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Assessment of recent changes from Kara community of Ogun State, South-Western, Nigeria: Inferences on Paleo Vegetation and Paleoclimate

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Abstract
A 150 cm long sediment core from Kara community in Ogun state was studied to infer Holocene palaeoenvironmental and climatic change during the last 3610 years using fossil pollen, spores, and particle size. Late Holocene sediments were radiocarbon dated and subjected to standard palynological procedures. These analyses yielded palynomorphs which include pollen of *Elaeis guineensis, Alchornea cordifolia, Tridax procumbens, Cyperus* sp., *Symphonia globulifera*, *Dryopteris* sp., Fungi spore, etc. At 3610 yr B.P., the estuary was a brackish-water. By 1470 yr B.P., Poaceae (grass) pollen increased to high levels, suggesting that the rising level of the core site led to its colonization by *Zea Mays* (corn), the lowest-elevation plant type within regional estuaries. An increase in pollen and spores of moisture dependent species suggests a climate with more available moisture after 2600 yr B.P. This change is similar to that found at 106 yr B.P., implying that regional climate changes were time transgressive from west to south. Increased post settlement sediment input resulted from nineteenth-century land disturbances caused by farming, dredging, grazing and fire. Sedimentation rates increased further in the twentieth century due to closure of the estuarine mouth. The endemic Arecaceae family was present at the site throughout this 3610-yr interval but was less numerous prior to 1470 yr B.P. This history may have contributed to the low genetic diversity of this species and the disappearance of majority of the parent plants of the recovered palynomorphs.

Keywords: anthropogenic, environment, Ogun, palynological, vegetation, paleoenvironment

1. Introduction

The most prominent environmental change experienced in Kara community in Ogun state is the proliferation of water hyacinths and the drying up of Ogun River during the late Holocene. This is as a result of several anthropogenic activities around the river bank and its environment. Until now, this area was largely vegetated with annual grasses, shrubs and small trees; some of them now located farther south in tropical areas. These plants are strongly influenced by their surrounding environment, which makes them reliable indicators of climate and ecology. The relationship between climate and geographic distribution of plants based on their environmental tolerances have been established in the study of past climate and vegetation. Presently, biological indicators from aquatic (chironomids, diatoms, ostracods, cladocera) and terrestrial environments (pollen, spore, plant macrofossils) are the most reliable proxies, because they react sensitively to climate change and define different aspects of environments, which should be assessed together for reliable reconstruction [35]. It is commonly stated that the present condition of the biosphere is as a result of the action of ecological and historical factors of the past and the relative importance of each of these agents in shaping present day world can be evaluated [17]. Pollen grains, spores of ferns, fungal spores and charred plant remains which are among the microfossils that are found in sedimentary deposits have played significant roles as proxy signatures in deciphering the events of the past.

Despite this marker suitable palaeoenvironmental records are still scarce in the Southwestern zone of Nigeria. This paucity could be attributed to complex landscape history, low sedimentation rates in sedimentary archives, logistical challenges for field work and present Land-use practices. Environmental changes have been studied using many analytical methods such as sediment geochemistry, particle size, palynology, and radiometric dating techniques. The Cretaceous-Tertiary sediments have been extensively studied in the oil-producing regions of the Niger [15, 24, 39]. As well as the late Quaternary period [31, 32, 43, 3, 23, 28, 7, 8, 9, 1] and the late Holocene [4]. However, until now, no Holocene archive was directly cored in this locality. Therefore, there is an urgent need to efficiently mitigate and manage threats by ensuring ecological sustainability. This study tends to reveal the extent of anthropogenic impact on vegetation in the past, and data from this study will assist in developing a model to predict future land-cover change in the study location. This study will further aid the policymakers in formulating environmental laws that will guide the conservation and management of these resources.

2. Materials and Methods

2.1 Study area

Kara is situated at the borderline between Lagos and Ogun state, it lies between latitude 06˚38'51.5"N and Longitude 03˚28'00.1"E (Fig. 1). It contains detailed stratigraphic records of past environments and events.

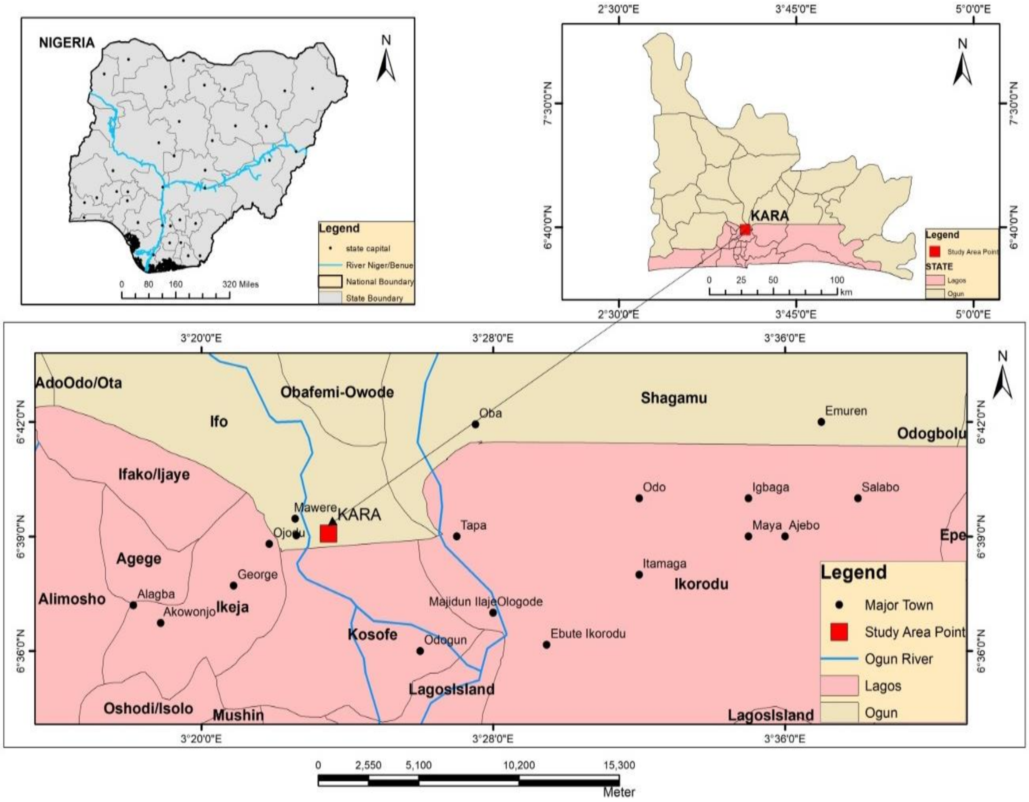

Fig 1: Showing the sites of the study location

The climate of the area is tropical with distinct wet and dry seasons; an average wind speed of 10.6kmph, a mean annual rainfall of 230mm and a temperature range of about 21oC - 33oC. The strongest and the first wet period lasts between April and July while the second and weaker wet period between September and November.

