Indexed, Abstracted and Cited: ISRA Journal Impact Factor, International Impact Factor Services (IIFS), Directory of Research Journals Indexing (DRJI), International Institute of Organized Research and Scientific Indexing Services, Cosmos Science Foundation (South-East Asia), International Innovative Journal Impact Factor, Einstein Institute for Scientific Information {EISI}, Directory of Open Access Scholarly Resources, Science Indexing Library, Science Indexing Library (UAE), Swedish Scientific Publications (Sweden), citefactor.org journals indexing, Directory Indexing of International Research Journals

World Journal of Biology and Medical Sciences

Published by Society for Advancement of Science®

ISSN 2349-0063 (Online/Electronic)

Volume 3, Issue- 1, 82-92, January to March, 2016

Journal Impact Factor: 4.197

WJBMS 2/04/60/2015

www.sasjournals.com

A Double Blind Peer Reviewed Journal / Refereed Journal wjbmedsc@gmail.com/wjbms.lko@gmail.com

RESEARCH PAPER

Received: 12/09/2015 Revised: 12/12/2015 Accepted: 20/12/2015

Recent Pollen rain in Anyigba: An Indicator of the Vegetation of Kogi State, Nigeria.

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ABSTRACT

Air borne palynomorphs of Anyigba, Kogi State, Nigeria were acetolysed and analyzed palynologically to determine the pollen types present in the atmosphere and the relationship between the airborne pollen assemblages with its vegetation. The trapped pollen grains of plants were representatives of the major phytoecological zones (Forest, Savanna, Human impact/ Introduced) of the catchment area. The major pollen contributors include those of Poaceae, Elaeisguineensis Jacq*, Lanneaacida* A. Rich, *Nauclealati folia* S.m.*, Syzygium guineense* (Willd.) DC.*, Danielli aoliveri* (Rolfe) Hutch. & Dalziel*, Alchorneacordi folia* Sw.*, Berliniagrandi flora* (Vahl) Hutch. and Dalz.*, Albizziazygia* (DC) J.F. Macbr.*, Commiphora Africana* (A. Rich) Engl*. All these are characteristic species of the Forest- Savanna ecozone. The presence of pollen record of Corylusavellana and Encephalartos species is a valid evidence of long distance transport. The excessive increase in the relative abundance of burnt plant parts is an indication of annual bush fire and residual precipitation associated with the vegetation of the study area. The presence*

of burnt plant parts in the atmosphere affirms the great influence of anthropogenic activities on the local vegetation. Analysis of variance for the various phytoecological indicator species showed that there was no statistical significant difference (P>0.05) between the pollen recorded for the various indicator species. Indicators of Savanna species were the highest pollen contributors. Results confirmed the vegetation of the study area to be Derived Savanna despite high level of anthropogenic activities. This study could be used to monitor the frequency and intensity of indiscriminate bush fire and other anthropogenic activities in the surrounding savanna vegetation and provide adequate restoration and conservation measures for safety health and environmental sustainability.
Keywords: Airborne Palynomorphs, Pollen, Derived Savanna, Vegetation, Anyigba and Nigeria.

INTRODUCTION

The study of vegetation and the way in which it has been altered and developed in the course of time indicates past changes that have occurred in our terrestrial environment. Variations in climate and in the intensity of human activity in historic and prehistoric times have made their mark upon vegetation, and the plants themselves have left a record of these changes in the form of vast quantities of pollen grains which have survived in contemporary sediments (Roberts, 1998).

The use of pollen and spores in environmental studies is primarily in its application to the study of vegetation history. Conclusion about climate and human disturbances could be deduced from such analysis and they are termed secondary deductions (Erdtman, 1969). Fact gathered from such analysis could be useful to climatologists and oil explorationists among others (Moore and Webb, 1983). Basically, pollen analysis is a technique for reconstruction of former vegetation by means of the pollen grains recovered from sediments. Since the pollen grain exine is resistant, it may have a long geological life once it is incorporated into sediment, but only if the grains avoid mechanical attrition and chemical changes such as oxidation (Hopping, 1967).

