Pollen Based Reconstruction of Vegetation and Climate of Ologun Area in Lagos, Nigeria.

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Abstract. Pollen and spores obtained from sediments of Ologun in the east Lagos coastal environment were analyzed, in order to reconstruct vegetation in the past and infer the paleoclimate. Sediments were collected by universal peat corer and palynomorphs were recovered following the standard palynological procedures. A total of 503 palynomorphs were recovered and photomicrographs taken. Radiocarbon dating results indicate that the sediments were deposited within the last 103 years BP, while lithology of the samples shows a mixture of sand and mudstones, or shales with acidic pH. It was assumed that fluctuation between wet and dry climatic conditions had taken place in this study location and, hence, the period was designated as Late Holocene.

Key words: climate, coastal environment, Holocene, east Lagos, palynomorphs

Introduction

Similar to most coastal cities, the coastal environment of Lagos has frequently degraded and has recorded significant loss of its vegetation through natural causes, population increase, settlement building, dredging, fishing, oil exploration and its degrading impacts, ancillary mining amongst others. Consequently, many plant species have either migrated from, or have sometimes been lost in their present environment. To evaluate the degree of these anthropogenic activities, quantitative analysis of pollen grains and spores from various horizons of sediments has been employed (Adekanmbi & Sowunmi 2006, Hooghiemstra & al. 2006, Ige 2009, Durugbo & al. 2010, Ige 2011). Such information provides an important baseline for understanding the long-term ecosystem dynamics and for calibration of the Earth system process models, such as vegetation changes on regional scale (Dupont & al. 2000).

Palynomorphs have been preserved in various geological deposits in the result of sedimentation processes (Adekanmbi & Sowunmi 2006). Thus, the geological environments of the past can be studied through palynomorphs in the sediments in which they were deposited (Traverse 2007). In Nigeria, most palynological studies have been largely concentrated in the oil-producing regions of Niger Delta and thus the earlier comprehensive studies lack information dealing with the reconstruction of changes in vegetation and paleoclimatic conditions in coastal Lagos. Nevertheless, there have been some works which treated this subject. For example, Sowunmi (2004) studied an 11 m terrestrial core from Ahanve village in Badagry coastal environment. Adekanmbi & Ogundipe (2009) compared pollen assemblages recovered from the shoreline, lagoon floor and land sediments from the Lagos Lagoon. Orijemie (2013) and Orijemie & Sowunmi (2014) have carried out some archaeological and palynological studies in the same area. Apart from these, no palynological studies known to the authors have been pursued in the coastal environment of Lagos. The present study was aimed at investigation and reconstruction of paleovegetation and climate of the coastal environment in east Lagos, so as to reveal the extent of anthropogenic impact.

Material and methods

Study site

Ologun is a coastal environment located along river Oshun in Alakuko town, at the boundary between Lagos and Ogun states. It lies between 6°45'0.30"N and 4°73'0.55"E (Fig. 1). The climate of the area is tropical wet and dry based on the Köppen climate classification system, with mean annual rainfall and temperature of about 1800 mm and 27 °C, respectively (Soladoye & Ajibade 2014). The area is dominated by two main seasons (rainy and dry) and the rainy season is characterized by two wet periods. The first and more profuse wet period lasts between April and July, while the weaker second one is between September and November. In-between these wet periods, in August and September there is a relatively dry period commonly referred to as the "August Break". The main dry season lasts from December to March and is characterized usually by the Harmattan northeasterly trade winds. The current vegetation is secondary swamp vegetation dominated by *Alternanthera sessilis, Aspilia africana, Brachiaria deflexa, Corchorus olitorius, Commelina*

