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ABUNDANCE OF AEROALLERGENS IN RUJIN SAMBO SOKOTO (NORTH-WEST), NIGERIA

[1]Ezikanyi, D. N. and [2] Ezemagu, C. E.
[1]Department of Applied Biology, Faculty of Science, Ebonyi State University, Abakaliki, Nigeria
[2]Department of Chemistry, Federal College of Education Technical, Gusau, North-West Nigeria

Correspondence: dimphna.nneka@yahoo.com
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ABTRACT

Exposure to aeroallergens has been associated with exacerbation of allergic respiratory diseases especially asthma. It is imperative to identify aeroallergens risk periods and triggers, for adaptation and immunotherapeutic approaches. Study on one-year abundance of aeroallergens was carried out in Rujin Sambo, Sokoto state, Nigeria, from August 2019 to July 2020. Aerosamples were collected using Tauber-like samplers modified to achieve a height of 1.52 m above ground level. Fungal spores were more quantitatively and qualitatively abundant than pollen. Aerosamples were infiltrated with dust in the months of November, March, April and May due to higher incidence of sandstorm, orchestrated by North-East trade wind, which could have refloated previously deposited aeroallergens. Incidence of sandstorm interposed the onset of dry and rainy seasons. The sand storm correlated negatively with humidity but positively with temperature and high influx of fern spores in November. Most fungal spores in the region were spores of *Curvularia* and *Alternaria*. Dominant pollen were dispersed from Poaceae, Amaranthaceae/Chenopodiaceae and *Pentaclethra macrophylla* Benth. In order to over-smart seasonal allergies and elicitation of asthma symptoms in Rujin Sambo, precautionary measures should be taken at the onset of rainy/dry seasons (March, April, May/ November) and August (active-rainy period) and October.
Keywords: Aeroallergens; sand storm; allergy; Sokoto; Nigeria
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INTRODUCTION

Aeroallergens are airborne organic entities which trigger or exacerbate allergic diseases in hypersensitive individuals. They include pollen, fungal spores, algal cysts, dust mites, animal dander, tiny flakes of skin, algal cysts, cells, fern spores, etc. Among these, airborne pollen and fungal spores always dominate in most environments (Ezike *et al*., 2016). Aeroallergens have been long associated with morbidity of allergic respiratory diseases such as asthma, conjunctivitis, allergic rhinitis (hay fever) and atopic dermatitis (eczema). Asthma is the most chronic allergic respiratory disease which represents a heterogeneous respiratory disorder (Guibert *et al*., 2018). It is characterised by shortness of breath, chest pain, cough, breathlessness and wheezing.

Clinical reports from Nigerian Thoracic Society showed that there has been an increase in the prevalence of asthma in recent times. Records on prevalence of asthma is important for health planning, as this will inform relevant stakeholders and policy makers to swing to action in order to reduce asthma burden. However, clinical reports on prevalence of asthma is inconsistent across various regions of Nigeria. Ozoh *et al.* (2019) carried out a national survey of asthma in Nigeria and found that the prevalence is higher in Lagos and lowest in Ilorin. Asthma affects about 300 million people worldwide (Ozoh and Bandele, 2012). It does not only affect the respiratory tracts but also the psychological, physical and social wellbeing of affected individuals (Ozoh and Bandele, 2012). In children, asthma is the leading cause of ill health, hospitalisation and emergency room visits as well as absenteeism in Columbia (Hsu *et al*., 2016). The prevalence of allergic rhinitis among children, adolescents and adults in Nigeria was found to be 22.8 % in 2019 (Ozoh *et al*., 2019). The prevalence of allergic conjunctivitis in Jos, Nigeria, was found to be 32 % in 2014 (Malu, 2014). The prevalence was similar to results obtained in some of the African hospitals studied but differed in presentation from the Caucasians. Clinical reports on other allergic diseases are documented (Nnoruka, 2004; Ibekwe *et al*., 2018).

