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# Changes in Vegetation in Relation to Human Activities in Atlas Cove, Lagos, Nigeria

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## Abstract

In the conservation and management of our environment, information on vegetation change and pollution monitoring as a result of human activities is still highly important. This necessitated a palaeoenvironmental investigation through drilled sediments of a 51 cm core in Atlas Cove on the Commodore Channel in Lagos State, in order to ascertain possible changes in the past ecological conditions of the study area over time. Eighteen sediment samples were collected at intervals of 3 cm between the depth of 0.00 cm and 51.00 cm and subjected to palynological, lithological, pH, salinity, and heavy metal analyses. The palynological study revealed a diversified and sparse array of palynomorphs. Pollen of *Asystasia gangetica, Alstonia congensis, Rauvolfia vomitoria, Cyperus* sp., *Kyllinga erecta, Rhizophora racemosa, Acrostichum aureum, Polypodiaceae, Paspalum* sp., *Pteris* sp., *Alchornea cordifolia,* and *Elchornia crassipes* were found to be dominant. The pH and salinity values of the sediment samples also varied considerably at different depths. A considerable number of lithological types were recognized, which varied in grain-size, grain sorting and grain-texture. The concentrations of Fe, Cu, As, Pb, Zn, Cr, Se, Ni, Mn, Co, Cd, and Al vary greatly. When the results were compared to the soil guideline value for commercial areas using the CLEA-Contaminated Land Exposure Assessment, they were found to be below the limit for commercial areas, indicating that environmental contamination is negligible. This study's findings will be used to develop realistic conservation and management plans for this biologically unique ecosystem in the future.



## 1. INTRODUCTION

The Lagos coastal environment, like most other coastal cities, is associated with many of the consequences of such ecological relationships, which include physical alterations and destruction of coastal habitats from crude oil storage and distribution. Oil spillage is an inevitable environmental malaise from oil distribution, storage, and exploitation activities. Despite the stringent measures put in place to avert oil spills, there are spillages at various stages of distribution and storage. This is largely caused by poorly maintained galvanized pipelines and vandalism, resulting from corrosion and siphoning of petroleum products. The effect of this is that the environment is vulnerable to both inland and offshore oil spill disasters. Since environmental degradation from an oil spill results in the gradual destruction of the ecosystem, which forms the basis for the survival of the human species and its interactions, the prevention of this kind of adversity through rapid and precise response action is not negotiable. There is a need to evaluate both extinct and extant plants because oil spills have adverse effects on plants as well as inhibiting the growth performance of the entire vegetation cover. Plants are the first victims of oil spillage in the land ecosystem and the second in the coastal environment. Because it has a negative impact on physiological, anatomical, and growth performance. This is due to the fact that when oil penetrates soil pore spaces, it eventually causes blockage, preventing other physiological processes such as aeration from taking place. This act, if not curtailed, could turn this productive area into wastelands, increasing soil infertility due to the destruction of soil microorganisms.

Atlas Cove is surrounded by three main ecological areas (mangrove, freshwater swamp forest, and lowland rain forest). The mangrove is the most affected by oil exploration and exploitation as it has very poor regeneration potential. The crude oil spills into the environment through tidal influences and characterize the ecosystem, which provides for wider dispersal and distribution in the intertidal flat areas. It tends to cover the lower trunk and the breathing roots of the plants, thereby reducing their access to oxygen transfer (Michel and Fingas, 2016). This in turn impairs the normal salt exclusion process, resulting in the accumulation of excess salt in the plant and enhancing the stress condition of the plant, which eventually leads to death for the impacted



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trees and habitat degradation and destruction (Gupta and Huang, 2016). Toxic fractions of the spilled oil may penetrate the soil, causing long-term effects that could develop into lethal conditions that may affect the overall recovery of the mangrove ecosystem, thereby affecting the recruitment and growth of younger mangrove seedlings. However, there is a need to curb degradation, restore the area to its original form, and sustain and preserve it thereafter. To evaluate human impact, data from past vegetation and climatic history is important to ascertain the level of damage. Pollen analysis has been the principal technique for long- and short-term vegetation reconstruction. It has also made significant contributions to our understanding of the processes and mechanisms of ecological change (Rull, 2001).

This present study was undertaken with a view to examining the past ecological changes and pollution levels in relation to human activity that have prevailed in the Late Holocene. The information obtained through this study can be used to formulate realistic conservation and management plans for this biologically unique ecosystem in the future.

