



## The Study of Airborne Pollen and Spores in Akoko South West Environment of Ondo State, Nigeria

O. E. IGE and O. R. AYENI

<sup>1</sup> Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria

\*Corresponding author E-mail address: [olugbengaige@yahoo.com](mailto:olugbengaige@yahoo.com)

### Abstract

#### Keywords:

Aeropalynology, Pollen, Spores, Airborne, Akoko South West.

*Airborne palynomorphs of Akoko South West Local Government environment, Ondo State, Nigeria were analysed palynologically to determine the taxa of biological and/or airborne palynomorphs present in the atmosphere. Out of the twenty-five pollen types belonging to seventeen plant families, consisting of thirteen dicotyledons and four monocotyledons encountered, three were identified to family level and twenty two to generic level. A total of 1,570 pollen grains, 273 fungal spores and 28 pteridophyte spores were documented. Other palynomorphs documented include 33 burnt plant parts and 41 charred Poaceae cuticles. There were observable monthly fluctuations in the quantity of pollen grains and other palynomorphs encountered. The identified pollen types reflect the vegetation around the geographical area investigated. The result also showed the presence of anthropogenic activities on the local vegetation of the study environment.*

Accepted: 7 June 2019

© Science Research Annals. All rights reserved.

### INTRODUCTION

Aeropalynology is mainly concerned with the study of airborne microorganism in relation to their identity, behaviour, and its variation with time and place. It involves the study of the release, dissemination, deposition, and allergic effect of pollen grains, spores and other palynomorphs present in the air. In addition to pollen grains and spores, other minute plant parts such as trichomes, charred epidermal cell and tissues, algal cysts, diatoms and insect parts, are also airborne (Agwu, 2001).

Observations in Nigeria and other parts of the world showed that anemophilous plant release large amount of pollen into the atmosphere whereas entomophilous taxon releases a few quantities (Schulz, 2000; Agwu and Osibe, 1992; Calleja *et al.*, 1993; Essien *et al.*, 2015). Their behavioural patterns lead to differences in the quantity of pollen and spores from various taxa released into the atmosphere, and which of them can be trapped during sampling (Essien, 2014). Daily

observations of airborne pollen incidence indicates that pollen grains and fern spores are suspended in air turbulence where they are transported over varied distance away from their source locality to other areas of the same or different ecological characteristics (Lezine and Erdoh 1991, Essien *et al.*, 2013).

In view of the fact that wind disseminates freshly released pollen according to their seasonally fluctuating direction and strength, it is important to choose a time frame for maximum pollen production and optimal wind action for such a study (Agwu, 2014). Meteorological factors especially precipitation are necessary for the growth of plant and sporulation of fungi and these affects the amount, timing and production of spores. The release of some fungal spores coincides with the falling of rain which suggests that spores are released by mechanical effects of rainfall (Hicks *et al.*, 1996).

Airborne palynomorphs have been reported to induce allergic reactions in susceptible individuals. When these palynomorphs are inhaled, it produces

proteins (histamine) which when in contact with the mucous membrane, releases an antigen which stimulates allergic manifestations in the host body. In allergic individual, these substances which in a normal person would be destroyed by antibodies, stimulates the histamine, leading to inflammation and other characteristic symptoms of the allergy, for example asthma or hay fever. This response is a type of hypersensitivity. Using clinical and immunological approaches, a large number of allergens have been identified in pollen grains of different species. Hence information on the spatial distribution of these palynomorphs in the environment could be used to study the general role of pollen incidence, finding areas and period which are comparatively safe for allergic persons; partly in order to give forecast of the pollen incidence for the following day or days. Consequently, studies of the geographic distribution and seasoned production of pollen can help those suffering allergies such as hay fever.

Studies in Aeropalynology have contributed significantly to climatology and medicine (Lewis *et al.*, 1993, Newnham, 2001; Snetselaar *et al.*, 2001), test models for predicting biological response to future climate change (Larson, 1993, Singh and Singh, 1994).

In Nigeria, few aeropalynological studies have been documented. (Agwu, 2001; Agwu and Njokuocha, 2004; Adekanmbi and Ogundipe; 2010; Agwu 2014; Essien *et al.*, 2014; Essien *et al.*, 2015). But such studies in Akoko environment of Ondo State are almost non-existing.