The relevance of atmospheric pollen content (APC) to the vegetation of a region is related to the palynomorphs produced *in situ* and those supplied from the surrounding ecological zones. Pollen and spores are generally produced in excess of the biological needs of the plants. Established observations have shown that anemophilous plants release large quantities of pollen into the air, while entomophilous taxa release smaller amounts. The behavioural patterns leads to differences in the quantity of pollen and spores of various taxa available in the atmosphere, and which of them can be trapped during sampling.

The widely dispersed pollen provides a broad picture of the surrounding vegetation of the areas in which they are produced. Even though sometimes, some of them are blown into these areas from distant places, experienced palynologists are most of the time able to detect these re-deposited pollen and spores by differences in preservation (e.g. colour, corrosion, wear), ecological or stratigraphical inconsistencies and other associated evidences of being re-deposited (Essien, 2014).

The quantity and quality of palynomorphs, especially pollen grains and spores in the air at any given time depend largely on the plant and fungi producing them, the abundance of the plant communities, the nature of palynomorphs, the flowering or season of reproduction and the meteorological factors such as rainfall, humidity, temperature, wind speed and wind direction (Agwu, 2001).

In recent years, many palynological studies have been carried out in West Africa. These studies have helped in reconstructing past vegetation types of different ecosystems as well as predicting the type of climatic conditions that prevailed during such periods (Lezine, 1988; Njokuocha, 2006; Njokuocha and Agwu, 2007; Amule, 2008; Ige, 2009, 2011; Essien *et al*., 2013).

The aim of the present study is to determine the pollen types present in the atmosphere of the study environment and the relationship between the airborne pollen assemblages with its vegetation.

MATERIAL AND METHODS

i. Study Area: The study area lies approximately between latitude $7^{0}30^{1}$N and longitude $7^{0}15^{1}$E. It is surrounded by smaller towns, villages and homesteads whose inhabitants have impacted on the environment in many ways (Fig.1).

ii. Geology of the Study Area: The study area has two main rock types, namely, basement complex rocks of the Precambrian age in the western half of the state and extending slightly eastwards beyond the lower Niger valley and the older sedimentary rocks in the eastern half. The various sedimentary rock groups extend along the banks of Rivers Niger and Benue and southeastwards through Enugu and Anambra States, to join the Udi Plateau.

iii. Vegetation of the Study Area

Derived Savanna is vegetation that developed from attenuated or modified tropical rainforest vegetation. Vegetation is an assemblage of synusia existing together in a particular location that may be characterized by its component species or by combination of structural and functional characters, which characterize the appearance or the physiognomy of the vegetation. In Nigeria, vegetation is determined mainly by latitudinal distribution of rainfall from south to north. This vegetation, though zoned into belts that correspond to the rainfall zones, is still controlled by edaphic, climatic and geomorphological factors (White, 1983). The vegetation of the study area is a Derived Savanna type.

Anyigba, Dekina Local Government Area of Kogi State, is generally characterized by a derived savanna which is located between the true Guinea Savanna in the North and the Tropical Rainforest belt in the South of Nigeria. It is otherwise known as the Mosaic of Lowland Rainforest and Secondary Grassland (White, 1983), which stretches east to west across the country with its widest north-south extension located in the Nsukka plateau area.

The climax vegetation of the Holocene climatic optimum in the study area was a tropical Lowland Rainforest of Guineo-Gongolian type, with basically a representative and homogenous floral composition throughout the area.

The vegetation is also characterized by the presence of fire tolerant and fire sensitive trees with appreciable occurrence of grasses and is co-inhabited by forest and savanna species. Anthropogenic activities and natural events have resulted in varying floral composition of the vegetation in different parts of the study area. Certain areas, particularly gallery forests and windward sides of highland, are populated by forest species while the open areas and senile soils are dominated by savanna species. Other places are more or less shared by both equally.