In between these wet periods is a relatively dry period in August to September commonly referred to as the "August Break." The main dry season lasts from December to March and is usually characterized by harmattan winds from the North-east Trade Winds during November.

Its vegetation is mainly the low land rain forest, guinea low land rain forest, fresh water swamp forest, and mangrove [48]. The current vegetation in the study location is secondary swamp vegetation dominated by *Elaeis guineensis*, Terminalia catappa, Dryopteris, Cyclosorus, Pennisetum purpureum and Psidium guajava. Characteristic herbs and shrubs which predominate in the site are *Tridax procumbens*, Alchornea cordifolia, Mimosa diplotricha, Celosia argentea, Ocimum grattisimum, Telfaria occidentalis, Abelmoschus esculentus, Syzygium guineensis, Phyllanthus amarus, Senna occidentalis, Ageratum conyzoides, Amaranthaceae, Poaceae and Acrostichum aureum. Other taxa present in small quantities are Gomphrena celosoides, Cyperus sp., Phycus sp., Panicum sp., Phyllanthus reticulates, Vernonia cinerea, Sacciolepis africana, Scoparia Dulcis and Andropogon sp.

2.2 Methods

A total of 15 bore-hole samples was collected at 10 cm interval from 0.00 to 150 cm using a Russian peat corer (5 cm in diameter, 100 cm long sampler). The 15 sub-samples were then subjected to standard palynological and sedimentological techniques using HCl, HF and acidified ZnCl2 solutions in order to disintegrate all siliceous and carbonaceous materials according to [19]. Then, H2SO4 and (CH3CO) 2O in the ratio 1:9 (acetolysis mixture) was added to the treated samples in other to remove pollen kit and other cellulosic materials thereby making it translucent. Residues were put in calibrated test tubes and a known volume of 100% glycerine was added to estimate the residue volume. Micro-slides were prepared for quantitative and qualitative microscopic analysis using an Olympus light microscope (× 40 objective lens). Identification of palynomorphs was achieved by using references slides in palynology and palaeobotany unit, Department of Botany, University of Lagos, Akoka, Lagos. Similarly, comparison of morphological characters with published description keys of African pollen grains and spores [21] were also consulted. Unidentified pollen and spores were categorized as Indeterminate and excluded from the Pollen Sum but considered in the percentage calculation. The pollen diagram was constructed using Tilia graph computer software after [22]. Salinometer was used and the salinity value of each sub-sample was read and noted. The sedimentological analysis was done by washing the sediments with distilled water using a 63 µm sieve. The sediments were oven dried, examined visually using stereo binocular microscope and described with the aid of Munsel colour chart (Table 1). Chronological data are based on Accelerator Mass Spectrometry (AMS) 14C measurements (Centre for Applied Isotope Studies, University of Georgia, Athens, the United States of America) performed on bulk organic matter (Table 3). Radiocarbon dates were calibrated subsequently converted into calendar ages BC/AD (0 cal. BP ¼ AD 1950) using the CalPal Online program [14]. The applied age model was obtained by assuming linear sedimentation rates between the 14C calibrated dates (Fig. 3). Pollen zones were recognized based on the changes in abundance values of the recovered palynomorphs and the use of phytoecological groupings (Fig. 4). To construct the pollen zones, phytoecological groupings was done for all the recovered pollen and spores in the study site. These phytoecological groups were recognized based on the present-day distribution of variously identified plant taxa following [8].

3. Results & Discussion

The 150cm long sediment core revealed that the distribution and preservation of palynomorphs varied considerably from one depth to another throughout the studied sections. All 34 palynomorphs belonging to 26 different plant families were recorded in the study location. Among these, eight, 13 and 12 were identified to familial, generic and species levels respectively. The unidentified pollen types were designated as pollen indeterminate. A total pollen and spore concentration of 1,021 were observed in this location. The most abundant pollen types were produced by Terminalia catappa, Zea mays, Phyllanthus amarus, Arecaceae, Asteraceae, Poaceae, and Septate spore. The palynological analysis of the sediments yielded pollen, fern and fungi spores of different phytoecological groups were identified across depths (Table 2). Seven phytoecological group were recognized which ranges from mangrove swamp forest, open forest vegetation, fern spore, guinea lowland rain forest, rain forest, fresh water swamp forest and savanna.

These groups were classified into wet and dry Paleoclimatic phases. The wet phase which includes: fresh water swamp forest, mangrove, rain forest, guinea low land rain forest, and fern spores. While the dry phase includes: open vegetation and savanna [45]. The pollen spectra revealed five main pollen zones (zones OGD I to V) which were done through the observation of noticeable changes in the phytoecological, and paleoclimatic inferences from the oldest to the topmost depth (Fig. 3). The pH and salinity values of the sediment samples varied considerably across sample depths (Fig. 2).

