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Palynological and Lithological Investigation of Forensic Materials at the University of Lagos, Nigeria: First Experimental Palynological Approach in Nigeria

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Abstract

Security agencies are always saddled with huge responsibilities of trying to establish evidences to link a suspect to a particular crime. But in most cases, there are always very limited physical evidences due to the complexity of the crime. However, forensic palynology provides a very good option, because pollen and spores from plants are very minute, ubiquitous in distribution and are seldom useful in recovery of vegetation of a certain locality. This present study aims to assess the feasibility of pollen, spores, and sand grains as associative evidences recovered from a suspect linked with a crime scene. Forensic materials including soil samples from foot wear, dirt from clothes, earlobes and nostrils were retrieved from the body of a suspect at a particular location in Nigeria. The retrieved materials were subjected to standard laboratory palynological, biochemical and lithological procedures. The dionex analysis (anion) and atomic absorption spectrometry (cation) shows great similarity in the results obtained with an exception to Zinc. A considerable similarity was observed in the potential of hydrogen and salinity values of soil samples from both the suspect and crime scene. The lithological data reveals a great correlation in the colour, grain size, grain sorting, and grain texture and grain shape of these two different soil samples. The palynological analysis yielded a recovery of palynomorphs including pollen of *Elaeis guineensis, Alchornea cordifoliia, Cassia fistula, Syzygium guineense, Cyperus papyrus, Pteris* species and *Nephrolepis biserrata* were also recovered. This reveals the potential of retrieved materials from the body of a suspect as good sources of pollen and spores. It is however important to corroborate the use of palynomorphs and sand grains with other lines of evidences in solving crime-related disputes.

Keywords: Crime; Scene; Lithological; Nigeria; Retrieved; Security; Palynological

Introduction

Security is vital for national cohesion, growth, political stability and sustainable developments. The present-day Nigerian society is overwhelmed by dreadful acts of kidnapping, cattle rustling, militancy, terrorism, communal clashes, boundary disputes, cultism, robbery, human and drug trafficking. The alarming level of these crimes in different geopolitical zones, pose a serious threat to the nation's economic growth. This level of crime can be linked to the use of hard drugs and alcohol, lack of proper education, influence of media/environment, unprecedented levels of corruption, and state of origin/indigenship syndrome, porosity of the borders, unemployment, weak judicial system, injustice, nepotism and a culture of impunity. However, the security agencies are always saddled with the responsibility of carrying out investigation. Unfortunately, the majority of criminal investigations carried out by the Security agencies are conducted by the officers below the rank of sergeant. Most of these constable investigators have only gone through the basic three-month entry training at the Security College, where the most significant part of their training is centered on physical drills with lesser attention on the art of investigation. The knowledge and skills of practical criminal investigation are left for the officer to discover and learn while on the job, and despite the fact that they are still neophyte, they are allowed to handle complex investigations. With these loopholes, significant numbers of offenders have cheated the justice system by escaping punishment due to incomplete or incompetent criminal investigations, leading to insufficient evidence upon which the courts can base a conviction. Criminal investigation is so significant to the entire criminal justice system that its absence, tardy or shoddy execution may lead to a delay in the administration of justice, the victimization of innocent citizens and escape of offenders from paying for their misdeeds and being reformed. On the 16th of July 2018, the Nigeria prison services reported that the total population of inmates stood at 72,631, those convicted was put at 23,472 (32%), while those awaiting trials for different offenses were put at 50,159 (68%). The increase in the numbers of awaiting trials of inmates could be associated to lack of evidences upon which the court can base a conviction. Therefore, there is a need to corroborate the use of biological evidences with other lines of investigations in solving crime-related disputes, especially in Lagos, Nigeria [1]. Forensic science is used to assist authorities in identifying evidentiary materials and their relationship to the scene of crime.

Palynology is a valuable forensic tool given the characteristics of pollen: they are microscopic in size, resistant to decay, can survive in sediments for many years, can remain on surfaces or objects for long periods of time, and sometimes can be identified to species level [2]. The particular pollen types can provide a locality of origin based on the plants that produced the pollen. This may allow persons or objects of interest to be linked through their movements from one location to another [3]. There have been a number of cases that have utilized this discipline as a forensic tool. These cases include crime such as common assaults, sexual assaults, kidnapping and murder; as well as civil cases involving the fields of geology and geography for example evidence for climatic change [4].