Thus this study was aimed at investigating the airborne palynomorphs in the environment of Akoko South-West Local Government Area, Ondo State Nigeria. The analysis of the atmospheric pollen content from the area will provide baseline information on the airborne palynomorphs present in the area. It would also provide a good template for the identification of all the taxa present.

## MATERIALS AND METHODS

### Study location

The study was carried out at the Akoko South West Local Government area of Ondo State. It lies between Longitude 30 44' East and Latitude 50 27' North of Ondo State (Figure 1). The climate of Ondo State is of the lowland tropical rain forest type, with distinct wet and dry seasons. In the south, the mean monthly temperature is 27°C, with a mean monthly range of 20°C, while mean relative humidity is over seventy five percent. However, in the northern part of the state, the mean monthly temperature and its range are about 30°C and 60°C respectively. The mean monthly relative humidity is less than seventy percent. In the south, it rains throughout the year, but the months of October, November and December may be relatively dry.

Figure 1: Map of Nigeria showing the Local Government Areas of Ondo State.

### Methodology

Four locations were selected within Akoko South West Local Government Area, Ondo State, Nigeria as sampling sites. These sites were chosen on the basis of safety from vandalization, accessibility and convenience. The sites were Supare, Oka, Oba and Akungba - Akoko.

At each site, a pollen trap (Modified Tauber Sampler) was buried in the ground in such a way that the collar was about 4 cm above the ground level (Tauber, 1974). Prior to this, a mixture of glycerol (65 ml), formalin (30 ml) and phenol (5 ml) was poured into each of the traps. This was meant to prevent the palynomorphs from drying up, kill insects and also prevent the decay of dead organisms. The trap was left to stand throughout the period of the study. Fortnightly in each month, sample 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 October to December 2017.

### Chemical Preparation and Extraction of Palynomorphs

After the periodic collection of sample from the pollen sampler, at the sites, the palynomorphs were recovered through centrifugation at 2000 r. p.m. for 5 minutes and supernatant decanted each time. The precipitate was washed twice with distilled water and recovered through centrifugation. The sediment was treated with glacial acetic acid to remove water before acetolysis.

This process removed all the protoplasmic content of the pollen, spores and all the exineous materials like tryphine and ubisch bodies. The mixture was placed in water-bath at 100<sup>0</sup> C for 5 minutes. At the end of this, the mixture was stirred and then centrifuged for 5 minutes and supernatant decanted. 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 vial in glycerin and ethanol solution (2:1).

### Mounting and Microscopic Examination

One drop of thoroughly shaken pollen suspension was mounted on microscope slide and covered with an 18 x 18 mm cover slip. The mount was sealed off with colorless nail varnish to prevent drying up of the palynomorphs. The prepared slide was then examined microscopically with Olympus microscope at X400 magnification for counting and Leica microscope at X100 magnification for detailed pollen morphological studies. Pollen and spore identification, counting and classification was done with the help of reference pollen and spore descriptions and photomicrographs from Kremp

and Kawasaki (1972); Sowunmi (2009, 1973); Barnett and Hunter (2002); Zillinsky (2008); Shubharani *et al.*, (2013).



Plate 2: Modified Tauber Sampler

## RESULTS

### Pollen Analysis

Analysis of airborne palynomorphs from the four study sites within Akoko South-West (Supare, Oba, Oka and Akungba - Akoko) showed biological particles consisting of pollen grains, ferns and fungal spores, fungal hyphae, charred Poaceae, insect parts, Johnson's grass smut, and burnt plants parts. The airborne pollen spectra of the area are shown in Table I.

A total of 25 pollen types belonging to 17 plant families (13 dicotyledons and 4 monocotyledons) were identified. Out of the 25 pollen types belonging to 17 plant families encountered, 3 were identified to family level and 14 to species level. Table 2 shows the fungal spores and other airborne palynomorphs identified in the study area, while Table 3 shows the absolute pollen count based on phytoecological zones. A total of 1,570 pollen grains, 273 fungal spores, 16 insects and insects' parts, 41 charred Poaceae cuticle, 33 burnt plants parts, 22 algal cysts, 26 diatoms, 30 Johnson's grass smut, 6 trilete spores and 8 pteris species were documented (Table 2). There were observable monthly fluctuation in the quantity of pollen and other palynomorphs encountered. The pollen of Poaceae (862), *Elaeis guineensis* (182), *Lannea acida* (31), *Aspilia africana* (78), and *Alchornea cordifolia* (85) were predominant. The pollen of Poaceae was predominant throughout the entire study period. The highest pollen count was

recorded for the month of December (930) whereas the lowest values were documented for October and November (307 and 314) respectively (Table 1). The identified pollen types reflected indicators of the major phytoecological zones of Nigeria (Table 3).

