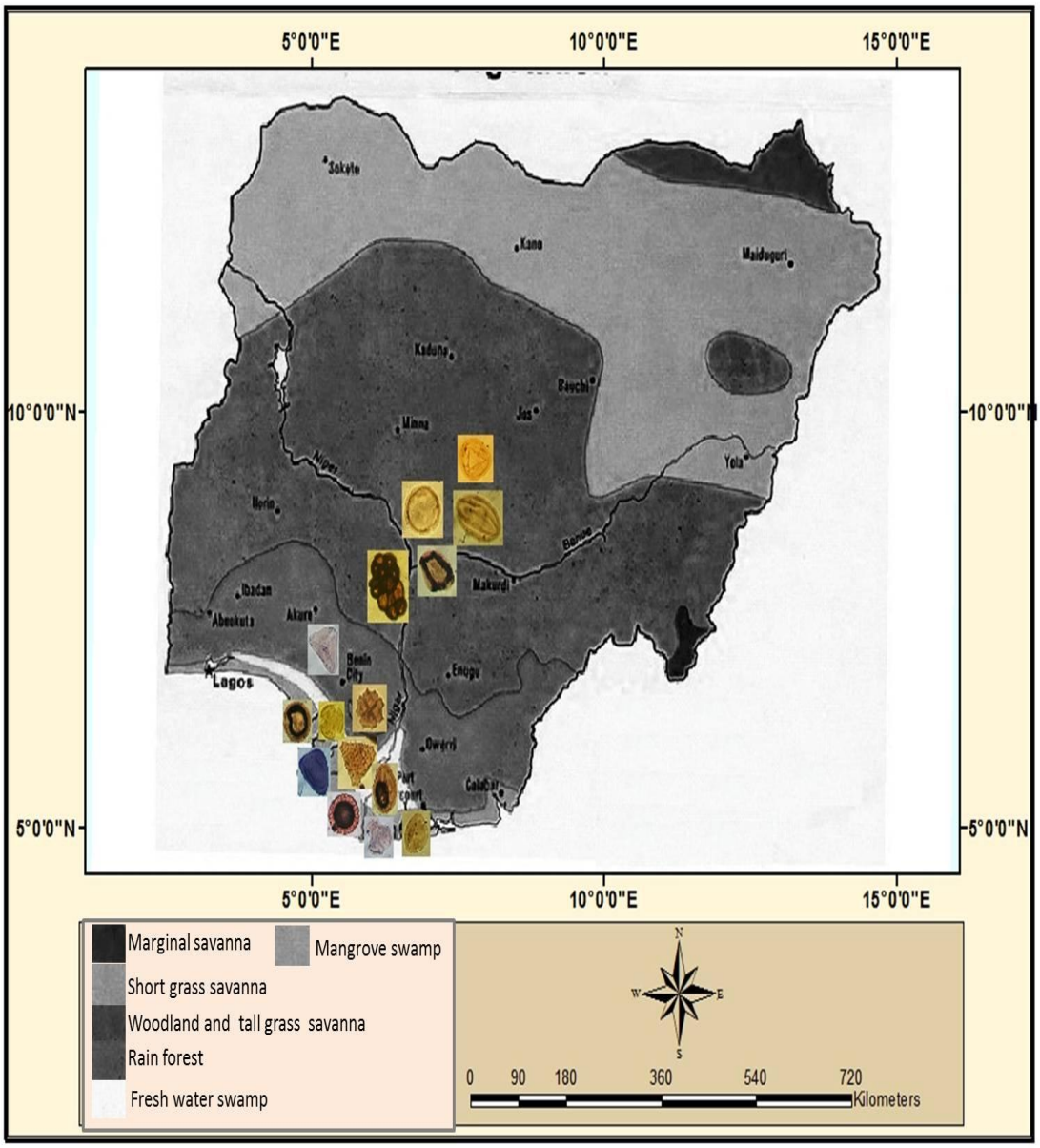


Figure 2: Phytoecological map of the study area

PALEOECOLOGY:

Pollen and spore is slightly more abundant in all the study location the location than any other palynomorphs (*Elaeis guinensis – Echitricloporites spinosus* zone*)*. abundant of fungal spore and acritarch which shows a clear distinctive characteristic of freshwater/rain forest (*Retistephanocolpites gracillis*) characteristic of the Benin formation and they are mangrove elements, *Zonocostites ramonae* and *Psilatricolporites sp*, the marine representative (foraminiferal test livings, dinoflagellate, acritarchs and diatom), indicating coastal and shallow marine environments, close to mangrove vegetation, although more typical of freshwater environment, can also occur in slightly brackish water, due to its tolerance to salinity (Rull, 1997b). The main palynomorph that characterize the Nsukka Formation and member of the Maastrichtian are (*Aletepollenites sp, Multiareolites formosus, Magneperiporities spinosus, Psilatricolporites sp, Echitricolporties spinosus, Retitricolporites sp, Fenestries spinosus, Elaeis guinnesis, Monoporites annuilatus, Retidiporites magdalenensis, Constructripollenites ineffectus, Echimonocolpites rarispinosus*. This is consistent with the presence of alluvial plain environments flooded by freshwater. From the vegetation point of view, the Benin formation with age Miocene–Pliocene, it is considered to be a mangrove assemblage which show a high numerical count of *Zonocostites ramonae* which is compose of palynomorph of vegetation flooded by fresh low salinity water and is characterize by transitional / tidal zone environmental conditions. But fungal spores represent another type of coastal swamps (palm/ fern swamps common in the Neotropics) in the freshwater swamp/rain forest of alluvial plain beyond the limit of tidal influence. Therefore, this assemblage is thought to represent the more inland vegetation required in this research work the pollen from mangroves was believed to have substantially increase to a very high grains, probably transported landward by wind: the first zone which is *Echitricolporites spinosus*; therefore, the significant could be due in part to environment and evolutionally factors, considering that;

(1) it could have originated in these environments, (2) the major transport agents for playnomorphs in alluvial plain are wind and (3) were deposited in more distal environments freshwater swamp/rain forest, this can be explained by an increased of wind capacity. Current paleogeographic reconstructions support these points. Therefore in the study area more work is needed to establish or infer a better vegetational history. Similar numbers of this pollen occur only inland, in freshwater environment, most probably due to wind transport (Muller, 1959; ten Broek and Nijssen, 1971).

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