Available online at www.worldnewsnaturalsciences.com

World News of Natural Sciences

An International Scientific Journal

WNOFNS 25 (2019) 168-187 EISSN 2543-5426

Palynological Study of Recent Sediments from an Urban Creek in Lagos State, Southwestern Nigeria

Linus Ajikah[1,*], **Olusola Adekanmbi**[1], **Ernest Durugbo**[2] and **Oluwatoyin Ogundipe**[1]

[1]Laboratory of Paleobotany and Palynology, Department of Botany, University of Lagos, Akoka, Lagos, Nigeria

[2]Department of Biological Sciences, Redeemers University, P.M.B. 230, Ede, Osun State, Nigeria

*E-mail address: linusajikah@gmail.com

ABSTRACT

A palynological study of recent sediments from Ijora Creek, an Urban Creek in Lagos, Southwestern Nigeria was carried out to provide inferences on paleovegetation and climate change over time in the study area. Two stations 90m apart were sampled at low tide in a boat using a Russian peat corer. Samples were taken at 10cm intervals and eighteen sediments samples were collected and processed using standard palynological methods. Two hundred and sixty six (266) and two hundred and thirty three (231) palynomorphs were recovered from stations 1 and 2 respectively. Palynomorphs recovered and identified to species level include *Alchornea cordifolia*, *Hymenocardia acida, Elaeis guineensis, Spathodea companulata, Triumfetta pentandra, Uapaca acuminata*, *Tridax procumbens*, *Berlinia* sp., *Eugenia* sp., *Celtis* sp., *Albizia* sp., *Cyperus* sp. together with species of Poaceae, Asteraceae, Arecaceae, Eurphorbiaceae, Acanthaceae, with common microforaminiferal test linings and fungal spores. Poaceae and fungal spores dominated the assemblage while station 1 recorded the highest pollen and spore abundance. The presence of microforaminiferal wall linings, fungal spores and the freshwater swamp species *Alchornea cordifolia* and the oil palm pollen *Elaeis guineensis* suggests a dominantly wet period in which, there was a marked marine transgression into the creek, interrupted occasionally by dry climate as inferred from the abundant records of Poaceae and Asteraceae. The presence of secondary forest species especially *Elaeis guineensis* suggests the impact of human activities on the paleovegetation.

Keywords**:** Palynomorphs, Paleovegetation, Ijora Creek, Southwestern Nigeria

(Received 01 July 2019; Accepted 17 July; Date of Publication 18 July 2019)

1. INTRODUCTION

Quantitative analysis of fossil pollen and spores from various layers or horizons of sediments is aimed at the reconstruction of past vegetation distribution and abundance (Sowunmi,1995; Leroy and Dupont,1997; Adekanmbi and Sowunmi, 2006; Hooghiemstra *et al.*, 2006; Durugbo *et al*., 2010, Ige, 2009, 2011; Ige *et al.*, 2011). Such information from sediments provides important baseline for understanding long term ecosystem dynamics and for the calibration of earth system process models such as regional scale environmental changes (Germeraad *et al.*, 1968, Dupont *et al.* 2000). Pollen grains are considered excellent for palaeovegetation reconstruction due to their extremely minute size, produced in large quantities, thus have high chances of fossilization and are dispersed to varying distances from the parent plant and can become fossilized in a suitable environment even that which the parent plant is rooted is unfavorable for fossilization. More importantly the outer most wall of pollen and spores known as the exine contains a unique substance sporopollenin which confers on it great resistance to decay processes. Moreso, pollen grains from lagoons and creeks sediments have been studied to provide a record of past vegetation, since vegetation is acknowledged as an accurate indicator of past climatic conditions of an area (Janssen, 1984; Sowunmi, 1987, Birks, 1993, Stutz and Prieto, 2003; Adekanmbi and Ogundipe, 2007).

From available literature, different researchers have used lagoonal palynomorphs as proxies for palaeovegetational reconstruction include Latorre *et al.*, (2010) who had investigated pollen deposition in the Mar Chiquita coastal lagoon Pampa Argentina. The samples were captured with Tauber traps and from surface soil. They compared the relationships between the two sets of samples so as to infer the representativeness of local, regional and extra regional vegetation. Their results showed that predominantly, the pollen records from the Tauber trap reflected the predominant vegetation types within the area as revealed by the surface samples palynomorph records. Again, based on the record type, they reported that the ecological groups revealed different quantitative pollen representations. They inferred that airborne pollen transport was mostly local and airborne surface samples relationships as revealed in their study would promote paleoecological interpretations of the study area.

Cambon *et al.*, (1997) had studied modern pollen deposition trend in the Rhône delta area France. The area was composed of both lagoonal and marine sediments. They were able to identify two major types of pollen sedimentation based on the pollen source areas viz; the lagoonal area where atmospheric pollen input dominated and the Rhône mouth area where fluvial pollen influx prevailed. They assessed four types of samples using horizontal pollen traps from which filters were removed every fortnight for one year at two stations, one near the Vaccares lagoon and the second around the mouth of the Rhône. The surface sediments were from Rhone River, while additional sediments were collected from the top of an off-shore core and two marine water samples from the Grand Rhône plume area. They grouped the recovered pollen into nine ecological categories. From the Vaccares lagoon area, halophytic and mesophytic communities dominated contributing about 20%, followed by xerophytic Mediterranean elements while the least were riparian and water plants. However, from the La Palissade surface samples revealed the dominance of halophytic plants, lower mesophilous elements and low records of xerophytic Mediterranean palynomorphs. They reported that some of the lagoonal samples closely resembled the atmospheric pollen spectrum, with less or more xerophytic elements and minor contributions from altitudinal trees and hydrophytes.

Furthermore, the opined that the preponderance of Amaranthaceae/Chenopodiaceae pollen was due to the collection of the samples during the fall the major flowering season of plants of the family. The high values of freshwater plants Typhaceae and Cyperaceae they attributed to their blooming during the months of June and July. They concluded that the pollen deposition in the Vaccares area and its adjacent salt marshes were mainly of atmospheric origin, while the low records of Cupressaceae arose from poor pollen preservation in the saline sediments.

Santos *et al.*, (2001) reported the pollen record of the last 500 years from the Doninos Coastal Lagoon in NW Iberian Penisula. They carried out pollen, diatoms, charcoal and sedimentological analysis of a 4.20m core derived from the margin of the coastal lagoon.

They identified forty five pollen taxa and attributed the relatively high percentages of *Castanea* and low counts of *Pinus* to modern deforestation. Again, they divided the pollen percentages and concentration records into three pollen assemblage zones (PAZs). The basal section (PAZ DON-2a) dated 530 yr BP, was characterized by maximum values of arboreal pollen dominated by *Castanea* which arose from a *Castanea* forest growing during the period studied. These arboreal pollen occurred together with low counts of *Quercus, Betula, Corylus* and *Alnus* pollen and high values of Poaceae (30%) and Asteraceae (25%) which they suggested to have reflected local open vegetation. Furthermore, they recovered Ericaceae, *Planatago*, Caryophyllaceae and Cerealia-type pollen. They attributed the presence of the latter to agricultural activities. The second PAZ(PAZ DON -2b) , revealed a gradual decrease in arboreal pollen percentages and concentration especially of *Castanea* coupled with the decrease to virtual disappearance of deciduous *Quercus* and sudden appearance of other cultivated taxa such as *Juglans*. They suggested that these trends signalled a reduction of forest cover through human activities. The uppermost section (PAZ DON 2c) was characterized by decreased counts of arboreal pollen except *Pinus* which slightly increased towards the top. They interpreted this to have resulted from modern reforestataion efforts, while the increased counts of Poaceae, Asteraceae and Ericaceae indicated an open environment. Again, the decrease in *Plantago* and Chenopodiaceae which coincided with increased counts of Cyperaceae pollen reflected removal of marine influence.