Figure 2 shows the pollen distribution across the study locations (L) while Figure 3 shows the distribution of fungal spores and other palynomorphs across the study locations.

Figure 3: Distribution of fungal spores and other palynomorphs in Akoko South West Local Government environment of Ondo State, Nigeria.

## DISCUSSION

Based on the aeropalynological investigation conducted in Akoko South West Local Government Area, Ondo State, Nigeria from October 2017 to December 2017, a very high concentration of airborne palynomorphs including pollen grains, spores of fungi and pteridophytes (ferns), algal cysts, burnt plant epidermis/ trichomes, charred plant particles, insect parts, among others, were documented. Previous aeropalynological research carried out in West Africa (Calleja *et al.*, 1993; Agwu and Osibe, 1992; Agwu, 2014 and Agwu and Njokuocha, 2004) on the abundance, distribution and diversity of airborne palynomorphs and other particulate entities showed the existence of a large population of diverse organic and inorganic fractions in the atmosphere.

Practically, the results have shown a true picture of the floristic composition of the vegetation of Akoko South West Local Government Area environment which releases the same group of pollen grains into the atmosphere at different periods of the year. The results compare favourably with the work of Agwu (2001) as well as, Lezine and Erdoh (1991) in which pollen grains were shown to reflect the vegetation around the geographical area investigated. The spectrum of palynomorphs trapped within the sampling period gives a glimpse of the amount of airborne palynomorphs present/circulating in the atmosphere of the environment. The results have also shown that most of the pollen types which occurred consistently in the environment during the study period were from wind-pollinated plants which include those of *Poaceae*, *Elaeis guineensis*, *Aspilia africana*, etc. 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.