In Nigeria and, perhaps, other African countries, it is difficult to ascertain the epidemiology of asthma due to suboptimal clinical records, wrong diagnosis and over- reliance on over-the-counter drugs by patients who suffer allergies and related illnesses. Local evidence, however, proves that many are becoming asthmatic, even people who were not genetically predisposed. Empirical evidence has also proven the escalation of other allergic diseases such as hay fever/ rhinitis, conjunctivitis and eczema (Kim *et al*., 2016). The association of pollen with asthma and other allergies has long been reported by Taketomi *et al*. (2006) and Xie *et al*. (2019). Spores of fungi have also been linked with exacerbation of myriad of diseases including allergies and mycotoxicity (Pringle, 2013; Li *et al*., 2016; Ezike *et al*., 2016; Adeniyi *et al*., 2017). Both pollen and fungal spore constituents of the aeroallergens are very sensitive to seasonal and weather changes. It is imperative to monitor the impact of weather on their spatial distribution and abundance over time, for appropriate adaptive strategies.

MATERIALS AND METHODS

Study Area

The study was carried out in Rujin Sambo in Sokoto North, about 10 km from Sokoto Government House. Sokoto is a major city located in the extreme northwest of Nigeria (Fig. 1), near the confluence of the Sokoto River and the Rima River, extending from latitudes 11°30" to 13°50" N and longitudes 4°00" to 6°00" E (Jibrillah *et al*., 2019). As at 2006, it had a population of over 427,760 people. Sokoto is the modern-day capital of Sokoto State and was previously the capital of the North-Western states. Sokoto is bordering the Republic of Niger to the north; it also shares boundaries with Kebbi state to the west and south, and Zamfara to the south and east (Jibrillah *et al*., 2018).

The ecosystem in Sokoto is greatly influenced by the tropical continental climate with acute water deficit. Rainfall is low, erratic and barely lasts for more than five months in a year, with the average annual rainfall around 630 mm while temperatures could be as high as 39°C or even higher. The month of April usually records the highest temperature (Jibrillah *et al*., 2019). The southern boundary is arbitrarily defined by the Sudan Savannah (Ekpoh, 2011).

Sampling Method

Tauber-like pollen traps were modified to achieve a height of 1.52 m above ground level for the collection of aeroallergens. A solution made of glycerol (50 ml), formaldehyde (10 ml) and phenol (5 ml) was prepared and poured into the traps. Two traps were mounted in the study locations which were five kilometres away from each other. The recipient solutions were collected monthly for the period of one year. Samples were sieved through 200 µm- mesh wire gauze to filter off large organic particles. The liquid with suspended aeroallergens was centrifuged at 2500 revolutions per minute for 5 minutes to recover the aeroallergen residues. The residues were washed three times with water and were acetolysed according to a modified version of Erdtman (1971) procedures; acetolysis mixture consisting of concentrated sulfuric acid and acetic anhydride in the ratio of 9:1 was prepared; 5 ml of the acetolysis mixture was poured into each sample and placed in boiling water bath for 10 min at 100°C. They were centrifuged, decanted and washed twice with distilled water. The recovered residues were stored in vials with two drops of glycerin. Temporary slides were prepared and examined using light Olympus CH Trinocular microscope (LM), equipped with Future Winjoe camera at x400 magnifications. Identification was based on comparison with reference collection of pollen slides, description and photomicrographs of pollen and spores using books and journals such as Agwu and Akanmbi (1985), Y'bert (1979) and collection of other pollen and fungal spores atlas. Aeroallergens obtained were identified and counted monthly. The counts were expressed in monthly frequencies. Data obtained were analysed using the SPSS statistical package version 20 (SPSS Inc. Chicago, Illinois USA). Correlation coefficients were generated to examine the relationship among pollen, fern spores, fungal spores, sand/dust storm frequency and meteorological data. Meteorological data were obtained from Nigerian Meteorological Centre, Abuja, Nigeria. The standard procedure of measuring sandstorm event is lacking. In this research, values were assigned to aerosamples based on the intensity of the sand/dust intrusion into them by physical observation.