Haghani *et al.*, (2016) had utilized Recent pollen assemblages in their study of the rapid evolution of coastal lagoons in response to human activities under rapid sea level change around the south Caspian Sea using sixteen core samples and ten surface samples (moss pollsters and mud). They recovered many cultivated / introduced plants especially *Pinus, Eucalyptus, Juglans, Platanus*, *Cerealia-t* and Urticaceae-Moraceae from the mud pollsters. These occurred in association with common *Alnus, Artemisia* and Poaceae. However, arboreal pollen especially *Alnus* dominated the core samples in association with other tree pollen such as *Carpinus betulus*, *Fagus*, *Quercus*, and *Salix.* The non arboreal pollen was dominated by Amaranthaceae with frequent Asteraceae, Poaceae and Cyperaceae with rare aquatic pollen and spores. Furthermore, aquatic algae and dinocysts were frequent with a noticeable gap in the middle of the sequence and high values of fungal spores characterized the non pollen palynomorphs.

Numerous palynological researches have been carried out in the Niger Delta due to the search for oil in Nigeria, but very little data exist on the paleovegetation of other parts of Nigeria and none for the Ijora creek, hence the need to investigate and reconstruct the paleovegetation and climate of this urban creek became imperative. Furthermore the vegetations of Nigerian coastal environment are frequently degraded and so many plants species are disappearing before they are identified and described scientifically (Adekanmbi and Ogundipe, 2007). Since climatic changes do affect the vegetation, the reconstruction of past vegetation will help us understand the mechanisms of such changes (Ivanor *et al.* 2007). Sowunmi (1987) had discussed the close relationship between vegetation, soil and climate of an area and opined that the flora of an area offers a clue to the major climatic regimes in such places. Therefore the aim of this study is to investigate climatic changes and reconstruct the paleovegetation of the Ijora creek located in the heavily populated commercial city of Lagos, Nigeria.

2. MATERIALS AND METHODS

2. 1. Study Area

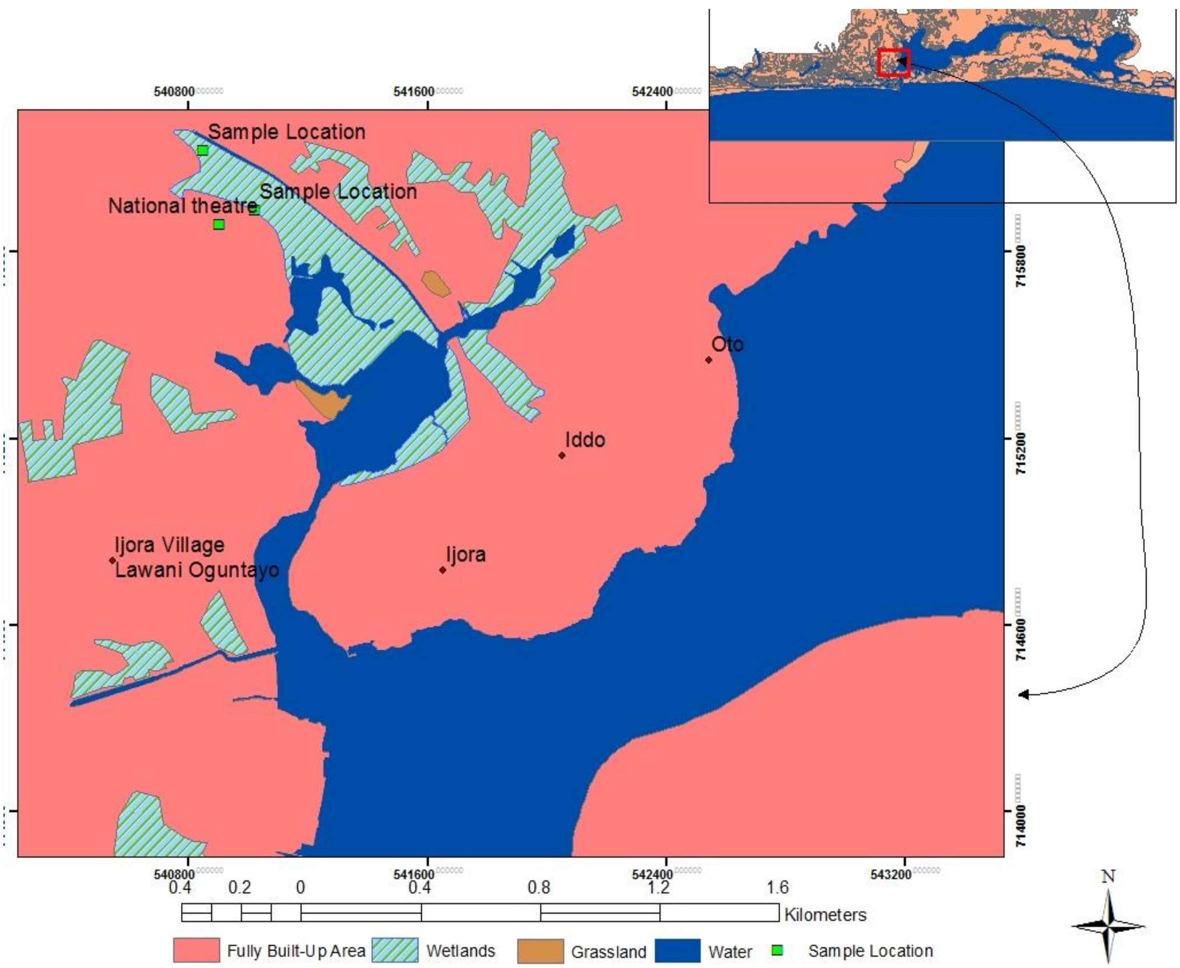

Figure 1. A modified map showing some parts of Lagos lagoon and Ijora Creek (Onyema and Nwankwo, 2006)

Ijora creek (Figure 1) is located inland along the upper part of the Lagos harbor, it is sheltered, tidal and traverses through the National Art Theatre Iganmu Lagos, located at latitude 6º476N and longitude 3º371E. It is fed by water from the Lagos harbor at high tide and as the tide ebbs, water from the surrounding region also drain into the creek. The site is exposed to two distinct seasons, the wet (May - October) with a break in August and dry seasons (November - April). An extensive expanse of mudflats which is submerged at high tide is evident as the tide ebbs. Notable riparian flora of the creek includes *Paspalum vaginatum*, *Panicum maximum*, *Mariscus alteriniforlius*, *Ipomoea* sp., and sparse populations of white mangrove *Avicenia nitida* and a patch of red mangrove *Rhizophora racemosa*. Birds are seen feeding on the exposed intertidal biota especially at low tide. (Onyema and Nwankwo, 2006) reported that apart from refined oils, waste discharges from numerous depots in the area, industrial effluents from surrounding industries, sewage and municipal waste from the heavily populated environs of Apapa, Oyinbo, Surulere and Ajegunle daily find their way freely into the creek, giving it a persistent offensive and unpleasant odour, The characteristic soil type of the creek is a darkish alluvium and brownish grey on the surface. There is very little arable land due to high population density coupled with the poor soil not conducive for agriculture because of waste discharges from numerous depots.