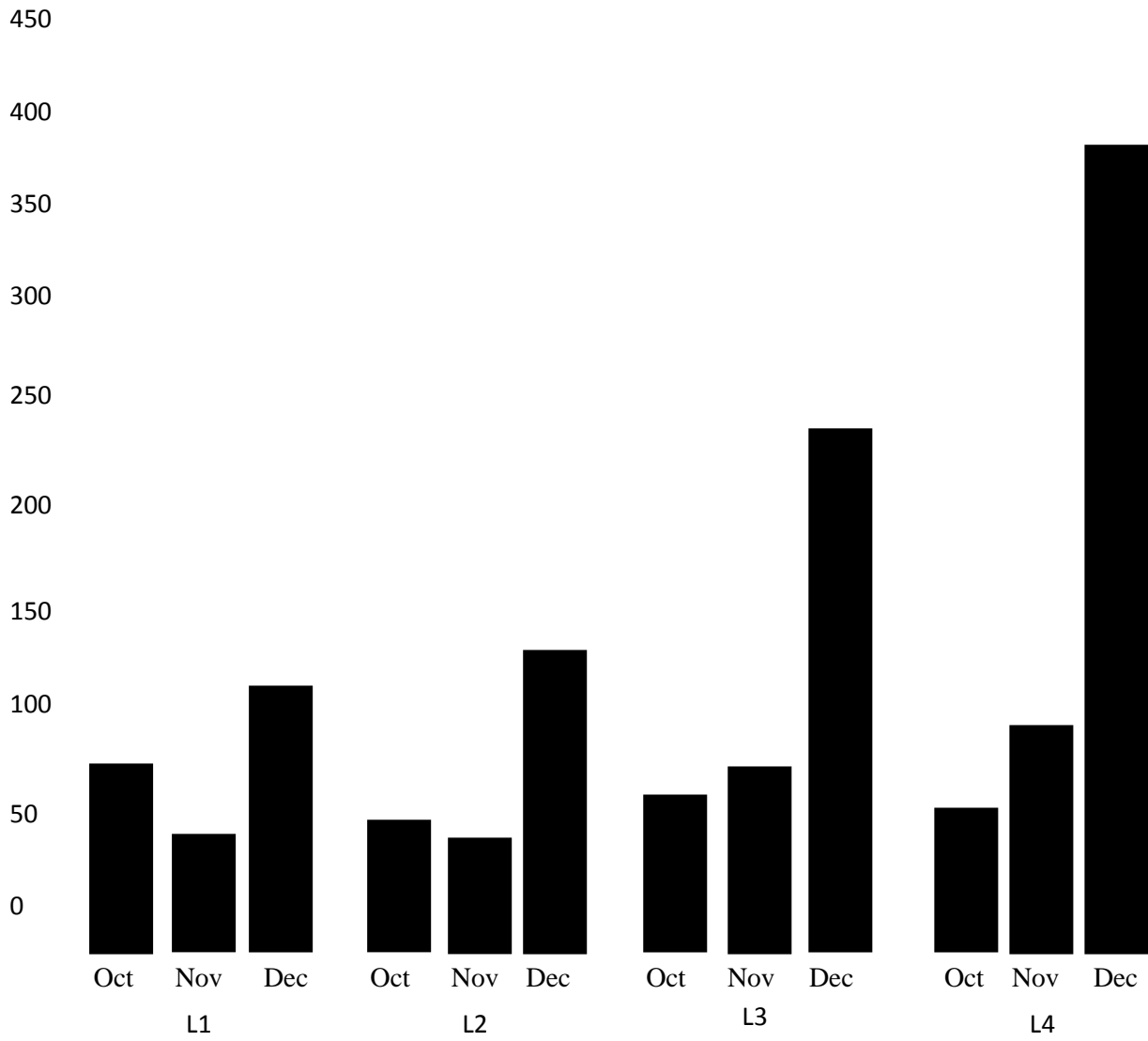


Figure 2: Pollen distribution in Akoko South West Local Government environment of Ondo State, Nigeria.

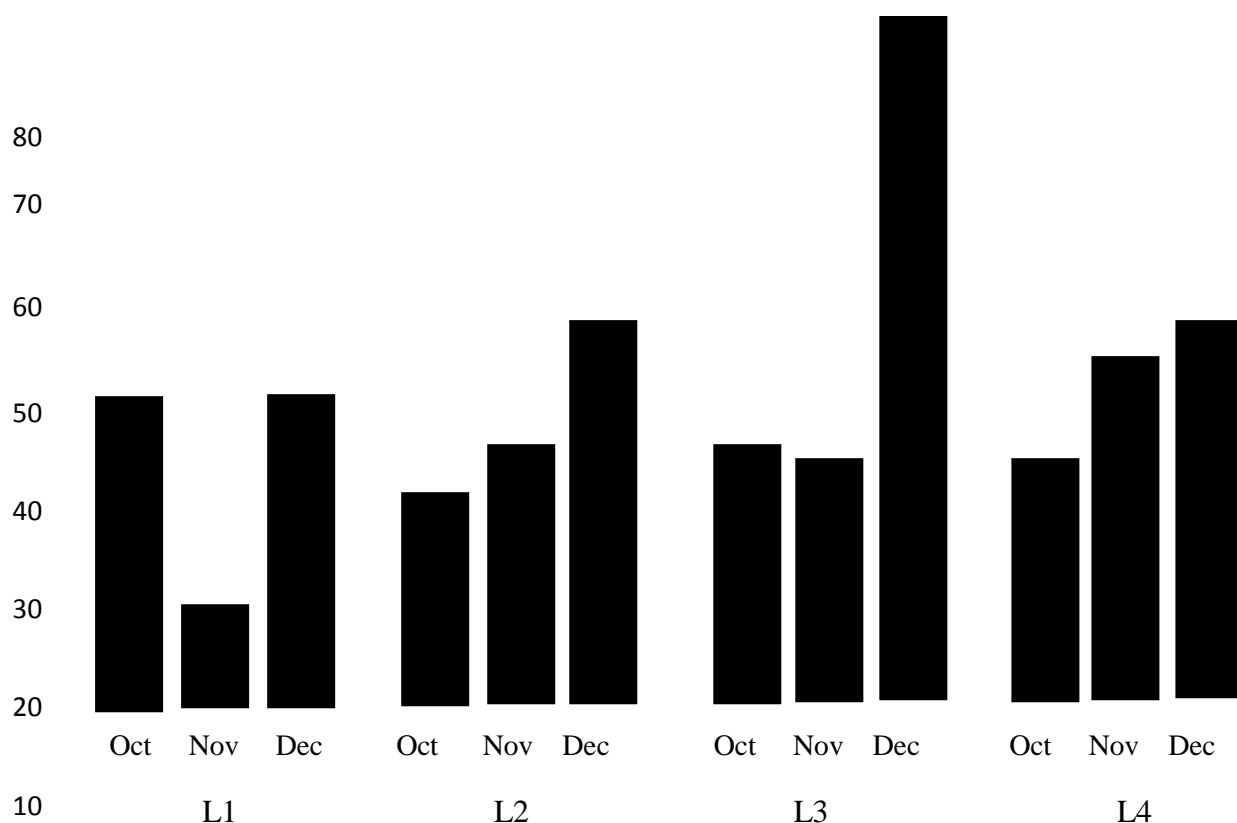


Figure 3: Distribution of fungal spores and other palynomorphs in Akoko South West Local Government environment of Ondo State, Nigeria.