### 1.1. The study area

The study was carried out in Atlas Cove, which is located in Lagos State, Nigeria. It is the foremost oil receptor and depot for all imported fuel into the country as well as products from the refineries. The facility is operated by Pipelines and Products Marketing Company Limited (PPMC), a subsidiary of the Nigerian National Petroleum Corporation (NNPC), and was constructed in 1981. Its activities involve the offloading, storage, and distribution of crude oil to the south-west and north-central regions of Nigeria, which makes it vulnerable to both offshore and inland oil spillage, thereby having an adverse effect on the ecosystem at large. It lies between latitudes 06˚22" and 06˚38' N and longitudes 03˚23' and 03˚40' E (Fig. 1). Eighteen representative samples were collected and subjected to standard laboratory palynological procedures. The neighbouring communities include Takwa Bay, Abagbo, Ebute Oko, and Store. The water in these localities is brackish and contains fish, crab, and periwinkle, among others, which is a source of livelihood as most residents in these communities engage in fishing and water transport services. The Lagos Lagoon is known to form part of the water system, which is made up of creeks and lagoons found along the coastal line of the Economic Community of West African States (ECOWAS) region, which is also connected to the Atlantic Ocean. The major pollutant in these study areas is oil spill, domestic, urban, and industrial waste. The vegetation in this location is mainly that of mangrove and freshwater swamp forest.

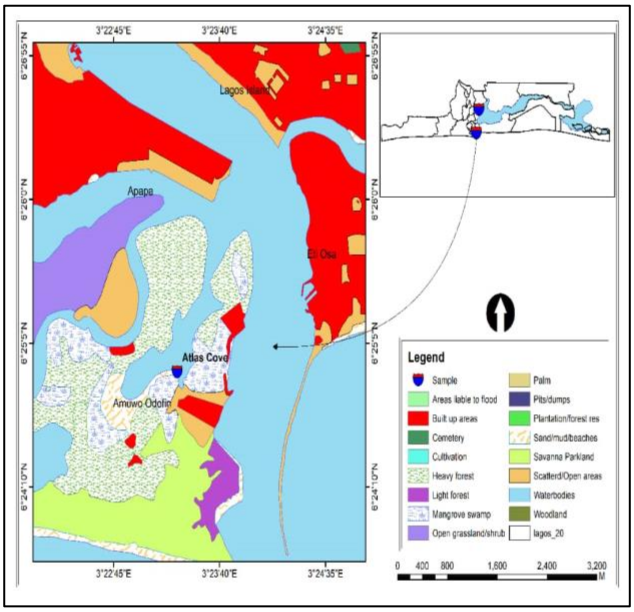


**Figure 1:** The sites of the study location in Lagos State, Nigeria

## 2. MATERIALS AND METHODS

Five grams of each sample were prepared for pollen analysis in the Palynology and Palaeobotany Laboratory, Department of Botany, University of Lagos, Akoka, Lagos, Nigeria. Pollen extraction followed a standard modified method from Faegri and Iversen (1989). which includes subjecting the sediment to both mechanical and chemical analysis. Mechanical procedures include wet sieving for eliminating small silt and sand fractions and/or dense liquid separation. Chemical procedures consist of hydrochloric acid (HCl) and hydrofluoric acid (HF) maceration to dissolve carbonate and silica particles. This also includes the treatment with acetic anhydride (CH 3CO) 2O and sulfuric acid (H2SO4) to eliminate labile organic matter. The techniques were aimed largely at removing the non-pollen materials in the sediment and concentrating the palynomorphs as much as possible. Samples were stored using 100% glycerine to prevent the palynomorphs from drying out. Slides were prepared for quantitative and qualitative microscopic analysis. The prepared slides were studied, i.e., scanned and counted, with the light microscope using an (*40) objective lens, and photomicrographs of selected palynomorphs were taken with a Moticam 2300.

### 2.1. Pollen type identification and nomenclature

Identifications of palynomorphs were achieved by using reference slides in the Palynology and Palaeobotany Laboratory, Department of Botany, University of Lagos, Akoka, Lagos. Similarly, palynomorphs were identified with and named after Alejandra et al. (2011); Nayar (1964); Kuyl et al. (1955); and Elsik and Ediger (1990). Those grains that could not be identified at all due to limited human knowledge are listed as unidentifiable.

### 2.2. Pollen spectra and diagram construction

The pollen spectra of the samples were constituted, and the percentage composition of each pollen grain and spore was calculated relative to a pollen sum (Lezine and Vergnaud-Grazzini, 1993). The approaches of Adeonipekun et al. (2015) and Adekanmbi et al. (2019) were followed in classifying the taxa into different phytoecological groups. The pollen diagram was constructed using Tilia graph computer software after Grimm (1991). The percentage composition of the recovered palynomorphs was used in the construction of the pollen diagram. Pollen zones were recognized based on the changes in abundance values of the recovered palynomorphs and the use of phytoecological groupings. Six phytoecological groups were made on the basis of the known present-day natural distribution of their parent plant habitats. The works of Sowunmi (1981), Durugbo et al. (2010), and Adeonipekun et al. (2015) guided the grouping.