One of the earliest reported cases using palynology occurred in Sweden in 1959. A woman was killed in May during a trip in central Sweden. Palynological examination of evidentiary soil samples from crime scene proved that the murder took place elsewhere because the dirt lacked pollen grains from plants common in the area where the body was found. It was also proved that murder took place in May because the season of pollination of Plantago and Rumex during that time was over. Later, during the 1960s and 1970s, a Swiss criminalist Max Frei also utilized pollen grains as forensic evidences to link suspects to crime scenes [5]. Reported a case of murder after kidnapping and sexual assault [6]. In this case, pollen fingerprint from the woman's shorts was found identical to the pollen fingerprints extracted from the suspect's sweater and soiled pants. In another case, illegal shipment of cocaine hydrochloride was seized in New York City and later pollen grain data showed that the cocaine was originated and processed in South America and then smuggled into some northern areas of United States [7]. Research on pollen rain dispersal in a forensic context has been carried out in New Zealand, United Kingdom and the United States of America [3]. Showed the significance of pollen evidence to assist the court. He proposed the likelihood ratio in forensic palynology to assess the significance of their evidence to assist the court in determining the guilt or innocence of the defendant [8]. To assist his findings, he presented three cases of alleged rape establishing the time of death. Compared soil from shoeprints and the shoes that made the prints. It was found pollen assemblages were significantly similar [9]. Compared pollen assemblages obtained from an alleged crime scene, an alibi scene and the victim's and suspect's clothing [10]. Although it was found that the alleged crime scene and the alibi scene contained different pollen assemblages, the amounts of similar pollen types were significant.

Compared samples from a suspect's clothing and shoes with the alleged crime scene [11]. It was found that it was highly likely that the suspect had been at the alleged crime scene owing to the strong correlation in the pollen assemblage and percentages between the samples obtained. Reported that palynomorphs can be used to estimate time of death for an individual/s [12]. By analyzing the contents of a deceased's stomach, it is possible to ascertain what food they may have ingested prior to death, and how long before death those foods were ingested given the rate of digestion. Alibis can be verified by correlating the pollen on clothing worn by suspects at a particular time with pollen found at the crime scene [6]. Reported that botanical evidences may be used to link suspects, victims, crime scenes and objects using four-way linkage theory: suspect, evidence, victim and scene [13]. The majority of literature pertaining to forensic palynology reports casework and how forensic palynology can be used, but little empirical research has been conducted and published [14]. Also, highlights the way in which Hypericum pollen was able to provide a 'link' to a location where there was an alleged case of sexual assault [15], which focused on elemental compounds such as carbon and nitrogen and highlights the importance and potential that soil analysis has as evidence in both civil and criminal investigations. Adding to this type of forensic evidence, palynology can assist in identifying a geographical area of interest based on the types and percentages of pollen found in a particular location. A correlation between the clothing samples and the alleged crime scene could be identified [16].

A study conducted by [28] indicates the potential use of 'elemental peak height ratios' (a measurement tool) in soil samples with regards to the identification of geographic areas [17]. The basis behind this concept is to match specific elements that make up the composition of different soil types. These are then compared and used to either match or discount particular geographic areas. Examined the retention of pollen on clothing after several days of wear and washing [18]. Pollen grains and spores trapped in the engine air filters of vehicles can be used to trace the routes taken by vehicles [19]. The parcels used in wrapping illegal drugs can trap pollen grains and spores which can reveal the producers' location and the distribution routes of illegal drug dealers [20]. Indicated that pollen analysis was applied to a mummified homicide victim in Nebraska, U.S.A, to determine the location of death [21]. Established the detection of contact traces of powdery substance in linking suspects and crime scenes [22]. Currently, forensic palynology was used as associative evidence in Bella Bond also known as Baby Doe murder case in the U.S.A [23]. This research study is to achieve certain intents which are designed to prove or disprove an alibi, study the vegetation reconnaissance of the crime scene, establish a link between the suspect and the crime scene, relate an item left at a crime scene to the suspect and relate an item found on the suspect to the crime scene.

Materials and Methods

Study Location

The study was conducted at the University of Lagos Campus in Collaboration with the Institution Security Unit. The coordinate of the crime scene is N6°31'4.3 and E3°23'53.2 (Figure 1). The crime scene is situated in the South-western part of Nigeria. The climate of the area is tropical with distinct wet and dry seasons; an average wind speed of 10.8kmph, a mean annual rainfall of 220mm and a temperature range of about 23 °C - 33 °C. The area is dominated by two main seasons (the rainy and dry seasons) with the rainy season characterized by two wet periods (Figure 2). The first wet period lasts between April and July while the second 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. The Institution is surrounded by the Lagos Lagoon and it's characterized by distinct plants from different ecological zones in Nigeria (Figure 3).