Typical plants found in these areas include *Daniellaoliveri*, *Prosopisafricana*, *Parkiabiglobosa*, *Meliciaexcelsa, Elaeisguineensis, Syzygiumguineensis, Bombaxbuonopozense, Khayasenegalensis, Daliumguineense*, *Parinaricuratellifolia*, *Lophiralanceolata, Haruganamadagascariensis, Rauvolfiavomitoria, Alstoniaboonei, Pentacletramacrophyla, Hymenocardiaacida*, *Vitexdoniana and Lannea spp*.

The dominant grasses and grassy materials make a continuous cover of savanna land. Most of these grasses are perennial and grow to a height of about 3m. These includes *Hyparrheniainvolucrata, Andropogongayanus, Andropogontectorum, Loudetia flavida, Imperatacylindica, Laucia spp., Panicum maximum, Cteniumnewtonii, Diheteropogongrandiflorus, Rottboeliacochinchinensis, Anthephoraampulacea, Pennisetumpedicellatum, Pennisetumunisetum, Digitariahorizontalis and Pennisetumpurpurum.*

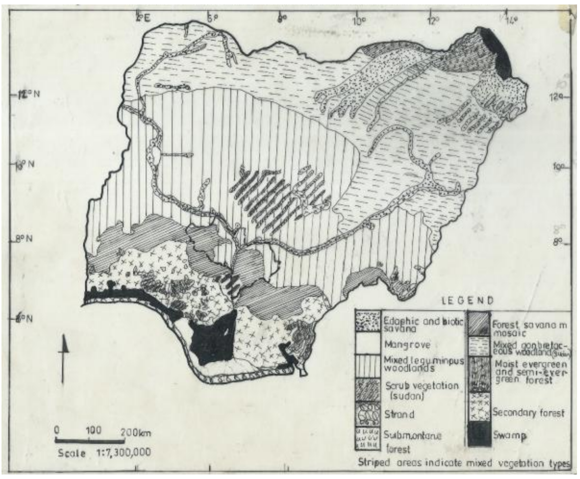
There are several forbs interspersed among the grasses. These include *Sennaobtusifolia, Chamaecristamimosoides, Crotalaria incana, Crotalaria retusa, Desmodiumascendens, Desmodiumvelutinum, Indigoferatritia, Indigoferahirsuta, Eriosemalaurentii, Sesbaniasudanica, Stylosanthesmucronata, Tephrosia nana, Tephrosiapeniculata, Vignaracemosa, Vignareticulata, Tridaxprocumbens, Emilia sonchifolia, Ageratum conyzoides, Amaranthusspinosus, Aspiliaafricana, Nauclealatifolia, Bidenspilosa, Boerhaviadiffusa, Boerhaviarepens, Celosia argentea, Centrosemapubescens, Cleome rutidosperma, Euphorbia hirta, Gloriosasuperba, Helianthus annuus, Hibiscus mutablilis, Ipomoea biloba, Mimosa pudica, Mirabilis jalapa, Mucunapruriens, Mucunautilis, Nicotianaplumbaginifolia, Sesamumradiatum, Solanumwelwichii, Talinumtriangulare, Stachytarphetajamaicensis, etc.*

There are other herbs which resemble grasses but are really not grasses. These include *Aframomumdaniellii*, *Ascolepiselata, Bulbostylisbarbata, Cyperusrotundus, Kyllingaodorata, Mariscusalternifolius, and Rhynchosporatriflora*.