### 2.3. Sedimentological Analysis

The lithology was done by washing the sediments with distilled water using a 63-m sieve. The sediments were oven dried, examined visually using a stereo binocular microscope, and described with the aid of the Munsel colour chart and American-Canadian stratigraphic code.

## 3. RESULTS AND DISCUSSION

The lithological data obtained from Atlas Cove on the Commodore Channel in Lagos State is represented as shown in Table 1. The pH and salinity results of the sediments are shown in Figure 2, and they varied considerably across sample depths. The concentrations of heavy metals are shown in Table 2. The recovered palynological assemblage consists of pollen, fern spores, and fungal spores. 1177 palynomorphs, which consist of 36 palynomorph types belonging to 22 plant families, were recorded. Among these, 2, 28, and 4 were identified at the familial, genus, and species levels, respectively (Table 3). The identified pollen and spore types and their percentage composition are enumerated in Table 2. The pollen diagram is presented in Figure 3. Twelve metallic elements were identified and their concentrations were known from the sediment sample collected (Table 2). The element was within the permissible limit for the natural concentration of marine water (EPA, 2002).

The recovery of low palynomorphs in this study location could be largely attributed to the soil type, which is sandy clay soil in the ratio 60:40. The large pore size of these grains makes oxidation possible, which leads to deterioration of the palynomorphs during burial.

**Table 1:** Summary of Stratigraphy of Atlas Cove core

| Depth (cm) | Soil colour | Texture |
|---|---|---|
| 0-3 | Brown | Fine detritus mud, medium compact, relatively fine sandy |
| 3-6 | Transition to grey brown | Clayish fine detritus mud, finer sandy |
| 6-9 | Grey | Fine sand |
| 9-12 | Light grey | Clay |
| 12-15 | Light grey | Clay and compact |
| 15-18 | Light grey | Clayish fine detritus mud, fairly soft, and rare plant remains |
| 18-21 | Light grey | Clayish fine detritus mud, fairly soft, and rare plant remains |
| 21-24 | Light grey | Clayish fine detritus mud, fairly soft, and rare plant remains |
| 24-27 | Darker | Clayish fine detritus mud, fairly soft, and rare plant remains |
| 27-30 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 30-33 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 33-36 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 36-39 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 39-42 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 42-45 | Light grey | Clayish fine detritus mud, very compact, fine sandy |
| 45-48 | Light grey | Sandy clay |
| 48-51 | Light grey | Sandy clay |

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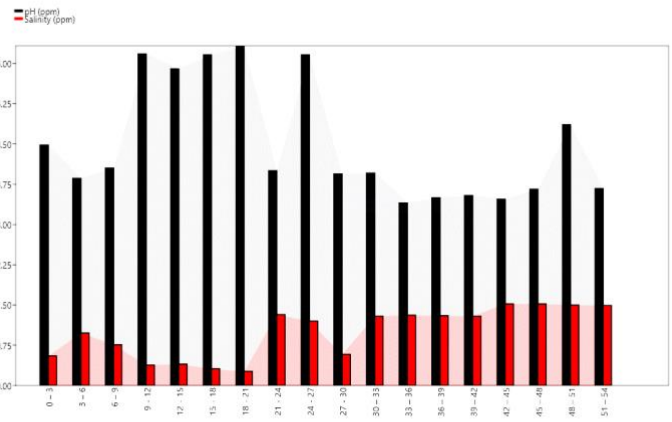


**Figure 2:** Values of pH and salinity of the sediments across sample depths

Pipeline vandalism is a major environmental issue in Atlas Cove, resulting in pollution of the air, water, and soil. Kakulu (1985) investigated Nigerian crude oil and discovered high concentrations of heavy metals such as Fe, Zn, Cu, Pb, and Hg. Human activities such as pipeline vandalism expose the Atlas to high concentrations of petroleum-related heavy metals. Heavy metal concentrations in the topmost sediment included Co, Cd, As, Sc, Pb, Ni, Cr, Cu, Zn, Mn, Fe, and Al. The highest concentrations are Al and Fe, while the lowest concentrations are Co and Cd. Heavy metal concentrations were generally low, with the exception of Al and Fe, which have concentration levels above 200 g/mL. The low concentration is likely linked to the presence of plants that have phytoremediation properties. Doni et al. (2013) used *Paspalum vaginatum* and *Tamarix gallica* to remove heavy



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metals and hydrocarbon pollutants from dredged marine sediment, including nickel (Ni), cadmium (Cd), zinc (Zn), copper (Cu), chromium (Cr), and lead (Pb). The majority of the plant taxa reported in each depth are likely to be capable of phytoremediation. This assertion is based on the heavy metals results, which indicate that despite the pollution level witnessed onsite, the heavy metals were still within the permissible limits.