Fig.1: Map of Nigeria showing Sokoto State

RESULTS

A total of 2, 349 aeroallergens were recovered from the aerosamples for one year. The major pollen contributors in the region were: Poaceae 409 (62.7%), Amaranthaceae/Chenopodiaceae 66 (10.1 %,) and *Pentaclethra macrophylla* 53 (8.1 %) (Table 1; Plate 1). Fungal spores most abundant were those of *Curvularia* 398 (23.45 %), *Nigrospora* 266 (15.67 %), *Alternaria* 95 (5.60 %) and spores of fern were 308 (18.15 %)(Table 2; Plate 1).These spores infiltrated the atmosphere during the peak of the rainy season to the end of the rainy period (August to October) and were among major sources of aeroallergens and suspected potent triggers of asthma in Rujin Sambo region. Aerosamples were dustier in November and marked with high influx of fern spores. Other months with high level of dust include March, April and May; these months were characterised with dominance of *Nigrospora*, *Curvularia*, fungal hyphae and could have refloated into the atmosphere due to sand/ dust storms preponderance in those months.

Total aeroallergens declined in the months of June (Table 3). Poaceae reached anthesis in August and gradually reduced from September to December. A lower quantity of Poaceae was recorded from December through to July. Amaranthaceae/Chenopodiaceae were more abundant in August –October.

The correlation between total monthly pollen with monthly relative humidity and rainfall was positive, whereas total monthly pollen negatively correlated with wind velocity and average monthly temperature. Monthly fungal spores were more abundant from July (active rainy period) to October (end of rainy season) (Table 2; Fig 2). They correlated positively with rainfall, relative humidity, temperature and sandstorm episode but negatively with the wind. Spores of fern correlated positively with temperature, wind and sand storm episode (Table 4).

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Table 1: Pollen count in Sokoto from August 2019 to July 2020

S/N	Pollen	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Total	%
1	*Hymenocardia acida*	4	2	6	1	0	0	0	0	12	0	0	0	25	3.83
2	Indeterminate type 1	9	2	1	3	1	0	0	2	0	0	0	0	18	2.76
3	Poaceae	205	67	76	7	1	2	0	19	6	9	2	15	409	62.7
4	Amaranthaceae/Chenopodiaceae.	29	11	13	5	2	1	0	1	1	1	0	2	66	10.10
5	*Trichilia*	3	2	0	0	0	0	0	3	0	0	0	0	8	1.23
6	*Celtis*	1	0	0	0	0	0	0	0	0	0	0	0	1	0.10
7	*Alchornea cordiforlia*	1	0	0	0	0	0	0	2	0	0	0	0	3	0.46
8	*Cyperus*	3	2	0	1	0	0	0	0	0	0	0	0	6	0.92
9	*Terminalia*	1	0	1	0	0	0	0	4	1	0	0	0	7	1.07
10	*Lannea*	0	2	0	0	0	0	0	0	0	0	0	0	2	0.31
11	Asteraceae	0	1	1	0	0	1	0	2	9	0	0	1	15	2.30
12	*Pentaclethra macrophylla*	0	2	32	12	6	0	0	0	0	0	0	1	53	8.10
13	*Lophira*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.10
14	*Celtis*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.10
15	*Spondias*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.10
16	*Eugenia*	0	0	1	0	0	0	0	0	0	0	0	0	1	0.10
17	*Syzygium*	0	0	0	1	0	0	0	1	0	0	0	0	2	0.31
18	*Phyllanthus*	0	0	0	1	1	0	0	0	0	0	0	0	2	0.31
19	*Coccinia grandis*	0	0	0	1	0	0	0	0	0	0	0	0	1	0.10
20	*Luffa*	0	0	0	1	0	0	0	0	0	0	0	0	1	0.10
21	*Olax*	0	0	0	0	0	2	0	0	0	0	0	0	2	0.31
22	*Mallotus*	0	0	0	0	0	3	0	2	0	0	0	2	7	1.07
23	Mimosaceae	0	0	0	0	0	1	0	0	1	0	0	0	2	1.07
24	*Polygala*	0	0	0	0	0	1	0	0	0	0	0	0	1	0.31
25	Anacardiaceae	0	0	0	0	0	1	0	0	0	0	0	0	1	0.10
26	*Eugenia*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.10
27	*Anthocleista*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.10
28	*Parkia biglobosa*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.10
29	*Albizia*	0	0	0	0	0	0	0	0	8	0	0	1	9	1.38
30	*Drypetes gigiana*	0	0	0	0	0	0	0	0	0	0	0	0	1	0.10
31	Indeterminate type 2	0	0	0	0	0	0	0	0	1	0	0	3	4	0.61
	Total	256	94	131	33	11	12	0	39	39	10	2	25	653	100.4