2. 2. Samples Collection

The creek was assessed at low tide with a manually operated boat, two points about 90m apart were chosen within the location and designated as Stations 1 and 2. A total of 18 sediment samples were collected at 10 cm intervals with a Russian peat corer into sealed sterile sample bags. The sample bags were then transported to the Paleobotany and Palynology Laboratory of the University of Lagos for treatment and analysis.

2. 3. Samples preparation/treatment

20g of each sample was weighed and subjected to standard palynological preparation techniques (Traverse 1988, Erdtman 1969) as modified by Oxford University Centre for Environment to separate the palynomorphs from the embedding matrix. Samples were treated respectively with hydrochloric acid (HCL), hydrofluoric acid (HF), acidified zinc chloride ($Zncl_2$) solutions, acetic anhydride and sulphuric acid. The final residues were stored in vials and two drops of glycerine jelly were added.

2. 4. Slide Preparation/Microscopic analysis

The prepared residue pipetted gently onto a 25 mm × 25 mm cover slip using a micropipette and placed briefly on a hot plate to dry. Care was taken to ensure that air bubbles were removed. The cover slip was gently placed on a labeled 25 × 75 mm microscopic slide. Nail polish was used to hold it firmly on the slide.

The prepared slides were studied quantitatively and qualitatively using an Olympus light microscope (X40). Photomicrographs of different palynomorphs were taken with a Motic (MC2000) 2.0 megapixel camera attached to the Olympus light microscope. Identification of the pollen and spores were carried out by studying characteristics or features such as aperture and shape, size, surface structure and ornamentation and by comparison with reference collection of published description keys of African pollen grains and spores notably (Sowunmi 1973, 1985, 1995; Bonnefille and Riollet, 1980; Salard-Cheboldaeff 1986; Willard *et al*., 2004; Gosling *et al.* 2013). Many of the pollen grains were identified to species level, some to generic and family levels respectively. However, those that could not be identified were referred to as “types or indeterminates”.

The distribution of the recovered palynomorphs were used to define phytoecological groups based on known present day natural distribution of the parent plants (Hutchinson and Dalziel, 1954; Sowunmi, 1981, Rull, 2003). Furthermore, different palynological assemblage zones (PAZ) were delineated based on the distribution of the recovered palynomorphs.

Lithological description as well as the pH and salinity of each sample was carried out and the textural characteristics which include size, shape, sorting and colour were determined using the standard grain size scale in the American/Canadian stratigraphic code.

3. RESULTS

3. 1. Pollen spectra

The distribution of recovered palynomorphs for stations 1 and 2 are shown in tables 1 and 2 below and the respective percentage plots of the recovered palynomorphs are displayed in Figures 2 and 3. Pollen grains identified to genus level were *Elaeis guineensis, Cocos nucifera, Hymenocardia acida*, *Adansonia digitata, Albizia adianthifolia, Spathodia campanulata, Alchornea cordifolia*, *Lannea welwitschii, Berlinia* sp, *Justicia* sp, *Celtis* sp, *Ipomoea* sp., *Dracaena* sp., and *Uapaca* sp. Some pollen were identified to family level, include pollen of Asteraceae, Cyperaceae, Combretaceae, Poaceae and Chenopodiaceae/Amaranthaceae. Other important recovered palynomorphs were microforaminiferal wall lining, *Puccinia* sp. and *Nigrosporia* sp. (Fungal spores). From station 1, a total of two hundred and sixty six (266) palynomorphs were recovered. The microflora was dominated by Poaceae which accounted for (25.2%), followed successively by fungal spores (23.3%). *Cyperus* sp. (4.88%), Microforaminiferal wall lining (4.51%), *Paspalum vaginatum* (4.16%), *Celtis* sp. (3.76%), Agavaceae. (3.0%) and others (Table 1).

The trend in occurrence was similar in Station 2, a total of two hundred and thirty three (233) palynomorphs were recovered. Poaceae accounted for (26.2%) also dominated the assemblage followed by fungal spores (18%), *Triumfetta pentandra* (14.2%), *Cyperus* sp. (8.15%), Microforaminiferal wall lining (4.72%), *Uapaca acuminata* (3.43%), *Tridax procumbens* (3.43%), *Celtis* sp. (3.0%) and others (Table 2). *Paspalum vaginatum* was observed to be absent in station 2, while *Triumfetta pentandra* was not recovered in station 1. Also fungal hyphae, Diatom frustules, Charred Graminae Cuticle and Trilete spores were not recovered in Station 2.

Taxa with significant ecological limits were chosen for the phytoecological groupings. Ferns (spores) and Poaceae, though not included in the pollen sum, were taken as individual groups because of their climatic significance especially when substantiated with other groups. The contrasting fluctuations in the proportions of the Spores phytoecological group and that of the Poaceae were part of the basis of the paleoclimatic inferences made. While the abundance of Spores indicates wet conditions due to their hydromorphic and epiphytic nature of many pteridophytes, the abundance of the Poaceae group indicates openness of the vegetation that is commonly associated with dry paleoclimatic.

3. 2. Phytoecological Groups

The eight phytooecological groups recognized were:

1) Fresh Water Swamp Forest: *Oncocalamus* sp, *Uapaca* sp, *Alchornea cordifolia*.

2) Riverine Forest: *Szygium guineense Hymenocardia acida*
3) Guinea Lowland Rainforest: Combretaceae, Sterculiaceae, *Eugenia* sp, *Blighia* sp, Apocynaceae, Moraceae
4) Open Forest: Asteraceae, Chenopodiaceae/Amaranthaceae, Areaceae, Convolvulaceae
5) Mangrove Vegetation: *Laguncularia* sp., *Rhizophoria* sp., *Acrosticum* sp.
6) Poaceae
7) Fern (spores)
8) Cyperaceae

A few palynomorphs were well preserved, while some appeared degraded, as some part of the exine, in most cases, appeared chipped off. A total of about 42 palynomorphs were encountered, out of which 26 were identified. Station 1 recorded 73 palynomorphs with (40 cm) as the richest depth, while the lowest was 4 palynomorphs (at 90 cm). See table 3 and 4, however in station 2, 130 recovered palynomorphs with depth (40 cm) as the richest and highest because of diversity in pollen grains found, furthermore pollen of Poaceae and Ferns spores were found to dominate in all samples. Based on marked occurrence of palynomorphs, were categorized into zones:

4. PALYNOLOGICAL ZONES

Station 1: Palynological Assemblage Zone A (90 -70 cm)

The recovered palynomorphs from station 1 were further utilized in delineating three palynological assemblage zones, which are succinctly described below. The section is characterized by low pollen content, with values between 4 at 90 cm through 15 at 80 cm and 9 at 70 cm. Poaceae dominated the assemblage in association with freshwater elements *Alchornea cordifolia*, *Berlinia* sp., *Celtis* sp., common fungal spores and rare microforaminiferal wall linings. This assemblage denotes deposition during a wet climate possibly around a coastal plain environment as grasses were common with no sedges.