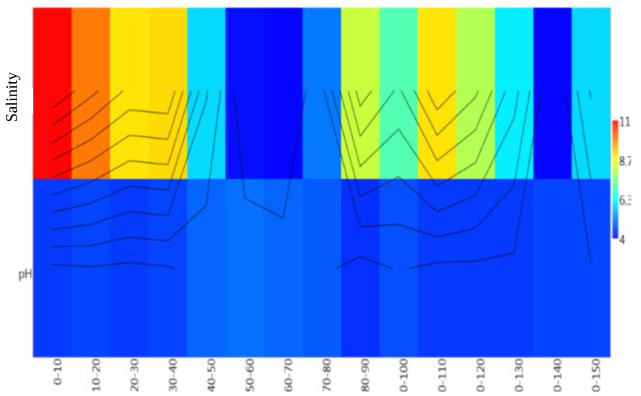

Fig 2: Values of pH and salinity of the sediments across sample depths

The lithological study of 15 units of sediments was subjected to grain sorting, texture, colour, size, fistility etc. (Table 1), and seven lithological types were recognized in the 150 meters' shallow core of alternating mudstones, clay, clay sandy, and sandy sediments. They are described as follows:

- lithofacies type 1: dark brown, coarse and sub-angular
- lithofacies type 2: fine clay, rounded, blocky and poorly sorted
- lithofacies type 3: creamy medium clay sandy, silty and sub-angular
- lithofacies type 4: moderately sorted sand grains, silty and sub-angular
- lithofacies type 5: well-sorted clay sandy and silty
- lithofacies type 6: fine clay, blocky, sub-rounded, and poorly sorted
- lithofacies type 7: poorly sorted, sub-rounded and blocky clay sand

Table 1: Lithological features of studied shallow core

Depth (cm)	Lithology	Litho-facies	Colour	Sorting	Roundness	Grain size	Fistilty	Dolomitic	Mica flakes	Carbonaceous-detritous	Hardness	Ferrugenous materials
0-10	Mudstone	1	Dark brown	Moderately	Sub angular	Coarse	Silty	-	-	+	Hard	+
0-20	Mudstone		Dark brown	Moderately	Sub angular	Coarse	Silty	-	-	+	Hard	+
20-30	Mudstone		Dark grey	Moderately	Sub angular	Coarse	Silty	-	-	+	Hard	+
30-40	Clay	2	Light grey	Poorly sorted	Rounded	Fine	Blocky	-	-	-	Moderately hard	-
40-50	Clay		Light grey	Poorly sorted	Rounded	Fine	Blocky	-	-	-	Moderately hard	-
50-60	Clay		Light grey	Poorly sorted	Rounded	Fine	Blocky	-	-	+	Moderately hard	-
60-70	Clay		Dark grey	Poorly sorted	Rounded	Fine	Blocky	-	-	-	Moderately hard	+
70-80	Clay		Dark grey	Poorly sorted	Rounded	Fine	Blocky	-	-	-	Moderately hard	-
80-90	Clay sandy	3	Light grey	Moderately	Sub angular	Medium	Silty	-	-	-	-	-
90-100	Clay sandy		Light grey	Moderately	Sub angular	Medium	Silty	-	-	-	-	-
100-110	Sandy	4	Light grey	Moderately	Sub angular	Medium	Silty	-	-	+	-	-
110-120	Sandy		Grey	Moderately	Sub angular	Medium	Silty	-	-	-	-	-
120-130	Clay sandy	5	Dark grey	Well sorted	Sub angular	Medium	Silty	-	-	-	-	-
130-140	Clay sandy	6	Dark grey	Poorly sorted	Sub rounded	Fine	Blocky	-	-	-	-	-
140-150	Clay sandy	7	Dark grey	Poorly sorted	Sub rounded	Fine	Blocky	-	-	+	-	-

Table 2: Composite spectra of identified pollen and spores across sample depths (in percentages)

Plant Taxa	Family(cm)	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Alchornea cordifolia	Euphorbiaceae	3.2	2.2	0	3.2	0	0	0	1.8	6.6	0	11.5	2.4	2.4	3.0	0	0
Amaranthaceae	Amaranthaceae	4.7	2.2	0	0	0	0	0	0	0	0	0	0.8	5.6	4.6	3.0	12.0
Arecaceae	Arecaceae	1.5	0	0	0	0	0	3.8	5.6	0	0	0	9.9	12.6	50.7	29.2	12.0
Asteraceae	Asteraceae	0	0	2.7	0	0	3.2	0	0	3.3	8.9	2.8	9.0	12.6	6.1	10.7	12.0
Cercophora sp.	Lasiopshaeriaceae	3.2	2.2	2.7	1.0	0	0	0	0	0	0	0	4.1	4.2	1.5	1.5	4.0

Chlorophytum sp.	Antheriaceae	0	0	2.7	0	0	0	0	0	0	0	0	0	1.4	4.6	1.5	4.0
Cyclosorus afar	Thelypteridaceae	19.0	2.2	8.1	5.4	0	0	0	3.7	3.3	0	4.3	2.4	2.8	0	0	0
Cyperus sp.	Cyperaceae	0	0	2.7	0	0	0	0	1.8	0	14.2	0	0	1.4	3.0	0	4.0
Dialium guineense	Fabaceae	0	13.0	29.7	9.5	1.5	0	0	0	0	0	0	0	0	0	0	0
Dryopteris	Dryopteridaceae	1.5	7.6	8.1	1.0	1.5	0	0	0	3.3	0	1.4	0.8	0	1.5	1.5	4.0
Elaeis guineensis	Arecaceae	3.2	23.9	0	1.0	0	0	0	0	0	0	7.2	0.8	1.4	3.0	0	0
Laevigatesporites sp.	Laevigatesporites	0	0	0	6.5	7.9	6.5	1.9	30.1	0	0	0	2.4	0	0	0	0
Mimosaceae	Mimosaceae	0	0	0	0	0	0	0	1.8	3.3	1.7	0	0.8	5.6	0	0	0
Olacaceae	Olacaceae	5.8	2.2	0	1.0	4.7	13.1	3.8	0	0	0	0	0.8	0	0	0	0
Oncocalamus sp.	Arecaceae	0	0	0	0	0	0	9.6	0	0	0	1.4	0	11.2	1.5	0	0
Panicum maximum	Poaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.0	0
Phyllanthus amarus	Euphorbiaceae	0	0	0	0	14.2	36.0	21.1	0	3.3	5.3	5.7	0	0	0	0	0
Pollen indeterminate	Indeterminate	1.5	0	8.1	2.2	0	0	0	0	3.3	0	8.6	2.4	5.6	0	0	0
Psidium guajava	Myrtaceae	0	0	0	1.0	0	0	1.9	0	6.6	1.7	0	0	7.0	0	0	0
Pteridophyte spore	Fern spore	0	0	0	0	0	6.5	17.3	1.8	13.3	1.7	0	0.8	0	0	0	0
Raphia sp.	Arecaceae	0	0	0	15.2	0	0	3.8	0	0	0	0	0	0	0	0	4.0
Rhizophora sp.	Rhizophoraceae	0	0	0	0	0	0	19.2	0	13.3	26.7	5.7	0.8	2.8	0	0	0
Senna sp.	Fabaceae	0	0	5.4	0	0	0	0	0	0	0	0	0	1.4	0	0	0
Symphonia globulifera	Clussiaceae	0	0	2.7	0	0	0	0	1.8	0	14.2	0	0	4.2	0	1.5	4.0
Szygium guineensis	Myrtaceae	0	0	8.1	7.6	0	6.5	9.6	0	0	0	0	0	0	1.5	1.5	8.0
Terminalia catappa	Combretaceae	0	0	40.5	28.2	66.6	0	0	0	0	0	0	0	1.4	7.6	9.2	4.0
Zea mays	Poaceae	7.9	6.5	8.1	0	0	13.1	3.2	41.5	30	5.3	0	0	0	0	1.5	0
Anacardiaceae	Anacardiaceae	0	0	0	3.2	0	0	0	0	0	0	1.4	0.8	0	1.5	0	0
Porate ascospore	Ascomycetes	0	2.2	0	0	0	0	0	0	0	0	0	9.9	5.6	4.6	6.1	8.0
Euphorbia sp.	Euphorbiaceae	12.7	0	0	0	0	0	0	0	0	0	0	1.6	0	0	1.5	4.0
Poaceae	Poaceae	12.7	15.2	18.9	8.6	1.5	8.1	0	0	3.3	0	20.2	13.2	4.2	1.5	1.5	0
Khaya ivorensis	Meliaceae	1.5	4.3	2.7	0	0	0	1.9	0	0	0	0	0	1.4	3.0	16.9	16.0
Fungi spore	Ascomycetes	25.3	21.7	22.6	1.0	1.5	6.5	1.9	9.4	10	19.6	28.9	35.5	2.8	0	9.2	0