The moderate occurrence of pollen of the family *Poaceae* is an indication of the proximity of Akoko South West Local Government Area to the fringe of the savanna belt of the North-Central Nigeria as reported by (Agwu and Osibe, 1992; Essien and Agwu, 2013). In this study, the higher pollen count (938) recorded for the month of December than October and November (308 and 315) might be attributed to the influence of the North-East trade wind. The variations in the monthly pollen counts at different sites (Figure 2) can also be a function of the frequency, density and abundance of plants species as well as their flowering behaviour at a given location. Similar findings have been reported by Essien and Agwu (2013); Snetselaar *et al.*, (2001) as well as Agwu and Osibe (1992).

Different genera of fungal spores were encountered in this study. Common among these fungal spores identified included those of *Alternaria sp.*, *Botryodiplodia sp.*, *Cerastosporium sp.*, *Curvularia sp.*, *Dreschelia sp.*, *Gliomastix sp.*, *Neurospora sp.*, *Pithomyces sp.*, and *Tetraploa*. Their presence could be attributed to several allergic reactions of the eyes resulting in symptoms such as sneezing, runny/ itchy nose as well as itchy and watering eyes prevalent in Akoko environment.

This finding agrees with the report of Njokuocha and Ukeje (2006) who opined that fungal spores are

cosmopolitan in distribution and constitute a large proportion of the airborne palynomorphs trapped in most aeropalynological studies; and are responsible for allergies such as rhinitis, pollinosis and exacerbation of asthmatic attack as well as pathogenic infections of the respiratory track. Some of the spore genera identified in this study have been reported by several researchers to be among the invasive airborne fungal spores that have been implicated in nosocomial (hospital) infection of patients with solid organ transplant (Essien and Aina, 2014; Essien *et al.*, 2013; Boral *et al.*, 2004; Newnham, 2001; Sanchez and Bush, 2001; Lewis *et al.*, 1993, Barnes and Rogers, 2008). Such spore genera identified include *Alternaria sp.*, *Dreschelia sp.*, *Nigrospora sp.*, and *Curvularia sp.* among others.

During domestic and wild fire incidences, charred plant particles from grasses, shrubs and trees wafted into the atmosphere. These serve as indicator of bush fire and they can be used in monitoring the intensity and frequency of bush fire.

Findings agree with the report of (Agwu, 2001) who demonstrated the application of Charred poaceae cuticle as a key identification of late cenozoic climate changes in the Niger Delta. The epidermis, cuticles and trichomes of burnt plant parts is recognizable, and an increase in number in the atmosphere of the study area could be attributed to an increase in the incidence

of bush fire in the surrounding derived vegetation. . This factor could be used to monitor the frequency and intensity of indiscriminate bush fire. The presence of pteridophytes spores; algal cysts and diatom frustules

have been documented in this study; and this confirms the great influence of anthropogenic activities on the local vegetation.