In addition to these, around villages and towns are established/ introduced trees such as *Gmelinaarborea, Eucalyptus spp., Tectonagrandis, Mangiferaindica, Citrus spp., Psidiumguajava, Anacardiumoccidentale, Azadirachtaindica, Cocosnucifera*. Both cash and food crops such as yam, cassava, maize, beans, rice, and melon are grown extensively. The plants in these area are green in the rainy season with fresh leaves and tall grasses, but the land is open during the dry season, showing charred trees and the remains of burnt grasses. The trees which grow in clusters are up to six metres tall, interspersed with grasses which grow up to about three metres. The different types of plants are however, not in their natural luxuriant state owing to the careless human use of the plants and the resultant derived deciduous and savanna vegetation. The vegetation in this area is essentially a Derived Savanna, where Forest and Savanna species co-exist side by side with relics of Forest vegetation disappearing to be succeeded by fire-hardy species of Savanna. Disappearance of Forest species is brought about by a combination of factors, including annual bush-burning, excessive lumbering, excessive firewood gathering, excessive grazing by livestock and shifting cultivation. As a result of these factors, the vegetation of the study area has become impoverished with several economic species at the verge of extinction (Usman, 2012). Vegetation map of the study area is shown in figure 1.

iii. Methods: Eight locations were selected within Anyigba, Dekina Local Government Area of Kogi State, Nigeria as sampling sites. These sites were chosen for safety and convenience reasons.

At each site, a pollen trap (Modified Tauber Sampler) was buried in the ground in such a way that the collar was about 4cm above the ground level (Tauber, 1977). Prior to this, a mixture of glycerol (65ml), formalin (30ml) and phenol (5ml) was poured into each of the trap. The positions of the traps at various locations were recorded using a Global Position System (GPS). The solutions in the trap prevented the palynomorphs from drying up, kill insects and also prevented the decay of dead organisms.



SOURCE: After Essien, 2014

Fig. 1. Vegetation Map of Nigeria showing Kogi State Vegetation.

The trap was left to stand throughout the duration of the study period. Fortnightly of each month, solution collection was done. The traps were washed with water to remove any contaminants and were then recharged with the above mentioned chemical solution. This procedure was repeated bi-monthly from March- December (dry season and rainy seasons' samples) for one year. The palynomorphs were recovered through centrifugation at 2000 r.p.m (revolution per minute) for 5 minutes and supernatant decanted each time. The precipitates were washed twice with distilled water and recovered through centrifugation. The sediments were treated with glacial acetic acid to remove water before acetolysis (Erdtman, 1969; Agwu and Akanbi, 1985). The recovered precipitates were washed with glacial acetic acid, and finally washed twice with distilled water, centrifuged each time and decanted. The recovered palynomorphs were stored in a plastic vials in glycerin and ethanol solution (2:1).

The palynomorphs were analyzed palynologically and microscopically with Olympus microscope at x400 magnification for counting and Leica microscope at x1000 magnification for detailed morphological studies. Palynomorphs identification, counting and classification was done with the help of reference descriptions and photomicrographs from Agwu and Akanbi (1985); Bonnefille and Riollet (1980); Sowunmi (1995); Shubharani *et al*., 2013and prepared slides of pollen samples in the Palynological Research Unit; Department of Biological Sciences, Kogi State University, Anyigba.

RESULTS

At the sampling locations, a total of 2714 pollen grains were counted. Out of forty-four (44) pollen types belonging to twenty-five (25) plant families (21 Dicotyledons, 3 Monocotyledons and 1 Gymnosperms) encountered, four (4) were identified to family level, fifteen (15) to species level and twenty-five (25) to generic level.

There were noticeable monthly fluctuations in the quantity of pollen grains counted. The pollen types which occur frequently include those of *Lanneaacida* (297), *Elaeisguineensis* (363) and *Poaceae* (1481) pollen grains. Other pollen types that were trapped from the atmosphere during the period of study were those of *Nauclealati folia*, Combretaceae/ Melastomataceae, Cyeraceae, *Berliniagrandi flora*, *Alchorneacordi folia* and

Newbouldialaevis (Table 1). Photomicrographs of some selected pollen grains were taken and are shown in Figure 2.

Table 1 Monthly Record of Atmospheric Pollen Content (APC) of the Study Area.