Table 2: Spore Count in SOKOTO from AUGUST 2019 to JULY 2020

S/N	Spores	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jly	Total	%
1	*Cladosporium*	2	0	0	0	0	0	0	0	0	0	0	0	2	0.12
2	*Curvularia*	63	74	104	52	5	5	2	29	34	2	2	26	398	23.45
3	*Venturia*	6	1	14	0	0	0	0	0	0	0	0	0	21	1.24
4	*Botrytis*	1	0	0	0	0	0	0	0	0	0	0	0	1	0.05
5	*Pithomyces*	1	12	0	0	0	0	0	2	1	0	0	1	17	1.00
6	*Nigrospora*	11	20	18	22	2	19	49	25	30	30	14	26	266	15.67
7	*Alternaria*	1	11	52	13	0	3	0	7	1	2	0	9	95	5.60
8	Indeterminate type 1	24	4	23	0	0	0	0	0	0	0	0	0	42	2.47
9	Diatom	2	11	5	9	2	8	2	14	0	1	0	4	58	3.42
10	Indeterminate type 2	3	0	0	0	0	1	0	2	8	0	0	1	15	0.88
11	*Puccinia*	8	12	1	3	0	1	0	0	1	0	0	0	26	1.53
12	*Spadicoides*	1	0	1	1	0	0	0	0	0	0	0	0	3	0.17
13	Fungal hyphae	0	1	0	1	0	3	2	39	15	3	2	6	72	4.24
14	Fern spores	0	0	2	284	6	1	2	3	7	0	0	3	308	18.15
15	*Stachybotrys*	0	0	0	2	0	1	0	10	0	0	0	2	15	0.88
16	*Beltrania*	0	0	0	2	0	0	0	0	0	0	0	0	2	0.12
17	Indeterminate type 3	0	0	0	3	2	0	0	0	0	0	0	0	5	0.29
18	Smut	0	0	0	22	8	0	0	2	0	0	0	1	33	1.94
19	*Venturia*	0	0	0	1	0	0	0	0	0	0	0	0	1	0.05
20	*Helminthosporium*	0	0	0	3	0	1	0	2	0	1	1	2	10	0.59
21	*Bipolaris*	0	0	0	0	1	0	0	0	0	0	0	0	1	0.05
22	*Dreschlera*	0	0	0	0	1	0	0	0	0	0	0	0	1	0.05
23	*Torulla*	0	0	0	0	0	8	0	0	1	0	0	0	9	0.53
24	*Fusarium*	0	0	0	0	0	8	0	0	0	0	0	0	8	0.47
25	Indeterminate type 4	0	0	0	0	0	4	0	0	0	0	0	0	4	0.24
26	CGC	0	0	0	0	0	1	0	1	1	0	0	1	4	0.24
27	*Stachybotrys*	0	0	0	0	0	0	1	0	0	0	0	0	1	0.05
28	Indeterminate type 5	0	0	0	0	0	0	1	9	0	0	0	0	10	0.59
29	*Spilocaea*	0	0	0	0	0	0	4	0	0	0	0	0	4	0.24
30	*Stemphylium*	0	0	0	0	0	0	2	0	0	0	0	0	2	0.12

31	*Helicoon*	0	0	0	0	0	0	0	4	2	0	0	0	6	0.35
32	*Trichocladium*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.05
33	*Cladosporium* sp.	0	0	0	0	0	0	0	20	1	0	0	1	22	1.30
34	Indeterminate type 6	0	0	0	0	0	0	0	1	2	0	1	1	5	0.30
35	*Pucciniagraminis*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.05
36	Diplosporium	0	0	0	0	0	0	0	0	3	0	0	0	3	0.18
37	*Chaetochalara*	0	0	0	0	0	0	0	0	1	0	0	0	1	0.05
38	*Diplococcium*	0	0	0	0	0	0	0	0	4	0	0	0	4	0.24
39	*Cordana*	0	0	0	0	0	0	0	0	1	0	0	0	1	0.05
40	*Dreschlera*	0	0	0	0	0	0	0	0	1	0	0	0	1	0.05
41	*Spadicoides*	0	0	0	0	0	0	0	0	1	0	0	0	1	0.05
42	Indeterminate type 7	0	0	0	0	0	0	0	0	1	0	0	0	1	0.05
43	Indeterminate type 8	0	0	0	0	0	0	0	0	7	0	0	0	7	0.41
44	*Oidium*	0	0	0	0	0	0	0	0	39	7	4	19	69	4.07
45	*Puccinia* sp	0	0	0	0	0	0	0	0	0	1	0	0	1	0.05
46	Indeterminate type 9	0	0	0	0	0	0	0	0	0	1	0	0	1	0.05
47	*Dactylella*	0	0	0	0	0	0	0	0	9	0	0	2	11	0.65
48	*Paathramaya*	0	0	0	0	0	0	0	0	0	0	0	1	1	0.05
49	Indeterminate type 10	0	0	0	0	0	0	5	2	0	0	0	0	7	0.41
	Total	123	146	211	418	27	64	70	264	171	49	24	130	1,697	