**Table 1: Airborne pollen spectrum in Akoko South West Local Government environment of Ondo State.**

	OCTOBER				NOVEMBER				DECEMBER				SUM
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	
<i>Afzelia africana</i>	-	-	-	-	-	-	-	-	1	-	-	-	1
<i>Albizia zygia</i>	-	-	-	1	-	-	-	-	-	-	-	1	2
<i>Alchornea cordifolia</i>	3	4	1	7	1	5	2	11		23	21	7	85
<i>Anacardium occidentale</i>	1	-	4	-	-	6	-	-	-	-	-	-	11
<i>Aspilla africana</i>	5	2	7	1	1	-	-	1	9	16	11	25	78
<i>Bombax buonopozense</i>	-	-	-	-	-	-	-	5	1	8	5	3	22
<i>Ceiba pentandra</i>	-	-	-	-	1	-	-	-	-	1	2	-	4
Combretaceae/ Melastomataceae		2	1		7			3		3	1		17
<i>Crossopteryx febrifuga</i>	-	-	2	-	-	2	-	-	4	-	-	-	8
Cyperaceae	1	-	-	5	-	-	-	4	3	2	8	22	45
<i>Elaeis guineensis</i>	5	7	14	31	8	2	4	15	3	26	21	46	182
<i>Euphorbia hirta</i>	2	-	7	-	2	1	-	5	-	1	31	1	50
<i>Gloriosa superb</i>	6	-	4	4	5	7	-	2	7	-	7	6	48
<i>Khaya senegalensis</i>	-	-	-	1			4		3		5	3	10
<i>Lannea acida</i>	3	-	9	-	-	8	-	1	-	4	-	6	31
<i>Mangifera indica</i>	-	-	-	2	3	-	-	-	-	-	2	-	7
<i>Nauclea latifolia</i>	3	-	-	-	-	2	-	-	3	2	1	4	15
<i>Newboldia laevis</i>	5	1	-	3	-	2	-	-		1	3	-	15
<i>Parkia biglobosa</i>	-	-	-	1			4		3		5	3	18
<i>Paullina pinnata</i>	-	-	-	5	-	-	-	-	-	-	2	-	7
<i>Pentaclethra macrophylla</i>	-	-	3	5	-	5	-	-	1	-	8	7	29
Poaceae	61	33	19	13	25	11	71	81	110	66	121	25	862
<i>Rauvolfia vomitoria</i>	-	7	-	1	-	-	2	-		2	1	5	18
<i>Senna occidentalis</i>	-	-	-	-	-	-	-	-	-	1	-	1	2
<i>Syzygium guinense</i>	-	-	-	-	-	-	1	-	-	-	-	2	3
<b>MONTHLY TOTAL</b>	95	64	71	79	52	53	86	128	147	156	252	394	1570
<b>GRAND TOTAL</b>	308					315			938				

**Table 2: Fungal spores and other airborne palynomorphs in Akoko South West Local Government environment of Ondo State.**

	OCTOBER				NOVEMBER				DECEMBER				SUM
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	
<b>Fungal spores</b>													
<i>Alternaria sp</i>	3	-	1	-	4	5	4	-	-	18	9	5	49
<i>Botryodiplodia sp</i>	5	-	3	-	-	-	-	-	2	-	-	-	10
<i>Cerastosporium sp</i>	-	-	1	-	-	-	2	-	-	-	2	1	6
<i>Culvularia sp</i>	2	4	-	3	-	2	2	4	4	5	8	4	38
<i>Dreschelia sp</i>	5	-	4	-	-	3	-	3	-	-	4	2	21
<i>Fungal hyphae sp</i>	-	2	-	2	1	-	1	-	3	2	4	1	16
<i>Gliomastix sp</i>	-	-	-	-	-	-	2	1	4	9	6	5	28
<i>Neurospora sp</i>	7	6	4	4		6	4	6	-	4	5	4	50
<i>Pithomyces sp</i>	5	3	3	6		2	3	5	3	4	6	5	45
<i>Tetraploa sp</i>	-	-	-	2	-	3	-	4	-	1	-	-	15
Total	27	15	16	17	5	21	18	23	16	43	44	27	273
<b>Thallophytes</b>													
Algae cysts	4	2	1		2		1		3	2	3	4	22
Diatoms	2	3	4		2	4		2	1	2	3	3	26
Total	1	-	-	1	3	-	-	2	-	3	4	-	14
<b>Pteridophytes</b>													
Pteris species				1	2					3	2		8
Trilete spores	1				1			2			2		6
Total	1	-	-	1	3	-	-	2	-	3	4	-	14
<b>Other Palynomorphs</b>													
Burnt plant parts			6	8			3	4	4		5	3	33
Charred Poaceae cuticle	6	2		4	3	5	2	4	5	2	5	3	41
Insect parts		2	2	3			4		2		3		16
Johnsons grass smut	5	2	2	4	2			3	4		5	3	30
Total													120
<b>GRAND TOTAL</b>	35	26	31	29	13	30	28	36	35	43	72	43	

**Table 3: Absolute pollen count based on phytoecological zones in Akoko South West Local Government environment of Ondo State.**