Table 3: Radiocarbon Analyses. The radiocarbon dates were calibrated and converted into calendar ages, using the CalPal Online program (Danzeglocke *et al*., 2010).

Sample Depth (cm)	Lab code	Conventional ^{14}C age (yr BP)	Calibrated age (cal yr BP)	Calibrated age (cal yr BP & AD) – 2σ deviation	Oldest–youngest difference	Material dated
0-10	OGD00001	106 ± 0.8	152.5	66 – 239	173	Bulk Sediment
50-60	OGD00050	1470 ± 30	1358	1331 – 1385	54	Bulk Sediment
100-110	OGD00100	2600 ± 40	2735	2711 – 2759	48	Bulk Sediment
140-150	OGD00150	3610 ± 40	3925.5	3876 – 3975	99	Bulk Sediment

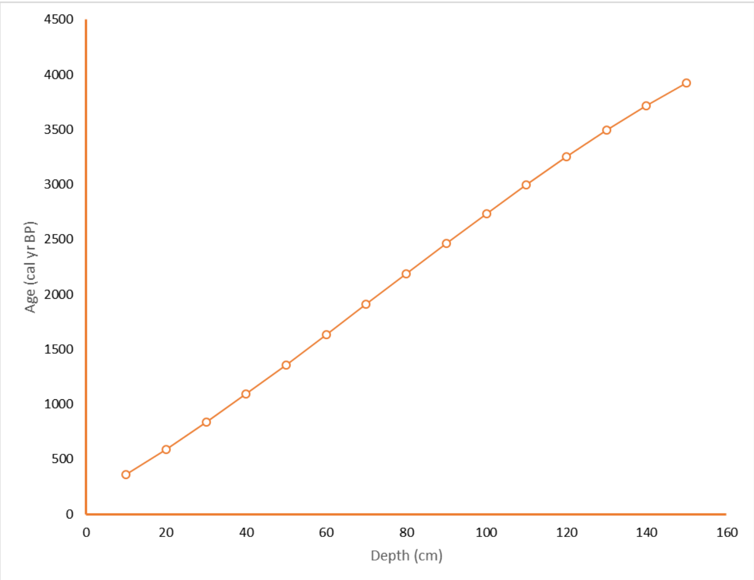

Fig 3: Depth-age model of the core OGD, Lake Kara, based on four AMS-14C measurements ages obtained on bulk organic matter. 14C ages were calibrated using the CalPal Online program.