**Zone A: 0-3cm**

The depth of the zone ranges from 0 to 3 cm. The zone's sediments are brownish to grey in colour, with a sandy clay texture. With a pH range of 4.6–6 and a salt content of 0.5-0.75 ppm, the sediment is slightly acidic. Mangrove swamp forest taxa found in the zone include *Rhizophora racemosa, Paspalum vaginatum, Acrostichum aureum, Poaceae, Cimbopogon citratus, Pteris* sp., *Kyllinga erecta,* and Laevigate spore. The presence of *Rhizophora racemosa* and *Acrostichum aureum* confirms the current vegetation of the site. The predominance of typical mangrove taxa in this zone indicates sediment deposition in a marginal mangrove-marine environment with frequent freshwater incursions due to flooding caused by excessive rainfall. The high representation of *Rhizophora* and *Acrostichum* pollen in this zone, on the other hand, was most likely due to major local, long-lived transgressions between the mangrove vegetation and the coastal line, which were 15 to 20 meters apart. The presence of *Zea mays* pollen is direct botanical evidence that the inhabitants engaged in farming activities. The recovery of charred Poaceae cuticle seemingly resulted from an anthropogenic bush burning during this period. Osayi et al. (2012) recorded a high influx of charred Poaceae cuticles, attributed to increased bush burning activities in their study area. Essien and Aniama (2014) also pointed out that the presence/abundance of charred Poaceae cuticle and fungal spores is indicative of anthropogenic activities on the local vegetation of an area.

**Zone B: (3-12cm)**

The zone's sediment is light grey fine clay with rare plant remains such as *Cimbopogon citratus, Kyllinga erecta,* Polypodiaceae, Poaceae, *Asystasia gangetica, Cyclosorus afar*, and Laevigate spore. At this depth, there was a significant increase in *Rhizophora racemosa, Cyclosorus afar*, and Pteris sp., indicating a rise in sea level and the recovery and re-establishment of the mangrove. These occurrences suggest that the sea is rapidly infiltrating the plains and that mangrove habitats are expanding. The slight increase in Poaceae (open vegetation) and secondary forest species (*Alchornea cordifolia*) suggested that there were gaps or openings in the forest vegetation. The presence of freshwater species (Cyperaceae and *Eichhornia crassipes*) was minimal. This corresponds to the introduction of *Elchornnia crassipes* into Nigerian territorial waters as a result of shipping activities. Avicenna was poorly represented, indicating that the mangroves were located further away from the coast. This phenomenon may be associated with a lower relative sea level. Because it naturally occupies elevated areas behind the Rhizophora zone, *Avicennia* may have been unaffected by sea level rise (Vedel et al., 2006). Furthermore, *Avicennia*, which is pollinated by insects, produces very little pollen (Behling et al., 2004). According to research, *Avicennia* pollen levels are low even in the immediate vicinity of parent trees, it is poorly dispersed in the atmosphere, and it is not transported over long distances (Lezine et al., 2002). This explains why it has a low representation in the pollen record. The high concentrations of smooth monolete spores like *Cyclosorus afar*, Laevigate spore, and Polypodiaceae indicate that the study area was wet and warm during this phase.

**Zone C: (12-21cm)**

This zone ranges in depth from 12 to 21 cm. It is composed of light grey, clayish, compact sand. The pH is 3.45-4, indicating that it is slightly acidic, and the salt content is 0.75-0.5 ppm. *Asystasia gangetica, Alstonia congensis, Rauvolfia vomitoria, Cyperus* sp., *Kyllinga erecta, Rhizophora racemosa, Acrostichum aureum,* Polypodiaceae, *Paspalum vaginatum, Pteris* sp., *Alchornea cordifolia,* and *Eichhornia crassipes* dominated this zone. Poaceae were fairly abundant in this zone, indicating that grasses may have been abundant in the mangrove swamp's immediate vicinity. *Asystacia gangetica, Alchornea cordifolia,* and *Paspalum vaginatum* have all been observed colonizing open or exposed swampy areas, particularly in mangrove swamp forests. Cyperaceae were abundant during this time period. In other words, the environment was open but also had some swampy conditions. Pteridophyte spores were found to be stable, followed by a decrease in *Acrostichum aureum*, which could be attributed to decreased wet conditions, but human impact could have obliterated the natural factors, making it difficult to determine what caused the fern spores to decrease.