	OCTOBER				NOVEMBER				DECEMBER				SUM
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	
<b>Lowland Rainforest Taxa</b>													
<i>Bombax buonopozense</i>	-	-	-	-	-	-	-	5	1	8	5	3	22
<i>Ceiba pentandra</i>	-	-	-	-	-	1	-	-	-	1	2	-	4
<i>Paullinia pinnata</i>	-	-	-	5	-	5	-	-	-	-	2	-	7
<i>Pentaclethra macrophylla</i>	-	-	3	5	-	5	-	-	1	-	8	7	29
Total	0	0	3	10	0	6	0	5	2	9	17	10	62
<b>Open Forest Taxa</b>													
<i>Azelia africana</i>	-	-	-	-	-	-	-	1	-	-	-	-	1
<i>Albizia zygia</i>	-	-	-	1	-	-	-	-	-	-	-	1	2
<i>Alchornea cordifolia</i>	3	4	1	7	1	5	2	11		23	21	7	85
Combretaceae/ Melastomataceae		2	1		7			3		3	1		17
<i>Elaeis guinensis</i>	5	7	14	31	8	2	4	15	3	26	21	46	182
<i>Newboldia laevis</i>	5	1	-	3	-	2	-	-		1	3	-	15
Total	13	14	22	42	16	9	6	29	4	52	63	54	302
<b>Savannah Taxa</b>													
<i>Crossopteryx febrifuga</i>	-	-	2	-	-	2	-	-	4	-	-	-	8
Cyperaceae	1	-	-	5	-	-	-	4	3	2	8	22	45
<i>Gloriosa superba</i>	-	-	-	1	-	1	-		3	-	2	2	9
<i>Khaya senegalensis</i>	-	1	-	-	-	1	-		2	-	2	4	10
<i>Nauclea latifolia</i>	3	-	-	-	-	2	-	-	3	2	1	4	15
<i>Parkia biglobosa</i>	-	-	-	1	-	-	4	-	3	-	5	3	18
Poaceae	61	33	19	13	25	11	71	81	110	66	121	251	862
<i>Rauvolfia vomitoria</i>	-	7	-	1	-	-	2	-		2	1	5	18
Total	65	41	21	21	25	17	78	85	128	72	140	291	985
<b>Human Impact/ Introduced Taxa</b>													
<i>Anacardium occidentale</i>	1	-	4	-	-	6	-	-	-	-	-	-	11
<i>Aspilia africana</i>	5	2	7	1	1	-	-	1	9	16	11	25	78
<i>Euphorbia hirta</i>	2	-	7	-	2	1	-	5	-	1	31	1	50
<i>Mangifera indica</i>	-	-	-	2	3	-	-	-	-	-	2	-	7
<i>Senna occidentalis</i>	-	-	-	-	-	-	-	-	-	1	-	1	2
Total	8	2	18	3	5	7		6	9	18	43	27	59

**REFERENCES**

Adekanmbi, O and Ogundipe, O. (2010). Aeropalynological studies of the University of Lagos Campus, Nigeria. *Not. Sci. Biol* 2(4): 34 – 39.

Agwu, C. O .C. (2001). A study of Niger Delta environment through air-borne palynomorphs, Port-Harcourt, Nigeria. *Palaeoecology of Africa*, 27: 191 - 205.

Agwu, C. O. C. (2014). Modern pollen rains in Nsukka: An indication of the vegetation of Nsukka plateau. *Wuerzbur Geographic HenArbeiten* 91 : 97 - 116.

Agwu, C. O .C. and Njokuocha, R.C. (2004). The study of airborne pollen and spores circulating at “Head level” at Nsukka Environment. *Journal of Biological Research and Biotechnology*, 2(2) : 7 - 14.