Table 3: Total aeroallergens count in Sokoto from August 2019 to July 2020

S/N	Aeroallergens	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Total	%
1	Total pollen	256	94	131	33	11	12	0	39	39	10	2	25	652	27.76
2	Total spore	123	146	211	418	27	64	70	264	171	49	24	130	1,697	72.24
3	Aeroallergens	379	240	342	451	38	76	70	303	210	59	26	155	2,349	100

Table 4: Correlation coefficients among aeroallergens, meteorological parameters and sandstorm

S/N	Aeroallergens	Rainfall	Rel. humidity	Temperature	Wind	Sandstorm
1.	Pollen	0.696*	0.546	-0.221	-0.352	-0.238
2.	Fungal spores	0.001	0.059	0.295	-0.658*	0.542
3.	Fern spores	-0.263	-0.285	0.017	0.433	0.434

* Correlation is significant at the p = 0.05 level (2-tailed)

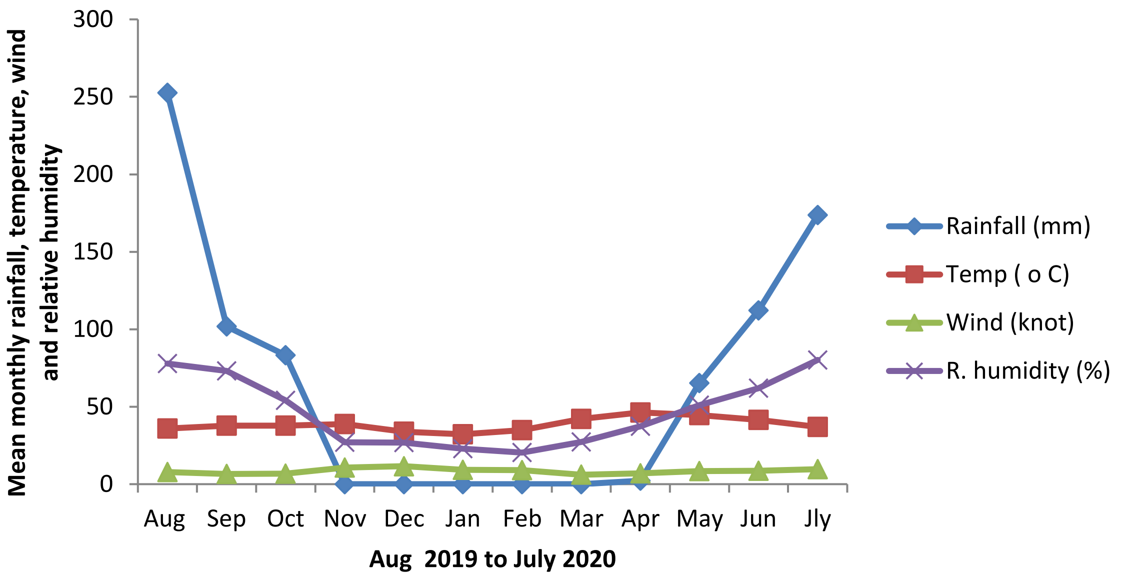

Fig 2: Mean monthly values of meteorological parameters in Rujin Sambo Sokoto

DISCUSSION

Some fungal spores are plant and animal pathogens while some cause diseases including exacerbation of respiratory allergic disorders (Gupta *et al*., 2002; Denning *et al*., 2014). In Rujin Sambo Sokoto, spores of *Curvularia*, *Nigrospora* and *Alternaria* dominated other fungal spores and could be responsible for allergenic diseases in the region. Some species of *Curvularia* and *Alternaria* have been reported to exhibit life-threatening exacerbation of asthma in patients hypersensitive to them if not well treated (Bush and Prochnau 2004; Denning *et al*., 2014). Research showed that exposure to *Alternaria* extracts induces the synthesis and secretion of IL-33, a cytokine that is known to induce Th2-type inflammation in airways (Denning *et al*., 2014). *Nigrospora* has also been reported to elicit allergenic effect in respiratory allergic patients by intradermal skin sensitivity test (Chaturvedi and Chaturvedi 2013).

Dominance of fungal spores in the region occurred more during the active rainy period than the end of the rainy period. The role of rain in sporulation and growth of hyphae has been previously highlighted by Ezike *et al*. (2016) and Njokuocha *et al*. (2016). Preponderance of *Curvularia*, *Alternaria* and *Nigrospora* has also been reported in the atmosphere of Southern Nigeria (Njokuocha *et al*., 2016). Ezike *et al*. (2016) referred to them as hydrophilic fungi. Their abundance during the active rainy period in the arid region of Sokoto attests to their water-irresistible impulse, needed for hyphal growth and sporulation.

The influx of fern spores in November could have coincided with their blooming period coupled with the influence of the sandstorm overturn episode. Adekanmbi and Alebiosu (2018) also reported influx of fern spores in November in Sokoto (location not mentioned), though their work did not report incidence of sandstorm. The similarity between the present work and the findings of Adekanmbi and Alebiosu (2018) on preponderance of fern in the same month attested to the influence of weather in blooming and dispersal of aeroallergens. The spores and sporangia of fern have been reported to possess active allergenic material (Jamil and Devi, 2019). The effect of the sandstorm would have refloated other aeroallergens previously deposited. The interpose of sandstorm episode at the onset of dry