Furthermore, the abundance of *Acrostichum* for the majority of this zone indicated that salinity was high and that freshwater was not introduced into the area. This is due to the fact that *Acrostichum aureum* is West Africa's only known salt-water fern (Keay, 1959). The abundance in the study area is indicative of a high level of salinity, which allows them to thrive. There was an increase in lowland rain forest taxa (*Alstonia congensis*) and a sharp decline and sudden increase in *Rhizophora racemosa* representation. *Eichhornia crassipes* was barely present but not significant, and it was only found in this and the previous zone.

**Zone D: (21-30cm)**

This zone has a depth of 21-30 cm. It is made up of light grey sandy clay with a pH range of 3.95 to 5.25 and a salt content ranging from 1 to 50 ppm.



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**Table 2:** Composite spectra of identified pollen and spores across sample depth

| | Sample Depth (cm) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **3** | **6** | **9** | **12** | **15** | **18** | **21** | **24** | **27** | **30** | **33** | **36** | **39** | **42** | **45** | **48** | **51** | **R/F** | **%** |
| *Asystasia gangentica* (Acanthaceae) | - | - | 23 | - | - | 1 | 2 | 1 | 4 | 12 | 23 | 4 | 11 | 21 | 34 | 9 | - | 8 | 153 | 13.00 |
| *Avicennia germinans* (Acanthaceae) | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.08 |
| *Agave sisalana* (Agavaceae) | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.08 |
| *Alstonia congensis* (Apocynaceae) | - | - | - | - | 19 | 1 | 1 | 14 | - | 14 | 16 | - | 1 | - | 20 | 22 | 15 | - | 123 | 10.45 |
| *Rauvolfia vomitoria* (Apocynaceae) | - | - | - | - | 14 | - | - | - | - | - | 1 | 15 | - | - | - | 1 | - | - | 31 | 2.63 |
| *Elaeis guineensis* (Arecaceae) | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.08 |
| *Cocos nucifera* (Arecaceae) | 5 | - | - | - | 1 | - | - | 1 | - | - | - | 1 | - | - | - | - | - | - | 8 | 0.68 |
| *Casuarina equisetifolia* (Casuarinaceae) | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.08 |
| *Symphonia globulifera* (Clusiaceae) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - | 2 | 0.17 |
| *Ipomoea aquatic* (Convolvulaceae) | 1 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 3 | 0.25 |
| *Cyperus esculentus* (Cyperaceae) | 1 | - | - | - | 1 | - | - | - | - | - | 13 | - | - | - | 1 | 1 | - | - | 17 | 1.44 |
| *Cyperus* sp. (Cyperaceae) | - | 1 | - | - | 1 | 1 | - | 1 | - | - | 12 | | - | - | - | - | 1 | - | 17 | 1.44 |
| *Kyllinga erecta* (Cyperaceae) | 17 | 1 | - | - | - | - | - | 15 | 1 | - | 16 | 12 | - | 1 | 1 | 6 | 1 | - | 81 | 6.88 |
| *Mariscus alternifolius* (Cyperaceae) | - | - | - | - | - | - | - | - | - | - | - | 1 | - | | - | - | - | - | 1 | 0.08 |
| *Alchornea cordifolia* (Euphorbiaceae) | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 2 | 0.17 |
| *Centrosema pubesens* (Fabaceae) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 0.08 |
| *Equisetum* sp. (Equigsetaceae) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 7 | 8 | 0.68 |
| *Paullinia pinnata* (Sapindaceae) | - | 3 | 1 | - | - | - | 1 | - | - | - | - | 1 | - | - | - | - | 1 | - | 7 | 0.59 |
| *Syzygium guineense* (Myrtaceae) | - | - | - | - | 1 | - | - | - | | 2 | 1 | 2 | - | - | - | - | - | 9 | 14 | 1.19 |
| *Nephrolepis biserrata* (Nephrolepidaceae) | - | - | - | - | - | - | 1 | 1 | - | - | 1 | - | - | - | - | 14 | 1 | - | 18 | 1.53 |
| *Nymphaea lotus* (Nymphaeaceae) | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 0.08 |
| *Polypodiaceae* | 1 | - | - | 1 | 13 | 1 | - | 1 | - | 1 | 1 | - | 15 | 14 | 13 | 15 | 17 | - | 93 | 7.90 |
| *Zea mays* (Poaceae) | 5 | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - | 8 | 0.68 |
| Charred Poaceae cuticle (Poaceae) | - | 1 | - | - | - | 1 | - | 1 | - | - | - | - | - | - | 1 | 1 | - | - | 5 | 0.42 |
| *Nigrospora* sp. | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - | 1 | - | - | 3 | 0.25 |
| Poaceae | 22 | 16 | 1 | - | 1 4 | - | 1 | 1 | - | 1 | - | 1 | - | 1 | 1 | - | 7 | - | 66 | 5.61 |
| *Paspalum vaginatum* (Poaceae) | 14 | - | - | 12 | 9 | 1 | - | - | 15 | - | - | 13 | - | - | - | 14 | - | - | 78 | 6.63 |
| *Cimbopogon citratus* (Poaceae) | 22 | 14 | - | - | 16 | 14 | - | - | - | 35 | 26 | - | - | - | 1 | 17 | 15 | - | 160 | 13.68 |
| *Eichhornia crassipes* (Pontederiaceae) | 1 | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | - | - | - | 5 | 0.42 |
| *Acrosticum aureum* (Pteridaceae) | 13 | - | - | 11 | - | - | - | 12 | 2 | 3 | - | 5 | 1 | 1 | 1 | 1 | 3 | - | 53 | 4.50 |
| *Pteris* sp. (Pteridaceae) | 21 | - | - | - | - | - | - | 4 | - | - | - | 1 | - | - | - | - | - | - | 26 | 2.21 |
| *Rhizophora racemosa* (Rhizophoraceae) | 2 | 6 | 11 | 23 | 1 | 1 | 16 | 1 | 1 | 12 | 44 | 1 | - | - | - | 1 | 11 | 4 | 135 | 11.46 |
| *Cyclosorus afer* (Thelypteridaceae) | 1 | 1 | - | - | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | 19 | 1.61 |
| *Typha australis* (Typhaceae) | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 0.17 |
| Septate spore | - | - | - | - | - | - | - | 1 | - | - | 13 | - | - | - | - | - | - | - | 14 | 1.19 |
| Laevigate spore | 17 | - | - | 1 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 19 | 1.61 |
| **Total** | | | | | | | | | | | | | | | | | | | **1177** | |