- Agwu, C. O .C. and Osibe, E. E. (1992). Airborne palynomorphs of Nsukka during the month of February- April, 1990. *Nigeria Journal of Botany*, 5:177-185.
- Barnett, H. L. and Hunter, B. (2002). *Illustrated Genera of Imperfecti Fungi*. Fourth Edition. APS press, Minnesota, USA. 218pp.
- Boral, D., Chatterjee, S. and hattacharya, K. (2004). The occurrence and allergising potential of airborne pollen in West Bengal, India. *Annals of Agriculture and Environmental Medicine*, 11:45-52.
- Barnes, H. A. and Rogers, C. A. (2008). Outdoor allergens. *Environmental Health Perspective*, 108 : 655 - 368.
- Calleja, M., Strick, R. M. and Duzer, D. (1993). Atmospheric pollen count of West Africa. *Review of Palaeobotany and Palynology*, 79:335-368.
- Essien, B. C., Agwu, C. O .C. and Ige, O .E. (2015). A Study of airborne bioparticles of Anyigba environment, Kogi State, Nigeria. *Journal of Biological and Chemical Research*, 32(1):152-159.
- Essien, B. C. (2014). Aeropalynological appraisal of the vegetation of Anyigba, Dekina Local Government Area of Kogi State, Nigeria. M.Sc. Thesis, Department of Biological Sciences, Kogi State University, Anyigba. Nigeria. 165pp.
- Essien, B. C. Agwu, C. O. C. and Taiga, A. (2014). A comparative analytical investigation of airborne palynomorphs within Kogi State University Teaching Hospital, Anyigba, Nigeria. *J. Appl. Sci. Res.*, 2(1):136-142.
- Essien, B. C. and Aina, D . O. (2014). The role of airborne pollen grains of some Angiosperms and Fungal Spores in Allergic and Pathogenic Infections in Anyigba, Kogi State, Nigeria. *International Journal of Advances in Medical Sciences and Biotechnology*, 2(3):23-28.
- Essien, B. C. and Agwu, C. O. C. (2013). Aeropalynological studies of Anyigba, Kogi State, Nigeria. *Standard Scientific Research and Essays*, 1(13):347-351.
- Essien, B. C., Taiga, A., Suleiman, M. N., Idachaba, S. O., Aniyama, S. O. and Edegbo, E. (2013). A study of airborne fungal spores of Anyigba, Kogi State, Nigeria. *American Journal of Biomedical and Life Sciences*, 1(4): 70-74.
- Hicks, S., Amman, B., Latalowa, M. and Pardoe, H. (1996). *European Pollen monitoring program. Project Description and Guideline*. 28pp.
- Kremp, G. O .W. and Kawasaki, T. (1972). *The Spores of Pteridophytes*. Illustration of the spores of the Ferns and Fern Allies. Hirokawa Publ. Co., Inc. Tokyo, Japan. 398pp.
- Larson, K. A (1993). Prediction of pollen season with accumulated activity method. *Grana*, 32:111-114.
- Lewis, W. H., Visnay, P. and Zenger, V. E. (1993). *Airborne and allergenic pollen of North America*. The John Hopkins University Press, London, 126pp.
- Lezine, A. M. and Erdoh, T. M. (1991). Modern pollen deposition in West African Sudanian environment. *Review of Palaeobotany and Palynology*, 67:41-58.
- Newnham, R. M. (2001). *Aeropalynology and global warming*. In: Goodman, D. K. and R. T. Clarke (Eds.). Proceedings of the IX International Palynological Congress, Houston, Texas, U.S.A., 570pp.
- Njokuocha, R. C. and Ukeje, H. O. (2006). The study of airborne pollen precipitation in the University of Nigeria, Nsukka Botanical Garden. *Bio-Research*, 4 (2):88-93.
- Sanchez, H. and Bush, R. K. (2001). A review of *Alternaria alternata* sensitivity. *Revistaiberoamericana de Micologia*, 18:58-59.
- Schulz, E. (2000). Holocene environment in the Central Sahara. *Hydrobiology*, 214:359-365.
- Singh, A. B. and Singh, A. (1994). Pollen allergy: *A Global scenario*. In: S.N. Agashe (ed). *Recent Trends in Aerobiology and Immunology*, Oxford and IBH Pub Co., New Delhi.170pp.
- Snetselaar, K. M., Carfioli, M. A and Ordisco, K. M (2001). Pollination can protect maize ovaries from infection by *Ustilago maydis*, the corn smut fungus. *Canadian Journal of Botany*, 79:1390-1399.
- Sowunmi, M. A. (1973). Pollen grains of Nigerian Plants- I. Woody Species *Grana*, 13:145-186
- Sowunmi, M. A. (1986). Change of vegetation with time. In: Lawson, G.W (ed) *Plant Ecology in West Africa*. John Wiley and Sons Ltd. 273-306pp.
- Shubharani, R., Roopa, P. and Sivaram, V. (2013). Pollen morphology of selected bee forage plants. *Global Journal of Bio-Science and Biotechnology*, 2(1):82-90.
- Tauber, H. (1974). A static non-overload pollen collector. *New Phytologist*, 73(2):359-369.
- Zillinsky, F. J. (2008). Common diseases of small grain cereals. A guide to identification. *American Phytopathological Society*, 126pp.