POLLEN TYPES/ MONTHS	MAR.	APR.	MAY	JUN.	JUL.	AUG.- OCT.	NOV.	DEC.	TOTAL
DICOTYLEDONS:									
AMARANTHACEAE/ CHENOPODIACEAE	-	-	-	5	-	-	6	-	11
ANACARDIACEAE									
Lanneaacida	-	15	95	41	21	8	61	56	297
APOCYNACEAE									
Rauvolfiavomitoria	-	-	-	-	-	-	3	-	3
ASTERACEAE TUBILIFLORAE									
Aspiliaaficana type	7	4	-	15	10	3	4	15	58
BETULACEAE									
Corylusavellana	3	-	-	-	-	-	2	-	5
BIGNONIACEAE									
Crescentiasp.	-	-	-	-	-	-	-	2	2
Newboulialaevis	-	-	4	2	-	-	12	1	19
BOMBACACEAE									
Bombaxbuonopozense	-	2	-	-	-	-	1	3	6
Ceibapentandra	4	5	-	-	-	-	-	4	13
BURSERACEAE									
Commiphoraafricana	-	14	9	-	-	-	8	8	39
COMBRETACEAE/ MELASTOMATACEAE	2	10	18	-	7	12	23	6	78
CONVOLVULACEAE									
Merremiasp.	2	-	-	-	-	2	-	-	4
EUPHORBIACEAE									
Alchorneacordifolia	12	7	3	1	-	-	-	16	39
Euphorbia hirta	3	-	-	-	-	-	-	-	3
Euphorbia sp.	3	-	-	-	-	-	-	-	3
Hymenocardiaacida	2	-	-	-	-	-	-	3	5
Jatrophasp.	-	3	-	-	2	-	-	-	5
Phyllanthussp.	-	2	-	3	-	-	2	-	7
Ricinuscommunis	-	3	3	-	-	-	-	-	6
FABACEAE - SUBFAMILY									
1. CAESALPINOIDEAE									
Berliniagrandiflora	21	5	2	-	1	2	-	-	31
Danielliaoliveri	-	2	-	-	-	-	2	2	6
Tessmanniasp.	2	-	-	-	-	-	-	-	2
2. MIMOSOIDEAE									
Acacia sp.	1	4	2	-	-	-	-	-	7

Albizziazygia	3	-	-	-	-	-	-	-	3
Mimosa sp.	2	-	-	-	-	-	-	-	2
3. PAPILIONOIDEAE									
Eriosemasp.	-	-	-	-	-	3	2	5	10
Indigoferasp.	3	-	2	2	-	-	-	2	9
MELIACEAE									
Khayasenegalensis	-	3	3	2	2	1	-	-	11
Trichiliaprieureana	3	-	-	-	-	-	-	-	3
MYRTACEAE									
Syzygiumguineense	-	5	-	-	-	-	3	15	23
NYMPHEAECEAE									
Nympheaesp.	3	5	-	-	-	-	3	-	11
POLYGONACEAE									
Polygonumsp.	-	-	-	2	-	-	1	-	3
RUBIACEAE									
Clausenaspecies	3	-	4	-	-	-	1	-	8
Morelia senegalensis	2	-	-	-	-	-	2	-	4
Nauclealatifolia	-	15	18	3	2	4	4	-	46
SAPINDACEAE									
Blighiaunijugata	-	3	-	-	-	-	-	2	5
Paulliniapinnata	5	-	-	-	-	-	2	6	13
SOLANACEAE									
Solanummelongena	2	-	-	2	-	-	8	2	14
ULMACEAE									
Celtissp.	3	-	-	-	5	-	-	5	13
VERBENACEAE									
Vitexgrandiflora	4	-	-	-	-	-	1	-	5
MONOCOTYLEDONS:									
ARECACEAE									
Elaeisguineensis	13	25	137	10	25	17	65	71	363
CYPERACEAE	4	3	8	-	-	-	-	4	19
POACEAE	13	85	502	173	168	114	225	201	1481
GYMNOSPERMS:									
CYCADACEAE									
Encephalartossp.	-	-	-	-	-	-	13	6	19
TOTAL POLLEN COUNTS	125	220	810	261	243	166	454	435	2714