Station 1: Palynological Assemblage Zone B (70-50 cm)

Moderate numbers of Poaceae were recorded within this period together with common *Cyperus* sp. at 60 cm, rare red mangrove pollen *Rhizophora* sp., *Paspalum vaginatum*, Guinea lowland forest elements Moraceae, Sterculiaceae, *Eugenia* sp, *Blighia* sp., and common fungal spores. The presence of the palm pollen *Elaeis guineensis* at 50 cm is suggestive of the onset of remarkable human activities around the Creek. This assemblage denotes deposition during a wet climate possibly around a mangrove fringed environment as grasses and sedges were common.

Station 1: Palynological Assemblage Zone C (50-10 cm)

This upper section revealed the highest abundance and diversity of palynomorphs. The highest count was recorded at 20 cm, followed by 40 cm with counts of 71 and 69 palynomorphs each. Poaceae still dominated the assemblage together with *Cyperus* sp, *Paspalum vaginatum*, *Typha* sp, relicts of freshwater elements *Alchornea cordifolia, Berlinia* sp, *Celtis* sp, Agavaceae and sparse records of riverine forest, Guinea lowland rainforest, and open forest species with rare mangrove pollen, common microforaminiferal wall linings and fungal spores. Possibly, these sediments were deposited during periods of fluctuating climatic conditions that were punctuated by brief periods of marine transgressions as inferred from the common microforaminiferal wall linings.

Station 2: Palynological Assemblage Zones A (90-60 cm)

The trend closely resembles the record from station 1. However, based on the distribution of the recovered palynomorphs, two subpalynological assemblage zones were recognized. Low occurrences of palynomorphs were recorded within the intervals 90 cm – 60 cm. the few recorded forms were Poaceae, Guinea lowland rainforest and open forest species Combretaceae, Asteraceae, with fungal spores and rare microforaminiferal wall linings and mangrove. The assemblage within this section suggests that these sediments were sourced far away from the vicinity of the Creek.

Station 2: Palynological Assemblage Zone B (60-10 cm)

There was a remarkable increase in both abundance and diversity of palynomorphs within this section. The highest count of 129 palynomorphs was recorded at 40 cm, the count was 39 at 50 cm, 29 at 10 cm, 20 at 30 cm and 8 at 20 cm. The microfloral assemblage is characterized by common Poaceae, *Cyperus* sp., *Alchornea cordifolia*, sparse records of riverine forest, Guinea lowland rainforest, and open forest species with rare mangrove pollen, common microforaminiferal wall linings especially at 40 cm, and fungal spores. These sediments reveal deposition during periods of wet or dry climatic variations

4. 1. Lithological description and pH

Table 1. Pollen Spectra and Percentage values of Recovered Palynomorphs from Station 1.

S/No		10 cm	20 cm	30 cm	40 cm	50 cm	60 cm	70 cm	80 cm	90 cm	Total	
1	Poaceae	6	24	10	15	3	2	2	3	2	67	25.2
2	*Cyperus* sp.	0	2	0	5	0	6	0	0	0	13	4.88
3	*Paspalum vaginatum*	7	0	0	0	1	0	1	2	0	11	4.16
4	Agavaceae	0	3	0	5	0	0	0	0	0	8	3
5	*Spathodea campanulata*	0	0	0	1	0	1	0	0	0	2	0.75
6	*Alchornea cordifolia*	0	1	0	2	0	0	0	2	0	5	1.88
7	Combretaceae	0	0	0	1	0	0	0	0	0	1	0.38
8	*Elaeis guineensis*	0	0	1	0	1	0	0	0	0	2	0.75

9	*Gomphrena celosioides*	0	3	1	0	0	0	0	0	0	4	1.5
10	Moraceae	0	0	0	0	0	0	1	0	0	1	0.38
11	Convolvulaceae	0	0	1	0	0	0	0	0	0	1	0.38
12	*Typha latifolia*	0	0	0	4	0	0	0	0	0	4	1.5
13	*Erythrina* sp.	0	0	1	0	0	0	0	0	0	1	0.38
14	*Celtis* sp.	0	0	1	0	8	0	0	1	0	10	3.76
15	*Rhizophora* sp.	0	0	0	0	1	0	0	0	0	1	0.38
16	*Oldenlandia* sp.	0	0	0	0	0	1	0	0	0	1	0.38
17	*Berlina* sp.	1	0	0	1	0	0	0	1	0	3	1.13
18	*Triumfetta pentandra*	0	0	0	0	0	0	0	1	0	1	0.38
19	*Blighia sapida*	0	0	0	0	0	0	0	0	1	1	0.38
20	*Oncolamus manni*	0	1	0	0	0	0	0	0	0	1	0.38
21	Arecaceae	1	2	0	1	0	0	0	0	0	4	1.5
22	Alismataceae	0	10	0	0	0	0	0	0	0	10	3.76
23	Sterculiaceae	0	0	0	0	1	0	0	0	0	1	0.38
24	*Albizia zygia*	0	2	0	0	1	0	0	0	0	3	1.13
25	*Securidaia longedinia*	0	1	0	0	0	0	0	0	0	1	0.38
26	Asteraceae	0	0	0	1	0	0	0	0	0	1	0.38
27	*Eugenia* sp	0	1	0	2	0	0	0	0	0	3	1.13
28	Chenopodaceae/Amanranthaceae	0	1	0	5	0	0	0	0	0	6	2.25
29	Euphorbiaceae	0	2	0	1	0	0	1	0	0	4	1.5
30	Bombacaceae	1	0	2	0	0	0	0	0	0	3	1.13
31	Trilete spores	0	0	0	2	0	10	0	0	0	12	4.51
32	Microforaminiferal wall lining	0	3	3	6	0	0	0	0	0	12	4.51
33	Fungal spores	2	13	13	15	2	9	2	5	1	62	23.3
34	Fungal hyphae	0	0	0	0	0	0	1	0	0	1	0.38
35	Diatom Frustules	0	0	0	0	1	0	0	0	0	1	0.38

36	Charred Graminae Cuticles	0	1	0	2	0	0	1	0	0	4	1.5
		18	70	33	69	19	29	9	15	4	266	100

The results of the pH, salinity and general lithology of the studied samples are shown in Tables 1 and 2. In station 1, the pH of the studied samples was generally acidic ranging between 3.93 at 30 cm to 5.97 at 50 cm, while the salinity values were between 3.00 ppt for samples at 50 and 90 cm to 4.00 ppt at 20 cm and 40 cm, and 5.00 for samples at 10 cm and 30 cm. The lithology revealed that these samples were mostly creamy white, fine to coarse sand with silt intercalations, rounded and poorly sorted. Some were greyish clay with peat, rounded in shape and moderately sorted while the rest were, sandy with coarse pebbles, sub angular and poorly sorted. There were variations in pH with values of 9.52 at 50 cm, and 4.60 at 40 cm in station 2. The other values were 8.91, 8.90, 8.80, 8.60, 8.10, 6.68, 4.71, at 70 cm, 90 cm, 60 cm, 20 cm 80 cm, 10 cm and 30 cm respectively. The salinity was mostly 3.00 (ppt or PPT) except at 10 cm where the value was 2.00 (PPT). Furthermore, the lithology revealed grey clay and sand with some coarse particles/sand intercalations, which were subangular in shape and well sorted. Some had ferruginous materials, carbonaceous detritus and woody materials, carbonaceous matter, while others were composed of Greyish white, fine to coarse calcareous sand, which were rounded and poorly sorted. Fungal spores were very common at both stations.