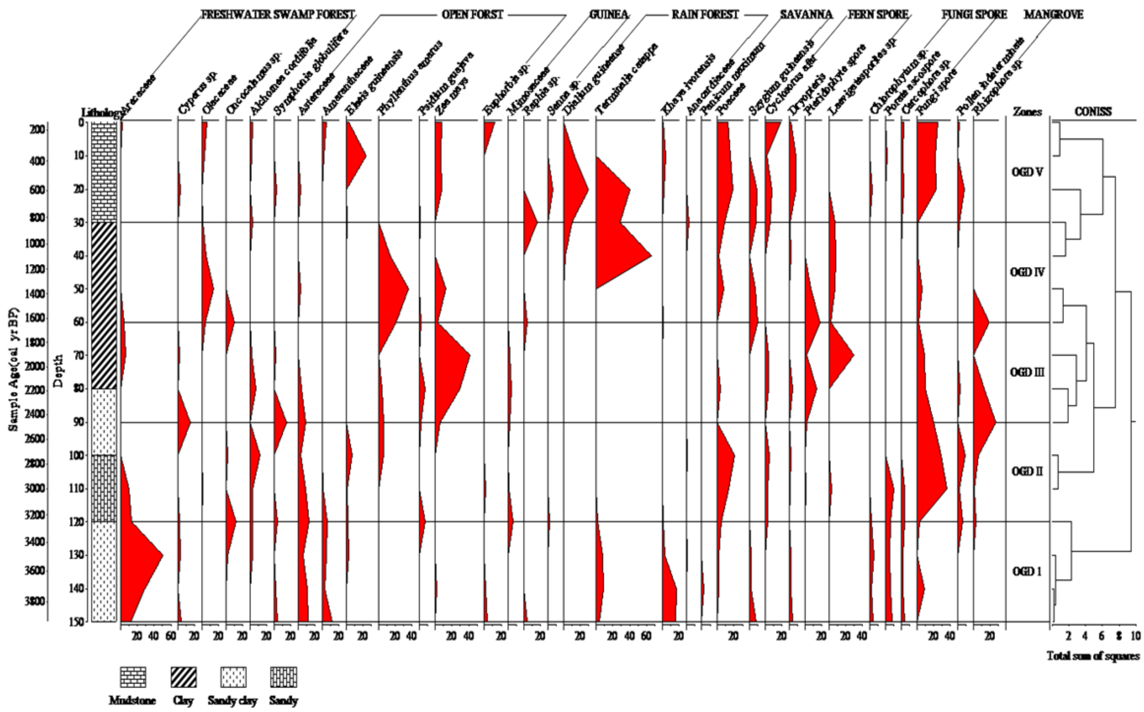

Fig 4: Pollen diagram of a 150cm shallow core showing the phytoecological group, pollen zones, chronology and lithology.

OGD 1 (150 -120cm; ca. 3,925 to ca. 3,254 cal yr BP)
A peculiar feature of this zone is the total disappearance of the mangrove and guinea lowland rainforest. Fern spores (3-8%), fungi spore (4.6 15.3%), savanna (1.5-8%) and Poaceae group (1.5-0%) are well represented, although in lower frequencies. The freshwater swamp forest reached a total dominance of (59.8-32.2%) and shortly after, recorded a drastic decline in representation (32.2-28%). Rain forest vegetation though fluctuated but remained greatly dominant in this zone. The open forest vegetation recorded a steady increase (16.7-28%). The dry paleoclimatic components such as savanna, Poaceae, and open forest vegetation groups are lower in proportions compared to the wet indicators. The recovered palynodebris which is characterized by low or absent particulate amorphous organic matter (PAOM – 0.5%), the sediments are made up of fine-grained sub angular to rounded clay sandy with the presence of carbonaceous detritus and ferruginous materials. Salinity and pH were relatively low.

OGD II (120-90cm; ca. 3,254 to ca. 2,463 cal yr BP)
This zone is characterized by the highest abundances and restoration of the Mangrove Swamp forest (26.7%). There was a weak representation in the occurrence of fern spore (1.7-2.8%), rain forest (1.4-2.8%) and Guinea lowland rainforest (1.7-7%). Total disappearance or non-occurrence of the savanna group was observed. There was a relatively high representation of freshwater swamp forest (24.4-33.6%), Poaceae group (20.2-4.2%) and open forest vegetation 21.2-29%). Fungi spore reached a total dominance (19.6-45.4%). Thus, assigning this zone to a generally wet zone. The zone is associated with lithofacies types four and five and its lithology varies from clayey sandy to indurated sandy with no carbonaceous and ferruginous materials.

OGD III (90-60cm; ca. 2,463 to ca. 1,631 cal yr BP)
Firstly, there was a relatively low or a drastic decline in representation of rain forest vegetation (19.0-0%), savanna (9.6-0%), Poaceae and freshwater swamp forest (21-3.3%). Secondly, the fern and fungi spore increased abruptly with a drastic drop in mangrove representation, which was still greatly dominant in this zone. Thirdly, the open forest vegetation recorded an all-time high (49.8%). The zone is associated with lithofacies types two and three and its lithology varies from clay to clay sandy.

OGD IV (60-30cm; ca. 1,631 to ca. 835 cal yr BP)
This zone marked the total disappearance of the mangrove and Guinea lowland rainforest. Savanna and Poaceae group were feeble represented coupled with the occurrences of fungi and fern spore. The open forest vegetation (5.2-52.3%) and rainforest (40.9-68.1) increased abruptly and a sharp drop in percentage occurrence of the rain forest at 50cm. Freshwater swamp forest (21.6-13.1%) was still greatly dominant in this zone. The zone is associated with lithofacies types two and its lithology is fine and blocky clay.

OGD V (30-0cm; ca. 835 to ca. 153 cal yr BP)
This is the topmost zone which marked the increase of the open forest vegetation (31.7-10.8%), while savanna (0-8.1%), fern spore (4.7-10.8%) and Guinea lowland rain forest (0-5.4%) were feeble represented. The freshwater swamp forest (26.3-16.2%) was declining as the rainforest (1.5-72.9%) recorded an increase in the percentage occurrence.
At this period, there is a total disappearance of mangrove vegetation (Rhizophora sp.) whereas fungi spore experiences relatively high representation. the lithofacies was mainly coarse mudstones which are sub angular in shape and they contain carbonaceous and ferruginous materials.

4. Discussion
Zone V: The type of vegetation that characterized this zone

could be described as less dense and sparse vegetation since it was marked by a low percentage of pollen grains when compared to other zones. Sustainable impacts of man are said to have influenced the savannah and forest regions of sub-Saharan West Africa after 4,000 BP [11]. Impact of man during this period resulted in a considerable change or modification of the vegetation. It was further stressed that grazing and bush burning are not the only factors responsible for less dense vegetation but the specific selection and support of different trees and shrubs serving human nutrition because trees and shrubs have been and still are of greatest importance in the human diet. The only principal mangrove elements recovered in these study was the Rhizophora sp., which were poorly recovered and was absent in zone I, IV & V. The total disappearance of these taxa and guinea lowland rain forest (Senna sp., Raphia sp., & Mimosaceae) at 3610 ±40 BP can be ascribed to the poor preservation state of the palynomorphs, typical of their predominant clay sandy lithology. Rhizophora sp., as always recorded high occurrence since its evolution at the Oligocene end [20]. The abundance of these taxa in subsurface sediments of the Niger Delta is so high that it is commonly excluded from pollen sum computation [40]. This species is disappearing at a fast rate, and certain measures have to be put in place to save the environments from further destruction [7]. The mangrove ecosystem is responsive to sea level changes and is therefore unequivocally regarded as a reliable indicator of sea-level fluctuations [24]. This zone is suggestive of a more dominantly cool and dry, due to the high recovery of freshwater swamp and fern spores which have been reported to be indicative of a humid condition [45]. The salinity values of sediments within this zone (9-11ppm.) are found within the range of freshwater, is indicative of possible varying levels of fresh water which mixes with seawater and where sediments are composed of accumulated deposits of mud at different periods of deposition. However, the low salinity of the water probably accounted for the poor recovery or absence of mangrove species and fern spore as recorded by [2]. These support the view that low salinity values are suggestive of a regressive terrestrial influence, rather than that of a transgressive seawater incursion [40]. The lithology of this zone, comprising of dark brown, coarse and sub-angular deposits, interposed with some mudstones. This type of deposit is similar to that which is laid down in the present fresh water upper deltaic flood plains and is an indication that both coast and the mangrove swamp were farther south at the time of sediment deposition [40]. The mudstone intercalations containing low quantities of Rhizophora sp. pollen is indicative of the presence of a minor and short-lived salt-water swamp in the locality [1]. The appearance of Zea mays and *Elaeis guineensis* during this period may signify the beginning and expansion of agriculture.