and rainy seasons could have been influenced by the North East trade wind which activity is usually stronger at that period. Evidence of sandstorm was through the intrusion of sand and enormous dust in the Tauber-like sampler mounted 1.52 m above the ground. Sandstorm is an ensemble of particles of dust or sand which are energetically lifted to great heights by a strong and turbulent wind (AMOFSG, 2010); this phenomenon was observed in samples collected in November (early dry season), March, April and May (early rainy season).

Research showed that airborne dust deteriorates air quality conditions, cause air pollution and impacted negatively on human health due to an increase in the concentration of particulate matter which can reach hazardous levels during extreme dust events (Zhang *et al*., 2022; Kim and Chung, 2008; Kim *et al*., 2016: Karagulian *et al*., 2019). Understanding the effects of such events on aeroallergens dispersal and abundance and its health implications is important especially in sandstorm-prone regions like Sokoto. Arnold (2020) noted that the respiratory tract and immune system both take a hard hit during a dust storm as bits of soil and dirt kicked up by the wind can carry bacteria, fungi, chemical pollutants and other pathogens. Some studies have associated sand storms with respiratory problems such as asthma and chronic obstructive pulmonary disease (Achudu and Oladipo, 2009). The relationship between sandstorm and allergic sensitisation is not yet established in Sokoto. Such relationship was investigated in Saudi Arabia and indicated that important allergenic fungal spores are predominantly observed in sandstorm dust samples. The study also highlighted the need for precautionary measures during sandstorm dust episodes (Vijayakumar *et al*., 2017).

Lower airborne pollen were recovered from Rujin Sambo Sokoto in comparison with previous airborne pollen counts in Sokoto (location not mentioned) (Adekanmbi and Alebiosu, 2018). Also, they were lower in comparison with airborne pollen counts in some southern Nigeria (Njokuocha and Ukeje, 2006; Njokuocha, 2006; Ezikanyi, 2021). This was due to sparseness of vegetation in Sokoto especially around Rujin Sambo. Poaceae (grass) pollen dominated and were almost persistently present throughout the year. In comparison with other published work in Abuja, North-Central Nigeria (Ezike *et al*., 2016), Poaceae achieved anthesis earlier in Sokoto; this could be due to higher monthly temperatures. There was a strong influence of rainfall and humidity in growth and blooming of Poaceae which dominated the aeroflora. The Poaceae family comprises over 12,000 wind-pollinated species. Research showed that grass family pollen are the major biological pollutant and the major triggers of pollen allergy worldwide (García-Mozo, 2017). This is due to their anemophily and high aerodynamism. It is difficult to segregate grass family into various species by the pollen architecture due to their similarities. This limitation requires an intensive approach for proper adaptive approach and immunotherapy. This, however, becomes a little complex due to the degree of cross-reactivity between many species (García-Mozo, 2017).