Table 2. Pollen Spectra and Percentage values of Recovered Palynomorphs from Station 2

S/No	Palynomorph taxa	10 cm	20 cm	30 cm	40 cm	50 cm	60 cm	70 cm	80 cm	90 cm	Total	%
1	Poaceae	11	7	6	31	2	2	0	1	1	61	26.2
2	*Cassia hirsuta*	0	0	0	1	0	0	0	0	0	1	0.43
3	*Cyperus* sp.	1	0	2	16	0	0	0	0	0	19	8.15
4	Agavaceae	0	0	2	2	0	0	0	0	0	4	1.71
5	*Alchornea cordifolia*	0	0	1	3	0	0	0	0	0	4	1.71
6	Combretaceae	0	0	0	0	0	1	0	0	0	1	0.43
7	*Elaeis guineensis*	0	0	0	1	0	0	0	0	0	1	0.43
8	*Tridax procumbens*	0	0	0	8	0	0	0	0	0	8	3.43
9	*Gomphrena celosioides*	1	0	0	0	0	0	0	0	0	1	0.43
10	Rubiaceae	1	0	1	0	0	0	0	0	0	2	0.86
11	*Celtis* sp.	0	0	2	5	0	0	0	0	0	7	3

12	*Rhizophora* sp.	1	0	0	0	0	0	0	0	0	1	0.43
13	*Oldenlandia* sp.	0	0	0	1	0	0	0	0	0	1	0.43
14	*Berlina* sp.	0	0	0	1	0	0	0	0	0	1	0.43
15	*Triumfetta pentandra*	0	0	1	0	32	0	0	0	0	33	14.2
16	*Blighia sapida*	0	0	0	0	3	0	0	0	0	3	1.3
17	*Uapaca acuminata*	0	0	0	8	0	0	0	0	0	8	3.43
18	Arecaceae	2	0	0	0	2	0	0	0	0	4	1.71
19	*Albizia zygia*	1	0	0	0	0	0	0	0	0	1	0.43
20	Tetrad	3	0	0	0	0	0	0	0	0	3	1.3
21	Asteraceae	1	0	0	0	0	0	1	0	0	2	0.86
22	*Eugenia* sp.	0	0	0	2	0	0	0	0	0	2	0.86
23	Chenopodaceae/Amanranthaceae	0	0	0	4	0	0	0	0	0	4	1.71
24	Euphorbiaceae	1	0	0	2	0	0	0	0	0	3	1.3
25	Bombacaceae	1	0	0	2	0	0	0	0	0	3	1.3
26	Monoporate verrucate	2	0	0	0	0	0	0	0	0	2	0.86
27	Microforaminiferal wall lining	0	0	1	10	0	0	0	0	0	11	4.72
28	Fungal spores	3	1	4	32	0	1	1	0	0	42	18
	Total	29	8	20	129	39	4	2	1	1	233	100