Zone IV: In this zone, some subtle vegetation changes were recognized. First, guinea low land rain forest vegetation and mangrove swamp forest were established after 2600 ± 40 BP and the disappearances of the savanna. After this, another possible change in vegetation must have occurred when there was a drastic decrease in rainforest members as well as fern spore which coincided with an increase in fern spore and open forest vegetation. During this period, there were sharp fluctuations in the occurrence of freshwater plants which suggest variability in dry and wet conditions. Secondly, the gradual increase shown by Poaceae suggests also possible dry condition existed during that period. However, during this period human impact has been reported in many parts of Nigeria [43]. This appreciable occurrence of lowland rainforest is an indication of open vegetation supporting a mosaic of a forest- savannah vegetation. This conclusion was further strengthened by the very low percentage occurrence of savanna pollen [23]. in his work reported that the existence of freshwater swamp forest and lowland rainforest is indicative of a wet and warm climate. The period covered by this zone can be suggested to be a period of rapid and unstable climatic conditions culminating in possible vegetation changes. In this zone, the percentage of *Elaeis guineensis* and Alchornea cordifolia: secondary forest species, decreased towards the top of the zone. Their reduction must have contributed to the drastic decline in guinea lowland rainforest vegetation. The relatively high occurrence of freshwater; an aquatic species suggests that a humid condition was prevalent [16]. reported that the occurrence of fern spores and Cyperaceae in sediment is indicative of the existence of the wet condition. The lithology of this zone ranges from clay sandy to sandy, these could have also contributed to the paucity of palynomorphs. The scantiness could be as a result of large pore size of the sand grains, thereby leading to oxidation and subsequent destructions of bio indicators. However, low alkalinity value was also recorded (8-9ppm), hence abundant palynomorphs are not usually recovered from deposits with these features.

Zone III: The presence of fungi spore, fern spore, Laevigatosporites, Dryopteris sp., which indicate thick and closed tropical forest [39] were low in representation. The frequency of the recovered spores may be dependent on seawater influence, tides, freshwater inputs during heavy flooding [13]. It is significant to note that a decrease in fungal spores was recorded in this zone. The reduction in the occurrence of fungal spores supports the suggestion that conditions were conducive for spore germination. Spore is a means of surviving adverse environmental conditions and that is why fossil forms are much in sediments. On the contrary [24], recorded an abundance of fungal spores in the study of the vegetation and climate history of the late Tertiary Niger Delta, Nigeria based on pollen record. In his work, he reported that increased occurrence of fungal spores supports the suggestion that conditions were adverse during that period. The increase in the occurrence of rainforest species immediately after 3610 ± 40 BP is also significant. This may be indicative of dense and luxuriant communities and the prevalence of wet the condition. The occurrence of the mangrove, freshwater swamp, guinea low land, fern spores, open forest vegetation and absence of savanna group is suggestive of a wet paleoclimatic phase. The relatively low recovery of Dryopteris sp., and other spores apart from fungi spore found in the study location was probably due to a combination of non-suitable microclimatic conditions favorable to the species there. According to [36] high species composition in areas with high moisture, humidity, and shaded microhabitats suggests that the species there has an adaptation for the environment. This is not the case with the Ogun wetland environment due to human activities such as farming, dredging, urbanization, bush burning, and animal husbandry which characterizes the State thus leading to loss of more biodiversity [6]. which suggested that any kind of disturbance in microclimatic conditions can hinder the growth and evolutionary processes occurring naturally in these plants thereby leading to a decline in their population.

Zone II: The general vegetation pattern in this zone symbolizes open forest woodland vegetation in which grasses were low in representation. Weed species increased with increasing anthropogenic activities [5]. Weeds are associated with man and his activities; more so they can survive unfavourable ecological conditions by producing abundant seeds, storage organs and efficient mechanisms for seed dispersal [30, 2] have also reported the dominance of weeds in the wetlands around Lagos lagoon and outlined the threat of weeds like Typha australis, Chromolaena odorata, Paspalum sp., Andropogon sp., Panicum sp., and Cyperus javanicus in the areas they studied. Prior to 1470 ± 30 BP, there was complete dominance of forest vegetation which was probably more compact than today. Rhizophora sp., Terminalia catappa, *Elaeis guineensis*, and Phyllanthus amarus defined this zone. *Symphonia globulifera*, Oncocalamus sp., Khaya ivorensis, Syzygium guineense and Psidium guajava though important woodland trees and shrubs were recorded in low frequencies. The decrease in Alchornea cordifolia and some other forest and savannah elements midway prior to 2600 ± 40 BP may be attributed to the opening of the compact vegetation probably by human activities creating room for expansion of grass community. [43] recorded a phenomenal rise in *Elaeis guineensis* sometime after ca. 3109 ± 26 BP. She reported that this was probably due to enhanced proliferation of the oil palm in openings created in the forest through human action. She noted that oil palm occurred naturally in open spaces within the secondary forest. She also reported the decline in Alchornea cordifolia which is a pioneer taxon [28]. observed an increased occurrence of *Elaeis guineensis* sometime after 1845 ± 41 BP which he attributed to the expansion of oil palms in the open forest and bushlands. He reported that the oil palm tree grew naturally or either planted or selectively protected because of its socio-economic importance. The disappearance of some rainforest members may also be attributed to anthropogenic impact [10]. reported a sudden and remarkable increase in oil palm strands which coincided with a decrease in forest trees and the appearance of human impact. He suggested that it strongly indicated that the oil palm expansion was due to the artificial opening up of the forest for farming purposes. The inhabitants of the area must have cut down the trees for various purposes. Archaeological evidence from iron smelting site dated 520 BC in Opi and 4005 ± 40 BP – 1715 ± 35 BP in Lejja, Nsukka [18]. This may also contribute to the reduction of forest vegetation during this period. The progressive increase in fern spores may signify a return to wet condition [16]. The particle size distribution shows a marked decrease in sand content. This appears to be indicative of a distinct change in environmental conditions as the peak coincides with a distinct increase in organic content.