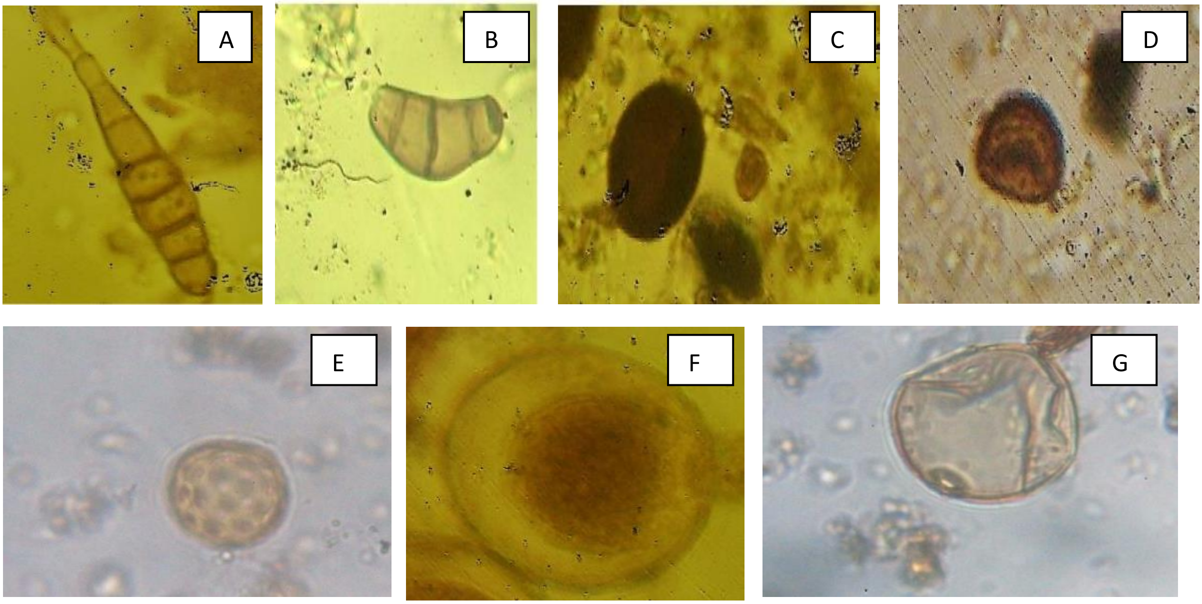

Plate 1: Isolated/identified fungal spores and pollen. Fungal spores: A- *Alternaria*, B-*Curvularia*, C-*Nigrospora*, D-Fern spore. Pollen; E- Amaranthaceae/Chenopodiaceae, F-*Pentaclethra macrophylla*, G–Poaceae. Magnification = x400

CONCLUSION

Aeroallergens such as pollen dispersed from Poaceae, Amaranthaceae/Chenopodiaceae, spores of *Curvularia*, *Nigrospor*a, diatom were found persistently present in the ambient atmosphere of Rujin Sambo Sokoto. The abundance and spatial distribution of the aeroallergens recovered were influenced by seasons. Rujin Sambo experienced higher incidence of sand/dust storm in March, April, May (onset of rainy season) and November (early dry season). These were orchestrated by the influence of the North- East trade wind, which could have refloated aeroallergens and influenced high dispersal of spores of fern-blooming in November. Abundance of fungal spores was higher during the active rainy period (July) through to October (end of rainy period). Identification of allergenic suspects and their risk periods will unravel the appropriate period for prophylaxis and other adaptive strategies in order to oversmart seasonal allergies and asthma symptoms. However, medical records of allergic diseases especially asthma in Rujin Sambo Sokoto is important to unravel the health implications of aeroallergens on the populace.

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