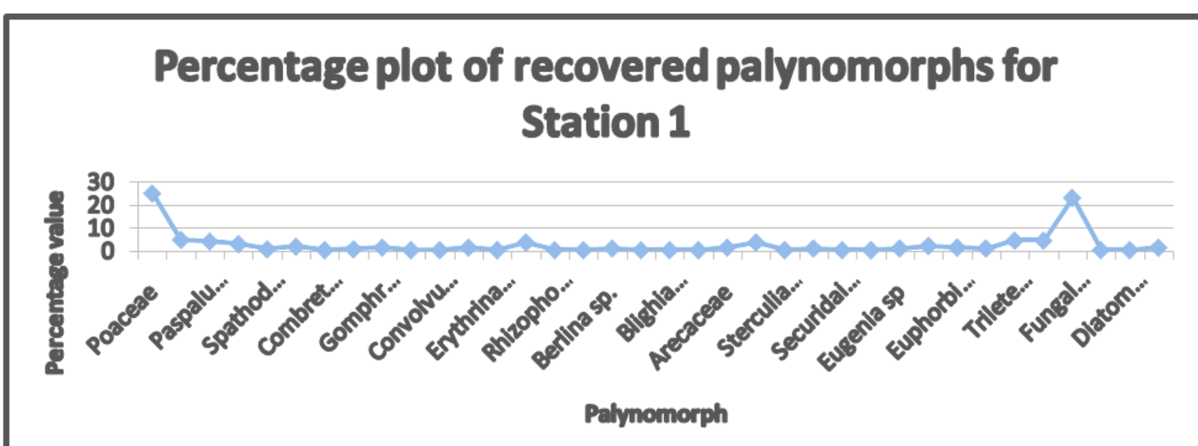

Figure 2. Plot of percentage occurrences of palynomorphs recovered in Station 1

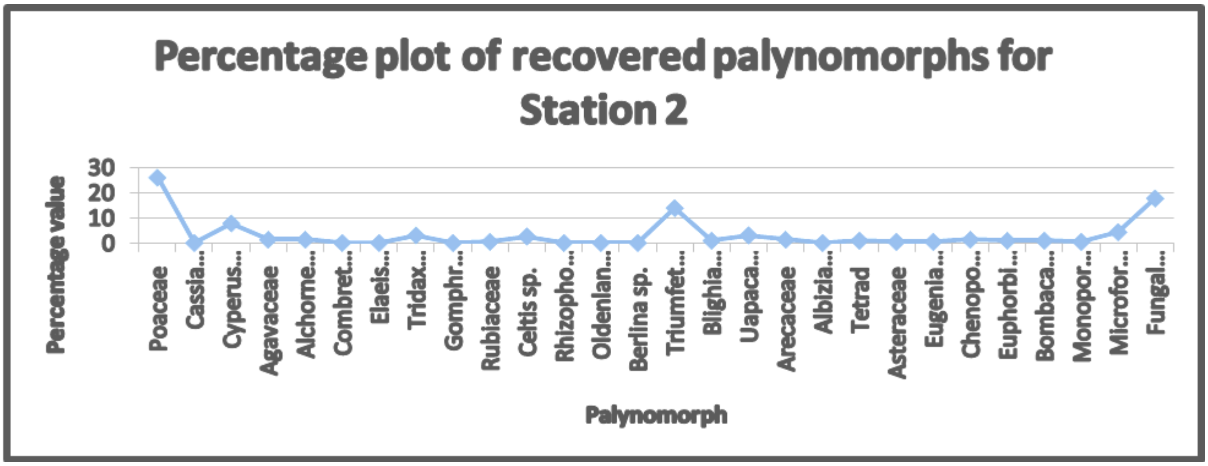

Figure 3. Plot of percentage occurrences of palynomorphs recovered in Station 2

5. DISCUSSION

The high percentage of Poaceae a good dry climatic indicator in this study denotes a dry climate and open vegetation. This agrees with the works of (Muller (1959; Germeraad *et al.*, 1968; Morley and Richards, 1995). However Sowunmi, (1981) remarked that since Poaceae is ubiquitous ecologically its source could only be determined by comparing its fluctuations with other pollen groups. She opined that pollen encountered could have come from different ecological sources viz: fringes of fresh water swamp, including areas periodically flooded and deltaic plains. Its common occurrence in the Ijora Creek samples suggests that the grasses came from all possible sources as reflected by the high percentage coupled with a decrease in the fresh water and swamp forest elements which might have allowed an extensive growth of the grasses. The variations in the different phytoecological groups could have been influenced by climatic and eustatic events (Poumot 1989). The high percentage of grasses recorded especially at the uppermost samples support the view of Germeraad *et al.* (1968) that grasses are usually indicators of dry conditions in the tropics. Adeniyi *et al.*, (2017) had reported the preponderance of Poaceae in five areas in Lagos state which supports their common presence in the studied samples. Furthermore, the increases in grass pollen at some depths is suggestive of a sources other than the fresh water swamp. The grass pollen most probably originated from the Guinea lowland forest in view of the decrease in other freshwater swamp pollen because of the variations in representation and the fluctuations in the extent of the saltwater community. This might have been due to changes in the extent and intensity of tidal flow.

The paucity of the red mangrove pollen, a prolific pollen producer (Sowunmi, 1981; Germeraad *et al.*, 1968) suggests either the absence of a pronounced mangrove community around the Creek and its catchment through human activities. This assertion is supported by the presence of the oil palm pollen *Elaeis guineensis,* the presence of which *(*Sowunmi, 1987) had associated with anthropogenic activities. These samples were quite different from those studied by Sowunmi (1981) from the Ofuabo Creek in the Niger Delta in which the mangrove pollen *Rhizophora* dominated Poaceae at some intervals. She had reported that the periods of abundant mangrove pollen indicated extension of the coastal plain which encouraged the proliferation of mangroves. The recovered palynomorphs from the Ijora Creek were quite different from those from the Niger Delta (Adekanmbi and Sowunmi, 2007; Sowunmi, 1981; Durugbo *et al.*, 2010). Furthermore, they are also different from those reported from Nigerian offshore location by Adeonipekun and Olowokudejo (2013).

These differences could have arisen from the high level of alkalinity noticed from the pH which fell between 8.9 – 8.10 especially in Station 2. According to (Ige *et al*., 2011, Adeonipekun, 1992) these values fell beyond the range generally considered conducive for good palynomorphs preservation. Again, the lithology result revealed that the grains were mostly rounded in shape. This indicates long distance transport and changes the sediments had undergone before deposition which could affect the porosity and permeability of the sediments.

5. 1. Comparative Inferences from surface samples and flora

The pollen analysis of the surface samples from the creek shows that most of the pollen grains and spores originated from plants in the vicinity. A comparison of the surface sample with the present day vegetation shows that about one third of the existing plants were represented in the modern pollen rain. Moreover, there were important indicator species which clearly reflected the prevalent vegetation. The percentage of grasses recorded for the top surface samples supported this assertion, since grasses are usually indicators of dry conditions in the tropics (Germeraad *et al.*, 1968). Therefore, their occurrence in high percentage could be an indication of dry conditions especially when corroborated by high percentages of related ecologically and climatically significant taxa such as Asteraceae, Chenopodiaceae /Amaranthaceae which are open vegetation indicators (Poumot, 1989). Therefore it can be safe to say that, the fluctuation in the percentages of grasses is a reflection of the changes in the extent of all the vegetation zones recognized for Nigeria. After all Germeraad *et al,* (1968) remarked that the Neogene of Nigeria showed fluctuation in the proportion of grasses which might be indicative of changes in the extent of the savanna. Another significant event in the study is the occurrence of microforaminiferal wall lining, a marine indicator, its presence suggests sea water incursions of tides or sea level oscillations (transgressions) the most frequent in the surface sediments near sea shore and in estuary. From the lithological assessment, no clear differences in the samples depth or strata were observed, however station 1 showed the samples were clayey, grey to creamy white in color, rounded to subangular shape but poorly sorted with some proportions of sand and a pocket of coarse particles in some of the horizons. Also, station 2 did not show clear differences in stratification from up. The sediments were clayey, fine to coarse sand, rounded to subangular shaped and grey to grayish white and poorly sorted with carbonaceous materials.

The pH of samples in station 1 of the Creek was found to fall within the range considered conducive for palynomorphs preservation (See Table 1). But, some depths in station 2 were found to fall beyond the range considered safe for palynomorphs preservation. However a reasonable quantity of palynomorphs was recovered. From the pH analysis both station 1 and 2 showed a degree of alkalinity in no particular pattern as compared to salinity with a relatively uniform values.

6. CONCLUSIONS

The palynological analysis revealed that most of the pollen grains and spores originated from plants in the vicinity of the Ijora Creek.