Zone I: This zone was characterized by the abundance of palynomorphs at the base. This could be as a result of favourable environmental conditions. Pollen grains of Arecaceae, Asteraceae, and Khaya ivorensis pollen were recovered and have all been identified as inhabitants of upper coastal plain forests [26, 25]. *Symphonia globulifera* another important species was recorded in low concentration. These further shows the openness and decimation of the forest of the source area mainly caused by anthropogenic activities [7]. Another important species that was recovered was the Cyclosorus afar, and it occurs mostly in marshy to waterlogged habitats in Southwestern rainfall belt [33]. Although spore longevity has a major impact on fern species migration and distribution, long-distance dispersal may expose the spores to unfavourable conditions for germination [12]. Their relative abundance in the study location is an indication that the plant possesses high aesthetic values and spreads rapidly. Large amounts of fossil pollen (mostly Angiosperms) with botanical affinities assigned to tropical rainforest plants recovered in this zone. Notable among them includes Mimosaceae, Euphorbiaceae, Senna sp. and Terminalia catappa which experienced a drastic decline in representation. Terminalia catappa typical beach forest elements indicate the existence of estuarine condition indicating warm and humid climate with higher rainfall during the depositional period than occurring at present. Therefore, there is the need to reduce to the barest minimum the loss of biodiversity due to infrastructural development. However, the laws, legislation, and regulations (Federal Environmental Protection Agency Act, 1988 Cap 131 LFN 1990; Environmental Impact Assessment Act, 1992 and Nigerian Urban and Regional Planning Act, 1992) have to be updated and appropriately applied as recommended by [29].

5. Conclusion

The palynological data from recent sediment has reveal changes and the level of destruction of the vegetation of the Southwestern Nigeria. This is mainly due to anthropogenic activities of agriculture, dredging, bush burning and urbanization apart from the overwhelming global warming-induced sea level rise and flooding. Therefore, appropriate policies and laws on biodiversity conservation need to be formulated and enforced to conserve these sites. Also, for more viable protection, the dwellers should be enlightened on the need to safeguard their environments and possibly integrate them in the conservation activities.

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7. References

1. Adekanmbi OH, Alebiosu OS. Palaeoecological studies of Quaternary sediments from the University of Lagos, Nigeria. Ife Journal of Science. 2017; 19(1):169-181.
2. Adekanmbi OH, Ogundipe OT. Mangrove Biodiversity in the Restoration and Sustainability of the Nigerian Natural Environment. Journal Ecology Natural Environment. 2009; 1:64-72.
3. Adekanmbi OH, Sowunmi MA. The age of Niger Delta sediments inferred from palynological evidence. Bulletin of Pure and Applied Sciences. 2006; 25(2):87-94.
4. Adeleye MA, Adebayo MB, Adeonipekun PA. Palynological study of recent surface sediments from coastal area of Lagos, Nigeria. Ife Journal of Science. 2018; 20(1):199-205.
5. Adeniyi TA, Oyebanji OO, Adeonipekun PA. Floral Diversity in the Wetlands of Ibeju-Lekki Area, Lagos, Nigeria. Ife Journal of Science. 2016; 18(3):729-737.
6. Akinsoji A, Agboola OO, Adeonipekun PA, Oyebanji

OO, Adeniyi TA, Ajibode MO. Occurrence and distribution of Pteridophytes in parts of Lagos and Osun states. Ife Journal of Science. 2016; 18(2):447-453.