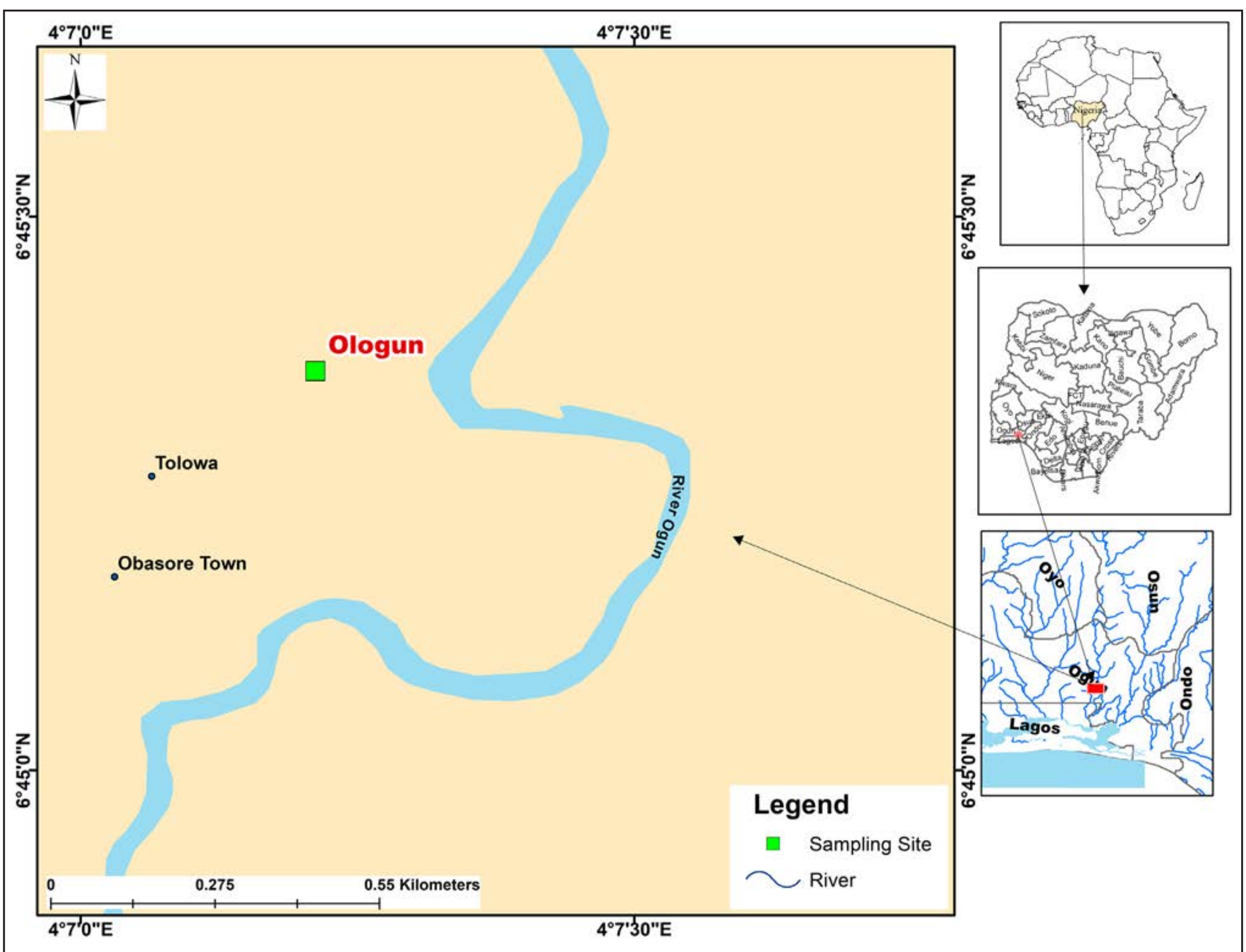

Fig. 1. Map of the study site.

diffusa, Cyperus esculentus, Mariscus alternifolius, Peperomia pellucida, Pentodon pentandrus, Senna occidentalis, Solenostemon monostachyus, Synedrella nodifloraq and *Tristema hirtum.*

Collection of samples

A total of 21 sediment samples were collected into sterile sealable sample bags using a universal peat corer at an interval of 3 cm between 0.3 cm and 63.0 cm, according to Jordan & al. (2010). The position of the sampling point was determined by GPS and the map of the location was developed using Arc GIS software.

pH Test

The pH of the sediment samples was measured with the aid of a digital pH meter. About 5 g of each sample was dissolved in distilled water in plastic cups, stirred and shaken vigorously to form a solution. The pH electrode was then inserted into the solution and values were noted on the pH meter and recorded.

Lithology

The lithological analysis was done by washing the sediments with distilled water in a 63 µm sieve mesh. The sediments were then oven-dried, examined and described with the aid of grain size comparator, rock colour chart, stereo binocular microscope, and hand-held magnifying lens at magnification of ×40.