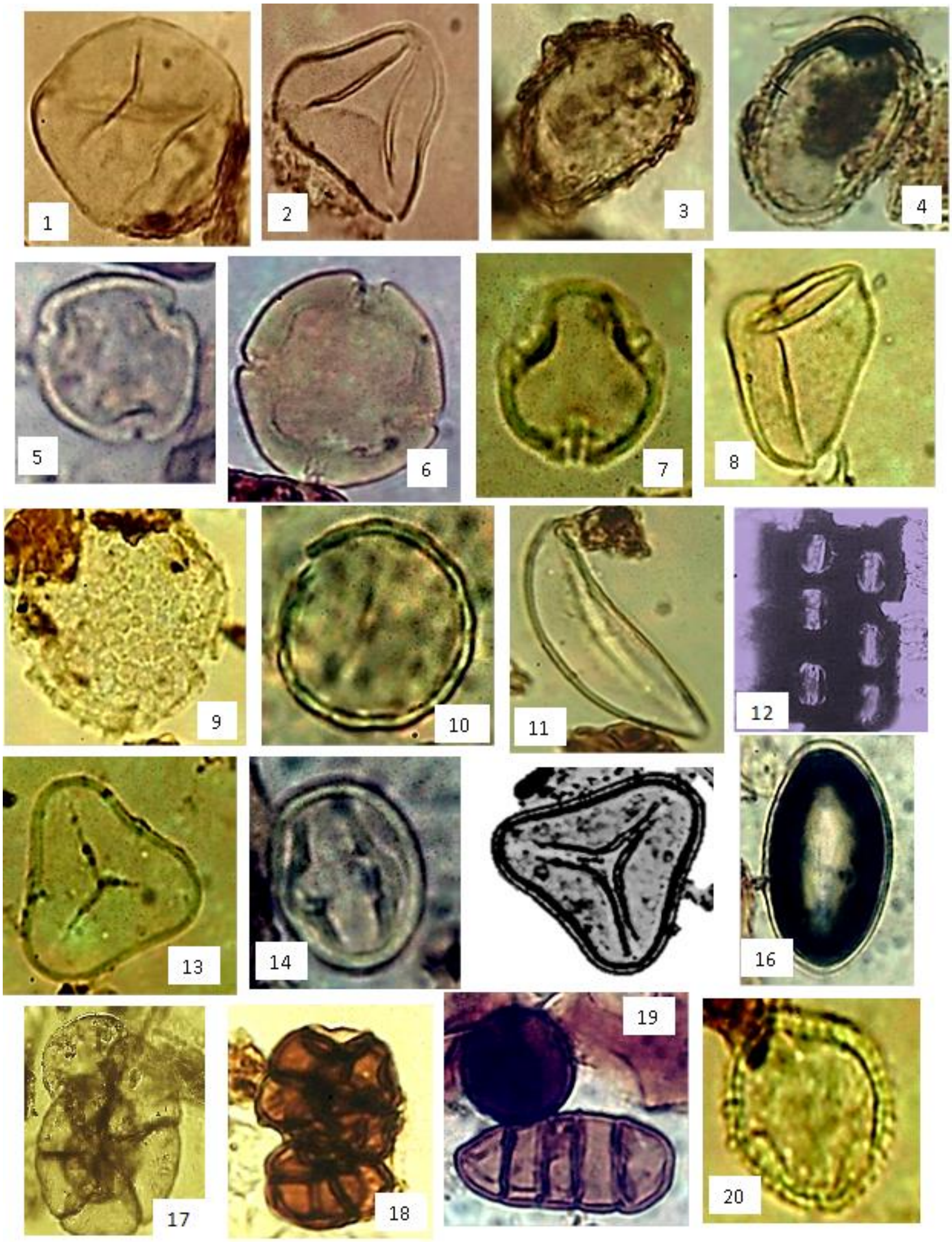

Figure 4. Photomicrographs of some of the Recovered Palynomorphs: **1 & 2** Folded Poaceae pollen, **3 & 4** *Nephrolepis* sp **5.** *Rhizophora* sp**. 6.** *Symphonia globulifera*. **7.** *Alchornea*

cordifolia **8.** *Cyperus* sp **9**. Bombacaceae **10**. Amaranthaceae **11.** Arecaceae **12.** Charred Poaceae curticle **13.**Trilete spore **14.** Eurphobiaceae, **15.** *Elaeis guineensis* **16.** Spore indeterminate **17 & 18**. Microforaminiferal wall linings **19.** Fungal spores **20.** Pollen Indeterminate

Comparisons of the samples with the present day vegetation show that, even though some of the recovered pollen were represented in the modern pollen rain, there was a change in vegetation from a more mangrove and freshwater to an open/savanna vegetation indicating a continued human activity around this Island. The results obtained from this work displayed the potency of the use of palynological methods in reconstructing the vegetational history of an area or place.

ACKNOWLEDGEMENT

Special appreciation to Tertiary Education Trust Fund (TETFUND) with grant number (TETF/DESS/NRF/UNILAG/20/19/CCU/VOL.1) for providing funds for this research to be carried. I also give credit also goes to the Department of Botany, University of Lagos for providing the platform to carry out this research work.

References

[1] Adekanmbi, O.H., and Sowunmi, M. A., The age of Niger Delta sediments, inferred from palynological evidence. *Bulletin of Pure and Applied Sciences*. 25b (2006) 87-94

[2] Adekanmbi, O.H., and Ogundipe, O.T., Pollen grains of some cultivated plants in Nigeria. *Journal Sci. Res. Dev.* 10 (2007) 101-110

[3] Adeniyi, T.A., Adeonipekun, A. P., and Olowokudejo, D.J. Annual records of airborne pollen of Poaceae in five areas of Lagos Nigeria. *Grana* (2017) 1- 8.

[4] Adeonipekun, A. P., Palynology of honeycomb and a honey sample from an apiary in Lagos, Southwest, Nigeria. *Asian Journal of Plant Science and Research,* 2 (3) (2012) 274-283

[5] Adeonipekun, A.P., The most significant period of the Quaternary. *Quaternary studies and paleoecology.* (1992) pp 1

[6] Adeonipekun, A.P. and Olowokudejo, D.J., Palynology of Recent Bottom Sediments from Shallow Offshore Niger/Cross River Delta Nigeria. *International Journal of Botany.* 9 (3) (2013) 100-200

[7] Adeonipekun, A.P., A paleoenvironmental study of HI-1well Niger Delta, Nigeria. University of Ibadan, Botany Department. Unpublished M.Sc Thesis. (1992) pp 1-76.

[8] Birks, H.J.B, and Line, J. M., The use of rarefaction analysis for estimating palynological richness from Quaternary pollen- analytical data. *The Holocene,* 2 (1) (1990) 1-10

[9] Birks H.J.B., Quaternary paleoecology and vegetation science – current contribution and possible future development. *Review of palaeobotany and palynology* 79 (1993) 153-157

[10] Bonnefille, R., and Riollet, G. *Pollens des savanes d'Afrique orientale*, *CNRS Editions, Paris*, (1980) 140 pp.

[11] Cambon, G.., Suc, Jean-Pierre, Aloisi, Jean-Claude, Giresse,P., Monaco,A., Touzani, A., Duzer, D. and Ferrier, J. Modern pollen deposition in the Rhone delta area (Lagoonal and marine sediments), France, *Grana*, 36 (2) (1997) 105-113

[12] Dupont, L.M., Jahns, S., Marret, F., and Ning, S. Vegetation change in equatorial West Africa; time-slices for the last 150 ka. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 155 (2000) 1-2

[13] Durugbo, E. U., Ogundipe O. T., and Ulu, O. K., Palynological Evidence of Pliocene-Pleistocene Climatic Variations from the Western Niger Delta, Nigeria. *International Journal of Botany*. 6 (4) (2010) 351-370

[14] Erdtman, G. Handbook of Palynology. An introduction to the study of Pollen grains and Spores. Hafnar Publishing Company, New York. (1969) 486 pp.

[15] Germeraad, J.H., Hopping, C. A., and Muller, J. Palynology of Tertiary Sediments from tropical areas. *Rev. Paleobot. Palynol.* 6 (1968) 189-348

[16] Gosling, W. D., C. S. Miller and D. A., Livingstone. Atlas of the tropical West African pollen flora. *Review of Palaeobotany and Palynology*, 199 (2013) 1-135

[17] Haghani, S., Leroy, S.A.G., Wesselingh, F.P. and Rose N.L. Rapid evolution of coastal lagoons in response to human interference under rapid sea level change: A south Caspian Sea case study. *Quaternary International*, 408 (2016) 93-112

[18] Hooghiemstra, H., Lézine, Anne-Marie. Leroy, S. A.G., Dupont, L., and Marret, F. Late Quaternary palynology in marine sediments: A synthesis of the understanding of pollen distribution patterns in the NW African setting. *Quaternary International* 148 (2006) 29–44

[19] Huctchinson, J., and Dalziel, J.M. Flora of West Tropical Africa, volume 1 2nd edition, revised by R.W.J. Keay. Grown Agents, London. (1954).