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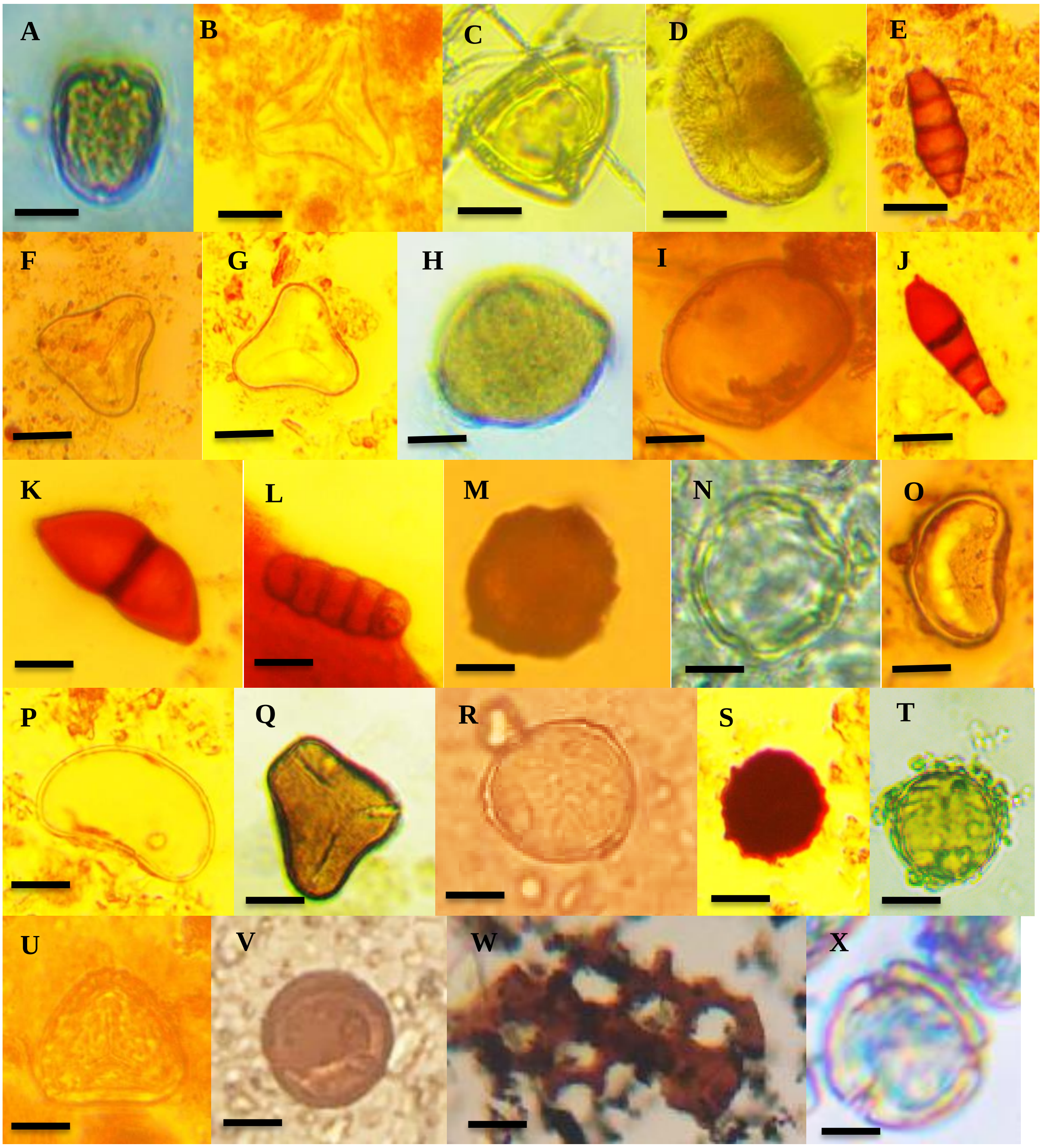