Processing of sediment samples

The sediment samples were treated according to the standard palynological methods of Erdtman (1969) and Faegri & Iversen (1989). They include treatment with hydrofluoric acid (HF) for the removal of siliceous material; hydrochloric acid (HCl) for the removal of carbonaceous material; heavy liquid mixture for separation of palynomorphs from sediments, and, finally, acetolysis to destroy cellulosic material and darken the palynomorphs for easy identification.

Pollen identification

Pollen grains and spores were identified by studying their distinct morphological characteristics, such as apertures, shape, size, structure, and surface ornamentation. Their morphological characteristics were then compared with the published descriptive keys of African pollen grains and spores, including Sowunmi (1995, 1973), Bonnefille & Riollet (1980), Salard-Cheboldaeff (1990), Willard & al. (2004), Gosling & al. (2013), as well as pollen albums and reference collections. Unidentified pollen grains and spores were recorded as “indeterminate”. Photomicrographs of some representative pollen and spores were taken with a Chex DC 5000 camera, Euromex camera 5.0 M pixel digital model and a Canon DS126181 attached to an Olympus light microscope at a magnification of ×40.

Radiocarbon dating

Standard Accelerated Mass Spectrometry (AMS) was applied to the top, middle and bottom sediment samples at Beta Analytic Inc. 4985 S.W. 74 Court Miami, Florida, USA, following a simplified approach to calibrating ^{14}C dates by Reimer & al. (2013).

Pollen sum and constitution of spectra

Only pollen grains and spores identified to a specific generic or familial level, as recommended by Moore & Webb (1978), were selected to calculate the pollen sum. The pollen spectrum featured the palynomorphs recovered during pollen analysis. The percentage composition was calculated as follows:

Numerical composition of each taxon (pollen grains and spores) in a sample ×100 pollen sum.

Pollen zones and phytoecological groupings

Pollen zones were recognized on the basis of changes in diversity and abundance of the recovered palynomorphs and by phytoecological grouping. To outline the pollen zones, phytoecological grouping was done for all recovered pollen grains and spores in the study core, including fungal spores that have the highest recovery values. These phytoecological groups were based on the present-day distribution of various identified plant taxa, according to Hutchinson and Dalziel (1958, 1963), Keay (1959), Sowunmi (1981, 1987), Poumot (1989), Durugbo & al. (2010), and Adeonipekun & al. (2015).

Results

The pH and lithological analysis revealed acidic to slightly alkaline sediments with values ranging from 6.70 at depths of 42–45 cm and 36–39 cm, to

5.2 at a depth of 3–6 cm (Table 1). These values fall within the range considered as conducive for preservation of palynomorphs. The lithological analysis recorded dominant alternation between light-brown, loose very fine-grained sand containing lots of plant material and very fine-grained sand, micaceous and brownish, without presence of plant material. Three sedimentary units are shown in this study. The deepest unit (63–36 cm) consists of brownish-colored, micaceous, very fine-grained sediment, with little or no organic remains. It is succeeded by a loose, brownish-colored, very fine-grained sedimentary unit (36–12 cm) containing lots of plant remains, and capping the core was a thin top soil layer consisting of dark-brown, silty sand with lots of plant material. Table 2 shows the radiocarbon dating results.

Table 1. Results of pH and lithology of sediments from Ologun per sampling depth.

Sample depths (cm)	pH	Lithological description
0–3	6.40	Dark-brown, silty sand with lots of plant material.
3–6	5.20	Light-brown, loose very fine-grained sand, containing lots of plant material.
6–9	5.60	Light-brown, loose very fine-grained sand, containing lots of plant material.
9–12	5.60	Light-brown, loose very fine-grained sand, containing lots of plant material.
12–15	6.20	Very fine-grained sandstone, rich in muscovites (loose sand)
15–18	6.50	Very fine-grained sand, micaceous and brownish but no plant material recorded
18–21	6.60	Very fine-grained sand, micaceous and brownish but no plant material recorded
21–24	6.40	Very fine-grained sand, micaceous and brownish but no plant material recorded
24–27	6.50	Very fine-grained sand, micaceous and brownish but no plant material recorded
27–30	6.50	Very fine-grained sand, micaceous and brownish but no plant material recorded
30–33	6.50	Very fine-grained sand, micaceous and brownish, containing plant material with lots of trace fossils
33–36	5.70	Very fine-grained sand, micaceous and brownish
36–39	6.70	Very fine-grained sand, micaceous and brownish
39–42	6.30	Very fine-grained sand, micaceous and brownish
42–45	6.70	Very fine-grained sand, micaceous and brownish
45–48	6.30	Very fine-grained sand, micaceous and brownish
48–51	6.50	Very fine-grained sand, micaceous and brownish
51–54	6.30	Very fine-grained sand, micaceous and brownish
54–57	6.10	Very fine-grained sand, micaceous and brownish
57–60	6.20	Very fine-grained sand, micaceous and brownish
60–63	6.10	Very fine-grained sand, micaceous and brownish