[20] Ige, O.E. A Late Tertiary pollen record from Niger Delta Nigeria. *International Journal of Botany* 5 (3) (2009) 203-215

[21] Ige, O.E. Vegetation and climate history of the late Tertiary Niger Delta, Nigeria based on pollen record. *Research Journal of Botany*, 6 (2011) 21-30

[22] Ige, O.E., Datta, K., Sahai, K., Rawat, K.K. Palynology studies of sediments from North Chioma-3 well, Niger Delta and its palaeoenvironmental interpretations. *American Journal of Applied Sciences*, 8 (12) (2011) 1249-1257

[23] Ivanor, D.A., Ashraf, A.R and Mosbrugger, V. Late Oligocene and Miocene climate and vegetation in the eastern Paratethys area (Northeast Bulgaria), based on pollen data. *Paleogeography, Paleoclimatology, Paleoecology*, 255 (2007) 342-360

[24] Janssen, C.R. Modern pollen assemblages and vegetation in the Myrtle Lake Peatland, Minnesota. *Ecol. Monogr*. 54 (1984) 213-252

[25] Latorre, F., Perez, C.F., Stutz, S., and Pastorino, S. Pollen deposition in Tauber traps and surface soil samples in the Mar Chiquita Coastal Lagoon area, Pampa Grasslands (Argentina). *Bol. Soc. Bot*. 45 (3-4) (2010) 321-332.

[26] Leroy, S.A.G. and Dupont L.M. Marine palynology of the ODP Site 658 (N-W Africa) and its contribution to the stratigraphy of Late Pliocene *Geobios*, 30 (1997) 351-359

[27] Onyema I.C., and Nwankwo, D.I. The Epipelic Assemblage of a Polluted Esturine Creek in Lagos Nigeria. *Journal of Science Poll Res.* 25 (3) (2006) 459-468

[28] Muller, J. Fossil pollen records of extant angiosperms. *The Botanical Review* 47(1) (1981) 1-142

[29] Muller J. Palynology of Recent Orino Delta and Shelf Sediments. African Earth Science 6 (4) (1959) 84-97

[30] Poumot. C., 1989. Palynological evidence for eustatic changes in the tropical Neogene: *Bull centres Rech. Explor. Prod. Elf Aquitane*, 13 (2) (1989) 437-453

[31] Rull, V. Botanical Affinities and Deduced Environmental Requirements of the Taxa selected for Numerical Analysis. *Palynology* 27 (2003) 75-98

[32] Salard-Cheboldaeff., M. Palynologie Camerounaise VII, Grains De pollen des savanes arbustives et arborées, Voire Boisées, De L' Adamaoua. *111 Congrés national des Sociétés savants Poitiers, Sciences fasc. II* (1986) 59-80

[33] Santos, L.; Bao, R., and Sánchez Goni, M.F. Pollen record of the last 500 years from the Donifios coastal lagoon (NW Iberian Peninsula): changes in the pollinic catchment size *versus* paleoecological interpretation. *Journalof Coastal Research*, 17(3) (2001) 705-713

[34] Sowunmi, M. A. Pollen of Nigerian Plants I. Woody species. *Grana*, 13 (1973) 145-186

[35] Sowunmi, M.A. Aspects of Late Quaternary vegetation changes in West Africa. *Journal of Biogeography* 8 (1981) 457-474

[36] Sowunmi, M. A. Pollen of Nigerian Plants II. Woody species. *Grana*, 34 (1995) 120-141

[37] Sowunmi, M. A. Aspects of Nigerian Coastal Vegetation in the Holocene: Some Recent Insights. *In*. Battarbee, R.W. *et al*. Past Climate Variability through Europe and Africa. Springer, Dordrecht, Netherlands (2004) 258pp.

[38] Stutz, S. and Prieto, A.R. Modern pollen and vegetation relationships in Mar Chiquita coastal lagoon area, southeastern Pampa grasslands, Argentina. Review of Palaeobotany and Palynology, 126 (2003) 183-195

[39] Traverse, A. Production, Dispersal and sedimentation of spores/ pollen in paleopalynology. Boston Unwin Hyman, Boston, Sydney Wellington. (1988) 375-430

[40] Willard, Z. A., Bernhardt, C. E., Weimer, L., Cooper, S. R., Gamez, D. and Jensen, J. Atlas of pollen and spores of the Florida Everglades. *Palynology*, 28 (2004) 175-227

Appendix 1a

Table 1b: The pH, salinity, general lithology and some palynological features of Ijora Creek samples for Station 1

Depth Of Samples (CM)	Salinity (PPT)	Sample PH	Lithologic Description Of Samples	Palynological Features of the Samples
10	5.00	4.91	Grey clay, with peat rounded in shape and moderately sorted	Clear sample with large inorganic particles
20	4.00	4.93	Grey clay, sandy with coarse pebbles, subangular and poorly sorted	Clear sample, and very few fungal spores
30	5.00	3.93	Creamy white, sandy with clay intercalations, subanguler in shape and poorly sorted	Clear sample and contain very few fungal spores
40	4..00	4.63	Creamy white, sandy with clay intercalations, rounded in shape and poorly sorted	Dirty sample with organic particles
50	3.00	5.76	Creamy white, sandy clay with some proportion of coarse particles and pebbles, subangular and poorly sorted	Clear sample with fungal spores and ferruginous materials.
60	3.00	4.74	Creamy white, sandy clay, rounded with coarse pebbles and poorly sorted	Very clear sample and no fungal spores
70	3.00	5.36	Creamy white, fine to coarse sand with silt intercalations, rounded and poorly sorted	Very clear sample and fungal spores
80	3.00	4.27	Creamy white, coarse sand with carbonaceous materials, rounded and poorly sorted	Clear sample and no fungal spores
90	3.00	5.97	White, coarse to fine sand with carbonaceous detritus and ferruginous materials, rounded in shape and poorly sorted	Clear sample and no fungal spores.

Appendix 1b

Table 1b: The pH, salinity, general lithology and some palynological features of Ijora Creek samples for Station 2

Depth Of Samples (CM)	Salinity (PPT)	Sample pH	Lithologic Description Of Samples	Palynological Features Of The Samples
10	2.00	6.68	Grey clay and sand with some coarse particles, subangualr in shape and well sorted	Dirty sample with fine organic matter
20	3.00	8.60	Grey clay and sand intercalations, with carbonaceous materials subangualar and well sorted	Clear sample and no fungal spore.
30	3.00	4.71	Grey clay and sand intercalations, subangualar shape and contain ferruginous materials, carbonaceous detritus and woody materials	Clear sample, crushed fern spores and small sized Poaceae pollen.
40	3.00	4.60	Greyish clay and sand intercalations, subangular shape, well sorted and contain ferruginous and carbonaceous detritus and woody materials	Dirty sample with organic particles and fungal spores
50	3.00	9.52	Greyish white, fine to coarse sand, rounded and poorly sorted	Clear sample with fungal spores
60	3.00	8.80	Greyish white, fine to coarse sand, calcareous , rounded and poorly sorted	Clear sample and no fungal spores
70	3.00	8.91	Greyish white, rounded, sandy with some proportion of silt and poorly sorted	Clear sample with fungal spores

80	3.00	8.10	Greyish white, rounded and sandy with some proportion of silt and contain carbonaceous material and poorly sorted.	Clear sample with fungal spores
90	3.00	8.90	Whitish, rounded shape, coarse to fine sand and poorly sorted	Clear sample with no fungal spores