**Plate 1**: (a) *Kyllinga erecta* (b) *Elaeis gineensis* (c) *Nymphea lotus* **(**d) *Asystasia gigentica* (e) Fungi spore **(**f-g) *Elaeis gineensis* (h) *Centrosema pubescens* (i) *Zea mays* (j-l) Fungi spore (m) *Avicennia* sp. (n) *Ipomea* sp. (o-p) Polypodiaceae (q) *Acrosticum aureum* (r) *Casuarina equisetifolia* (s) *Nigrospora* sp. (t) *Paulinnia pinnata* (u) *Pteris vitata* (v) *Rhizophora* sp. (w) Charred poaceae cuticle (x) *Alchornea cordifolia* Scale bar: 10um.



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**Table 3:** Heavy Metals Concentration and Intensity in Topmost Sediment Sample

| S. N | Element | Flags | Concentration (Units g/mL) | Intensity | CLEA |
|---|---|---|---|---|---|
| **1.** | Fe 238.204 | x | 247.3402557 | 9439285 | |
| **2.** | Cu 327.395 | 0 | 0.737288058 | 39733.70313 | Not available at present |
| **3.** | As 188.980 | 0 | 0.0480299 | 92.29455566 | 640mg/kg |
| **4.** | Pb 220.353 | 0 | 0.43372342 | 1628.976563 | 2300mg/kg |
| **5.** | Zn 213.857 | 0 | 1.590512753 | 47374.26953 | Non available at present |
| **6.** | Cr 267.716 | 0 | 0.561541975 | 27719.38867 | 5000mg/kg |
| **7.** | Se 196.026 | 0 | 0.061138976 | 74.11196136 | 1300mg/kg |
| **8.** | Ni 231.604 | 0 | 0.519989431 | 3560.740967 | 1800mg/kg |
| **9.** | Mn 257.610 | x | 5.772631168 | 1259052.875 | |
| **10.** | Co 238.892 | uv | -0.253584743 | -2464.240479 | |
| **11.** | Cd 214.439 | uv | -0.046513852 | 444.3538818 | 410mg/kg |
| **12.** | Al 396.152 | x | 247.727066 | 12114316 | |