Table 2. AMS ^{14}C dating of Ologun study samples.

Sample data	Measured radiocarbon dates	Isotope results ‰	Conventional radiocarbon age
Beta-456307 Ologun 0–3 cm	102.7 ± 0.4 pMC	d13C = -30.3	103.8 ± 0.4 pMC
Beta-456308 Ologun 48–51 cm	111.8 ± 0.4 pMC	d13C = -25.4	111.9 ± 0.4 pMC

A total of 503 palynomorphs were recorded. Palynomorphs were counted and recorded for each sample depth. Pollen grains of *Poaceae, Elaeis guineensis* and *Symphonia globulifera* dominated the assemblage, with a count of 56, 53 and 43, accounting for 11.56 %, 10.55 % and 8.56 %, respectively. Fungal spores also showed a dominant recovery of 61, representing 12.15 %. Other palynomorphs were *Asteraceae* (4.58 %), *Cyperaceae* (38 %), *Rhizophora* sp. (4.18 %), *Arecaceae* (3.98 %), and *Pteris* sp. (3.98 %). The recovered palynomorphs per depth are shown in Fig. 2, while percentage composition of individual pollen grains and spores is given in Fig. 3. Plate 1 shows the photomicrographs of some selected recovered palynomorphs at various depths, at ×400. Five phytoecological associations were recognized from the recovered palynomorphs, they include mangrove, freshwater swamp, lowland forest, fern spores, open forest, and savanna vegetation. The topmost depth study (surface to a depth of 15–18) recorded the highest number of palynomorphs, dominated by the savannah element (*Poaceae*) and open forest vegetation (*E. guineensis),* suggesting drier paleoclimatic conditions in the last 103.8 +/– 0.4 B.P. (Table 2).

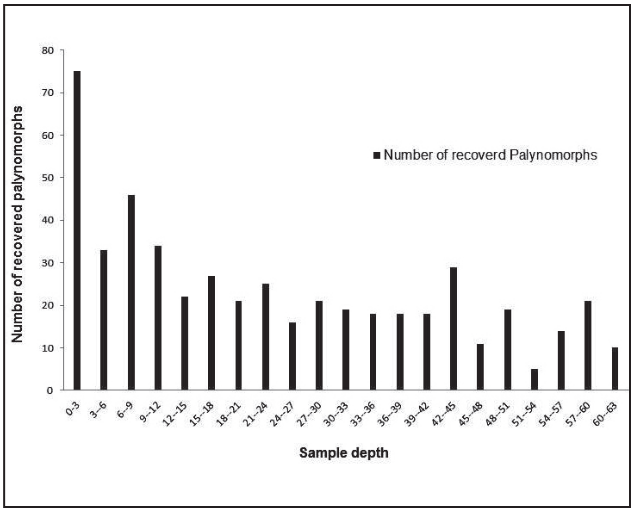

Fig. 2. Number of recovered palynomorphs per sampling depth.

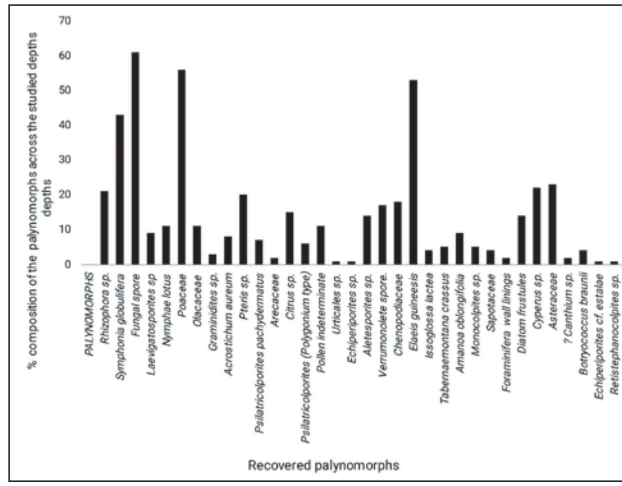

Fig. 3. Percentage composition of the total palynomorphs count in Ologun.