Photomicrographs of some selected pollen grains

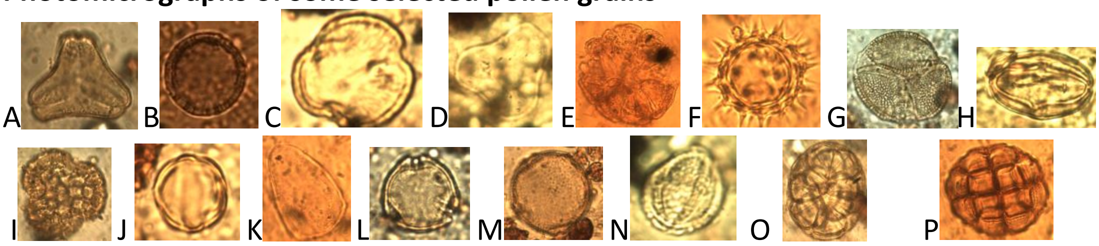


Fig. 2: A- *Tessmannia sp.*; **B-***Amaranthaceae/Chenopodiaceae*; **C-** *Lanneaacida*; **D-** *Elaeisguineensis*; **E-** *Rauvolfiavomitoria*; **F-** *Aspilliaafricana*; **G-** *Newbouldialaevis*; **H-** *Sennaoccidentalis*; **I-** *Delonix sp.*; **J-** *Combretaceae/ Melastomataceae*; **K-** *Cyperaceae*; **L-** *Alchorneacordifolia*; **M-** *Hymenocardiaacida*; **N-** *Phyllanthus sp.*; **O-** *Adenantherapavonina*; **P-** *Albizziazygia*;**Q-***Trichiliaprieureana*; **R-** *Syzygiumguineense*; **S-** *Poaceae*; **T-** *Talinumtriangulare*; **U-***Morelia senegalensis*; **V-** *Solanummelongena*; **W-** *Eriosema sp*.

DISCUSSIONS

The airborne pollen assemblage trapped in this study generally reflects the regional vegetation of the catchment area which depicts derived savanna. The pollen types recorded in this study represent the subtype vegetation of the study area which includes lowland rainforest, open forest, savanna and human impact ecotones. The floristic composition of these subtype vegetations are subsumed into three major phytoecological groups upon which other small localized subtype vegetations are represented. These are (i) the lowland rainforest/ open forest species represented by pollen of *Elaeisguineensis*, Cyperaceae, *Sennaoccidentalis*, *Alchorneacordifolia, Bombaxbuonopozense*, among others; (ii) the savanna and woodland components represented by pollen grains of Poaceae, *Danielliaoliveri*, *Hymenocardiaacida, Nauclealatifolia, Syzygiumguineense, Khayasenagalensis, Lanneaacida, Berliniagrandifolia* and *Rauvolfiavomitoria*among others; (iii) the human impact species represented by pollen of exotic and indigenous plants that serves aesthetic, economic and agricultural purposes as well as other related functions. They include Amaranthaceae/ Chenopodiaceae, Asteraceaetubiliflorae type*, Jatropha sp., Delonix sp., Crescentia sp.* and *Mimosa* speciesamong others. The co-existence of these major phytoecological groups distinguishes the pollen rain of the mosaic of lowland rainforest and secondary grassland from that of true savanna in the core North and lowland rainforest in the Southern part of Nigeria.

Of importance also is the presence of pollen types that are indicators of human impact such as those of*Solanummelongena, Ricinuscommunis* etc, reflected evidence of agriculture and other anthropogenic activities. However, the result of the study was limited in terms of pollen –vegetation relationship. The first major reason is concerned with the differences in pollen production and dispersal among tropical plants in our study area. The entomophilous taxa are known to produce low quantities of pollen grains with poor dispersal quality and the anemophilous taxa are copious pollen producers with good aerodynamic qualities. This advantage makes the anemophilous plants to be well represented or even to be over-represented in pollen assemblage compared to the entomophilous taxa. A second possible explanation is the difficulty of identification of all pollen grains to the generic or specific level. For instance, some pollen types are identified only to family level such as Poaceae, Combretaceae/Melastomataceae, Amaranthaceae/ Chenopodiaceae and Cyperaceae.