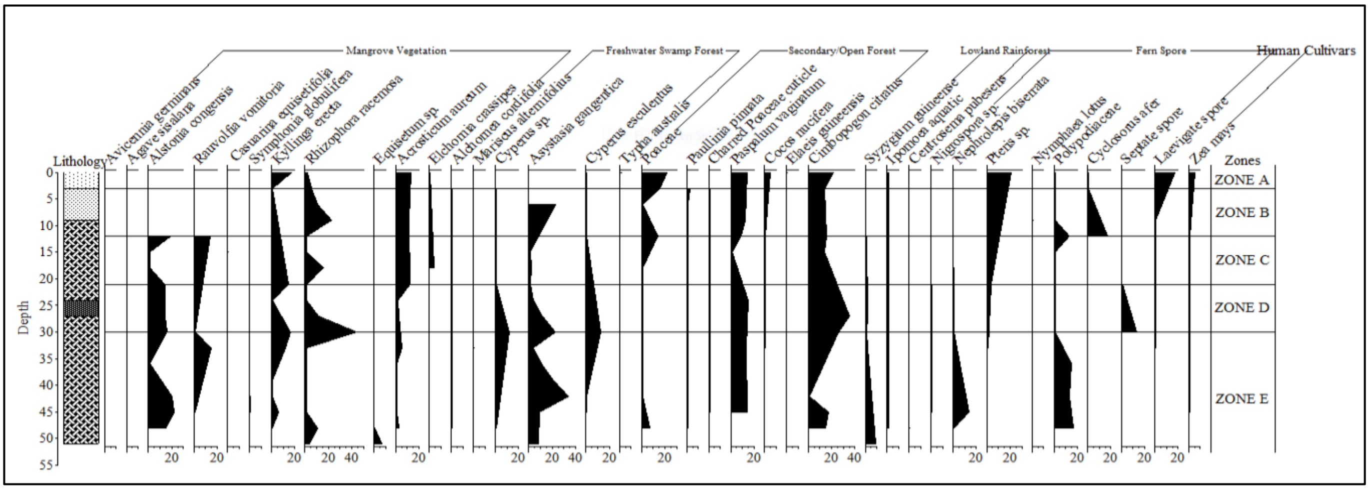


**Figure 3:** Pollen diagram showing representative of plant taxa

Freshwater pollen (*Cyperus* sp., *Kyllinga erecta,* and *Pteris* sp.) was also found, lending support to the inferred wet period. During the same time period, Rhizophora reached its peak, implying a rise in sea level, but it only increased slightly and remained stable. Sowunmi (1987) also reported a peak in *Rhizophora* as well as a re-appearance or significant increase in other groups, most notably the rainforest species, at subsection 9.80 m - 6.60 m of a sampled core in Nigeria's Niger/Delta. These occurrences point to the sea's rapid transgression and the expansion of mangroves, which have encroached on much of the lowland rainforest area. *Acrosticum aureum, Rauvolfia vomitoria, Cyperus* sp., *Kyllinga erecta,* and *Pteris* sp. witnessed a sharp decline and marked increase, it appears that there was a minor and brief period of wetness, as evidenced by the sharp decline and marked increase of both fresh water swamp and fern spores. The characteristic lithology of over 90% clayish fine detritus mud, very compact, fine sandy could have resulted from the transgressive stage during the transition between the two successive depositional phases.



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**Zone E: (30-51cm)**

In this zone, *Rhizophora*, *Avicennia*, and *Acrostichum* were greatly reduced. Human-caused felling and reduced salinity are two major factors affecting mangroves. The mangrove taxa fluctuated, but the relatively low *Rhizophora* values indicated that the mangrove swamp forest had declined dramatically. Reductions in mangroves caused by rising sea levels are usually followed by an increase in freshwater swamp forest species, as was the case in Ahanve, Nigeria (Sowunmi, 2004). Even though Poaceae increased, there is no pollen evidence of human presence in this zone; there were also no significant increases in anthropogenic indicators such as Alchornea sp. As a result of the pollen evidence, the drastic decreases in *Rhizophora* and other mangroves were not caused by anthropogenic factors. The relatively high percentages of *Alchornea*, on the other hand, indicate human presence at the site. This zone was dominated by *Syzygium guineense*, indicating that it was more of a secondary forest than a closed wet forest. Human activities such as bush clearing and agriculture promote the spread of weeds and plants associated with human habitations where humans are present. No pollen from weeds or those associated with human habitations was recovered at this level. As a result, even if humans were present at the time, their impact was minimal. Human activities may have contributed to landscape alteration and transformation, preventing mangrove re-establishment and favouring their replacement by secondary forest and coastal vegetation. The decrease in fresh water inflow into the site did not last long enough, and as a result, conditions favourable to the development of the mangrove swamp forest were not fully realized.

## 4. CONCLUSION

In this study, the palynomorph assemblages were not diverse, and pollen recovery was generally low. The palynological data show that some of the recovered fossil palynomorphs' parent plants are still present as extant plants in the study site. This demonstrates the extent to which these plants have survived despite anthropogenic activities in this area over time. More research is needed to determine how some of the plants can be tested for phytoremediation potential. Mangrove swamp forests should be protected at all costs. Appropriate legislation governing mangrove swamp forest reserves should be reviewed and strengthened. The federal and state governments should work together to fund university research in this field. The results of such efforts should be incorporated into a project to sustain mangroves.

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