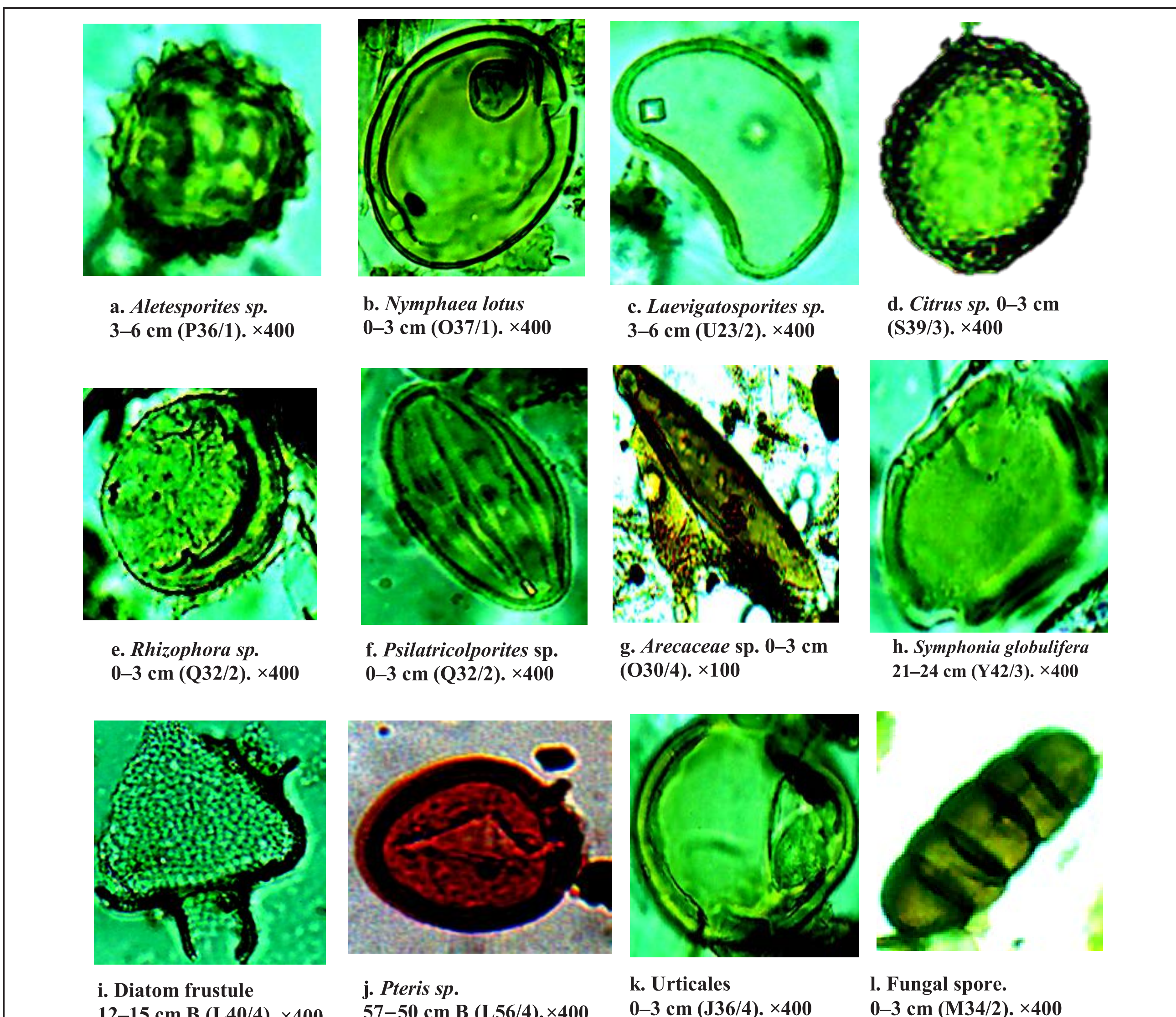

Plate I. Photomicrographs of some selected recovered pollen and spores from the various sampling depths showing their England finder coordinates.