However, despite these limitations, the identified pollen grains so far still confirm the great floristic diversity and heterogeneity of the vegetation of Kogi State and the floristic heterogeneity in the study area. Similar findings have been reported in South Congo (Elenga *et al*., 2000), Nigeria (Njokuocha and Ukeje, 2006) and Southern Cameroon (Vincens *et al*., 2000).

Practically, the results have shown a true picture of the floristic compositions of the vegetation of Anyigba environment which releases the same group of pollen grains into the atmosphere at different periods of the year. The results compares favorably to the work of Agwu (2001), Lezine and Edorh (1991) in which the modern pollen grains was shown to reflect the vegetation around the geographical area investigated. The spectrum of airborne pollentrapped within the sampling period gives a glimpse of the amount of airborne pollen grains present/circulating in the atmosphere of Anyigba environment. The results has also shown that most of the pollen types which occurred most consistently in the environment during the study period are from wind pollinated plants which include those of *Poaceae* family, *Elaeisguineensis, Asteraceaetubuliflorae*typeand *Chenopodiaceae/ Amaranthaceae*. This finding is in line with the result of Calleja *et al*., (1993) who reported that these plants releases into the atmosphere large amount of pollen grains which are readily carried by wind far beyond the distance required for it to accomplish its biological function.

In this study, it was found that the pollen load of the entire study area varied quantitatively and qualitatively not only from month-to-month but also from site-to-site. The period of collection of pollen grains (in months) does not affect the dispersal mechanism and rate of concentration of pollen grains in the atmosphere. In the same way, atmospheric pollen studies conducted in various parts of the world showed that there were variations not only in monthly pollen concentration, but also site-to-site variations in monthly pollen content of major individual pollen types as regards maximum count (Andersen, 1980; Gonzalez-Minero and Candau, 1997; Rogers and Levetin, 1998; Monlina*et al*., 2001; Njokuocha and Ezenwajiaku, 2010).

CONCLUSION

The analysis of the atmospheric pollen content (APC) of Anyigba, Dekina Local Government Area, Kogi State, Nigeria revealed great diversity of palynomorphs consisting of pollen grains. The abundance and persistent supply of oil palm (*Elaeisguineensis*) pollen is related to the large extent of oil palm farm (wild and cultivated) in and around the study environment. The pollen types encountered represent the flora of the regional vegetation which is a derived savanna. The abundance of anemophilous pollen in the atmosphere is enhanced by their generally small size and good aerodynamic properties. In contrast, the entomophilous pollen (e.g.*Asteraceae, Acacia sp.*) is large and requires strong winds to dislodge them. As a result, they are less represented in the air. Apparently, the speed of the winds in the months of March to May and November to December was strong enough to dislodge the pollen of *Acacia sp. and Asteraceae*. The activity of cattle herdsmen (overgrazing) has not only destroyed several flora in the vegetation, but has also exposed the topsoil to various agents of denudation making the environment susceptible to desertification. The activities of people that engage in hunting expedition with the use of bush fire has destroyed several flora and fauna in the environment, which if conservation and restoration measures are not applied, could result in extinction of wildlife.This study still confirmed that the vegetation of the study environment is a Derived Savanna type despite high level of anthropogenic activities on the ecosystem.

ACKNOWLEDGEMENTS

The corresponding author (B.C. Essien) is grateful to the Almighty God for life, wisdom, divine protection, inspiration and the manifestations of the reality of Heaven on Earth and the fulfillment of the Scriptures according to Acts 4:11, Daniel 11:32b and Proverbs 4:18;

and to his Soul-mate, Miss Glory Asuquo Thomas for the resources, love, encouragement and steadfastness during all the turbulent times in his life and career.

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