7. Adeonipekun PA, Olowokudejo JD. Palynology from recent sediments from shallow offshore Niger/Cross River Delta Nigeria. A Preliminary study. International journal of botany. 2013; 9(3):100-122.
8. Adeonipekun PA, Sowunmi MA, Richards K. A new Late Miocene to Pleistocene palynomorph zonation for the western offshore Niger Delta. Palynology. 2015; 41(1):2-16.
9. Adeonipekun PA, Adeniyi TA, Mateawo J, Agbalaya B. The Late Quaternary vegetational and environmental history of western tropical Africa: the eastern Benin Basin, Lagos, Nigeria, Geology, Geophysics and Environment. 2017; 43(4):277-291.
10. Alabi RA. The Nigerian environment and challenges to Archaeology. Journal of Environment and Culture. 2004; 1(2):100-120.
11. Anhuf D. Palaeovegetation in West Africa for18, 000 B.P. and 8,500 B.P. Quaternary Science Journal. 1997; 47:112-119.
12. Barrington D, Paris C, Ranker T. Systematic inferences from spore and stomata size in the ferns. American Fern Journal. 1986; 76:149-159.
13. Blasco F, Saenger P, Janodet E. Mangrove as indicators of coastal change. Catena. 1996; 27:167-178.
14. Danzeglock U, Jöris O, Weninger B. CalPal-2007. Online available at: http:// www.calpal-online.de (accessed 06.03.11), 2010.
15. Durugbo EU, Ogundipe OT, Ulu OK. Palynological evidence from Pliocene-Pleistocene Climatic Variations from the Western Niger Delta. International Journal of Botany. 2010; 6(4):351-370.
16. Dupont LM, Agwu COC. Enviromental control of pollen grain distribution pattern in the Gulf of Guinea and offshore North West Africa. Geologische Rundschau. 1991; 80:567-589.
17. Emerson BC, Gillespie RG. Phylogenetic analysis of community assembly and structure over space and time. Trends in Ecology and Evolution. 2008; 23(11):619-630.
18. Eze-Uzoamaka PI. Iron Age Archaeology in Lejja, Nigeria. In: Pwiti G, Macamo S, Radimilahy C. (Eds.). Dimension of African Archaeology: Studies in the African past. E & D Vision Publishing Limited, 2009.
19. Faegri K, Iversion J, Kaland PE, Krzywinski K. Textbook of Pollen Analysis, Wiley, Chichester, 1989.
20. Germeraad JH, Hopping CA, Muller J. Palynology of tertiary sediments from tropical areas. Review of Paleobotany and Palynology. 1968; 6:189-348.
21. Gosling WA, Miller CS, Livingstone DA. Atlas of the tropical West African Pollen flora. Review of Palaeobotany and Palynology. 2013; 199:1-135.
22. Grimm EC. Tilia Graph. Illinois State Museum Research and Collection Centre, Springfield, Illinois, USA, 1991.
23. Ige OE. A Late Tertiary pollen record from Niger Delta Nigeria. International Journal of Botany. 2009; 5(3):203-215.
24. Ige OE, Datta K, Sahai K, Rawat KK. Palynology studies of sediments from North Chioma-3 well, Niger Delta and its palaeoenvironmental interpretations. American Journal of Applied Science. 2011; 8(12):1249-1257.
25. Mahmoud MS, Schrank E. Late Cretaceous spores, pollen and dinoflagellates from two boreholes (Nuqra-1 and 3) in the Aswan area, southeastern Egypt. Revue de Paléobiologie. 2007; 26(2):593-613.
26. Morley RJ, Richards K. Gramineae cuticles: a key indicator of Late Cenozoic climatic change in the Niger Delta. Review of Palaeobotany and Palynology. 1993; 77:119-127.
27. Mphoweh JN, Tchindjang M, Mfondoum NAH. The degradation of raffia palms and it's socio-economic and ecological consequences: the case study of Bamunka, Ndop, North West province Cameroon. http://cameroontour. com/geography/Jude_article.pdf, 24, 2004.
28. Njokuocha RC. Holocene pollen deposits and recent vegetation distribution of Obayi Lake, Nsukka. Quaternary International, 2012; 262:20-24.
29. Nwafor JC. Environmental Impact Assessment for Sustainable Development. The Nigerian Perspective. Environmental and Development Policy Centre for Africa (EDPCA), 160, 2006.
30. Ogunyemi S. The distribution of some weeds of arable crops in Southwestern Nigeria. Proc. 7th Annual Conference Weed Science Society of Nigeria, 1977.
31. Oloto IN. Maastrichtian dinoflagellate cyst assemblage from the Nkporo shale on the Benin flank of the Niger Delta. Review of Palaeobotany and Palynology. 1989; 57:173-186.
32. Oloto IN. Palynological assemblage from the Danian of south west Nigeria. Acta Palaeobotanica. 1990; 30(112):23-30.
33. Oloyede FA, Aponjolosun B, Ogunwole AA. Reproductive potentials of a tropical fern Cyclosorus afer (christ.) Ching (Thelypteridaceae: Pteridopyhte) at Obafemi Awolowo University, Ile Ife, Nigeria. Ife Journal of Science. 2011; 13(1):143-148.
34. Olubode OS, Awodoyin RO, Ogunyemi S. Floral Diversity in the Wetlands of Apete River, Eleyele Lake and Oba Dam in Ibadan, Nigeria: Its Implication for Biodiversity Erosion. West African Journal Applied Ecology. 2011; 18:109-119.
35. Pestryakova L, Herzschuh U, Wetterich S, Ulrich M. Present-day variability and Holocene dynamics of permafrost-affected lakes in central Yakutia (Eastern Siberia) inferred from diatom records. Quaternary Science Reviews. 2012; 51:56e70.
36. Richard AF, Dewar RE, Schwartz M, Ratsirarson J. Mass change, environmental variability and female fertility in wild Propithecus verreauxi. Journal of Human Evolution. 2000; 39:381-391.
37. Rull V. A quantitative palynological record from the Early Miocene of western Venezuela, with emphasis on mangroves. Palynology. 2001; 25:109-126.
38. Samant B, Phadtare NR. Stratigraphic palynoflora of the early Eocene Rajpardi lignite, Gujarat and the lower age limit of the Tareswar Formation of south Cambay Basin, India. Palaeontographica Abt. B, 245, Lfg. 1997; 1-6:1-108.
39. Sowunmi MA. Aspects of Late Quaternary Vegetational Changes in West Africa. Journal of Biogeography. 1981; 8:457-474.
40. Sowunmi MA. Palynological Studies in the Niger Delta. In: Alagoa, E.J., Anozie, F.N. and Nzewunwa, N.

(Eds.). The Early History of the Niger Delta. Helmat Buske Verlag Hamburg, UK, 1987.
41. Sowunmi MA. Pollen Grains of Nigerian Plants II. Woody Species. Grana. 1995; 34:120-141.
42. Sowunmi MA. The significance of the oil palm (*Elaeis guineensis*) in the late Holocene environments of West and West Central Africa: A further consideration. Vegetation Hist. Archaeobotany. 1999; 8:199-210.
43. Sowunmi MA. Aspects of Nigerian Coastal Vegetation in the Holocene: Some Recent Insights. In: Battarbee, R.W., Grasse, F. and Stickley, C.E. (Eds.). Past Climate Variability through Europe and Africa. Springer, Netherlands, 2004.
44. Sowunmi MA. Pollen Grains of Nigerian Plants I. Woody Species. Grana. 1973; 13(3):145-186.
45. Tossou MG. Recherche palynologiquesur lavégétationholocène du Sud-Bénin (Afrique de l'Ouest). Ph.D. Thesis, Proefschrift Universite de Lome, 2002, 136.
46. Van Der Zwan CJ, Brugman WA. Bio signals from the EA Field, Nigeria. In: Jones, RW, Simmons MD. (eds.), Biostratigraphy in production and development geology. Geological Society, London, Special Publications, 1999.
47. Willard DA, Bernhardt CE, Weimer L, Cooper SR, Gamez D, Jensen J. Atlas of pollen and spores of the Florida Everglades. Palynology. 2004; 28:175-227.
48. White F. The Vegetation of Africa. UNESCO, Paris, 1983.