Discussion

Generally, acidic pH is known to support palynomorphs and this was recorded at most sampled depths in this study. However, pH values of the sediments (6.20 and 6.30) between depths 15/18–42/45 were found to be slightly alkaline, suggesting a relatively low recovery of palynomorphs. This is consistent with Havinga (1971), who reported that high alkalinity is usually the cause for scarcity of pollen grains and spores. The recorded slightly alkaline pH values are also indicative of a likely varied level of freshwater inundation into the study location at different periods of deposition. Therefore, it could be assumed that during the last 111.9 cal B.P. the sediments were deposited in a mangrove-fringed environment with occasional freshwater incursion during dominantly wet climatic conditions.

Lithology of the study site shows an intercalation of very fine-grained sand, micaceous and brownish in color. The dark-brown, silty sand, with lots of plant material, up to loose light-brown, very fine-grained sand has been interpreted as indicative of sub-aerial exposure that led to oxidation during a low-water level, probably as a result of human activities. This is in line with the report of Valero-Garces & al. (2004). There was a good representation of wet-climatic phase markers, as well as dry markers. Judging by the grain sizes and the organic component, the studied sediments might have been deposited during channel overflowing (over-bank deposit or crevasse splay).

Surface depth showed the highest number of palynomorphs dominated by *Poaceae*; this could be an indication of human activities, while at a depth of 48–51 cm was recorded the lowest number of palynomorphs. On the basis of paleoecological results obtained with regard to palynoecological groups, the palynomorphs from Ologun revealed five associations of the recovered palynomorphs. High number of fungal spores was recovered indicating wet conditions; this trend of occurrence in the Ologun sequence seemed to have been cyclic and reflected the bathymetric changes of the depositional site. According to Adeonipekun & al. (2017), the trend is synchronous with the paleoclimatic changes with high water level corresponding to the wet conditions. Open forest or dry climate conditions were surmised from the recovery of *Asteraceae, Amaranthaceae*, *E. guineensis,* and *Citrus* sp. This corroborates the reports of Behling & al. (1998), as well as of Rull (2002). The occurrence of pollen of *Rhizophoraceae* and the microforaminiferal wall lining indicated brackish water environment. According to Durugbo & al. (2010), this suggests a dominantly wet or humid climate, occasionally interrupted by marine transgression. Mangrove vegetation was inferred from the presence of pollen of *Rhizophoraceae* and *Acrostichum aureum*, which agrees with the report of Berrio (2002) and Jaramillo & al. (2007). Furthermore, the presence of *Arecaceae*, *Nymphaea sp., Adiantiaceae (Pteris), Symphonia globulifera, Polypodiaceae*, and *Cyperaceae* was interpreted as indication of freshwater swamp vegetation. The latter is consistent with the report of Sowunmi (1987). Lowland rainforest was also conjectured from the presence of pollen of *Olacaceae, Euphorbiaceae, Malvaceae, Sapotaceae,* and *Acanthaceae;* this corroborates the findings of Sowunmi (1995). The recovery of *Rhizophora* pollen was indicative of the presence of a minor and short-lived salt-water swamp in the locality.

The results show that historical study of any site or environment can be based on naturally preserved pollen grains and spores found at different sediment depths or layers. The present study reveals dominance of fungal spores, followed by the pollen of *Poaceae,* which is a major biomarker of open forest or savannah vegetation. The occurrence of pollen grains of freshwater species such as *Nymheae lotus, Canthium* sp. and members of the family *Arecaceae* and *Cyperaceae* suggests that these sites were occasionally invaded by fresh water from the surroundings. Furthermore, human activities and impact, especially of farming, could be assumed to have taken and still taking place at the study location, owing to the presence of *Poaceae* and *Arecaceae* pollen grains. The present study has revealed that the last 103.8 to 111.9 years BP have witnessed an alternation between wet-dry climatic conditions, which characterize the Late Holocene.

Conclusion

The study reveals a shift between wet-dry paleoclimatic conditions in this area. The parent plants of the recovered fossil palynomorphs are still present today. This comes to prove their sustainability, despite the insatiable human-induced impact over time, especially during the Late Holocene. As mangrove and fresh-water ecosystems are continually depleted, especially by anthropogenic activities in Lagos – Nigeria, this calls for further conservation strategies in order to avoid their absolute extinction in our environment and saving them for future generations.

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