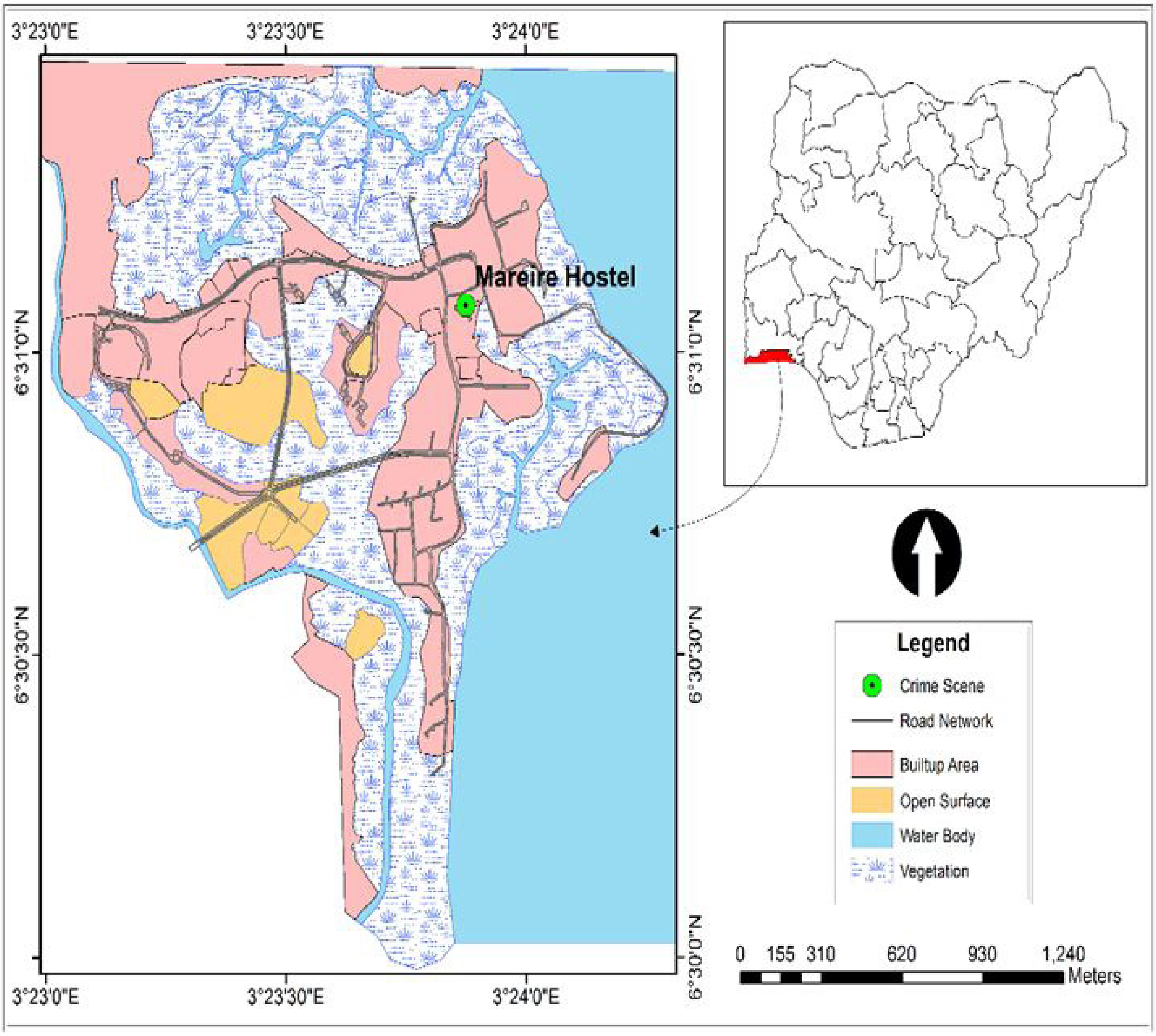

Figure 1: Map showing the crime scene, University of Lagos, Nigeria

Figure 2: Hall of residence/ Crime scene

Figure 3: First entrance of the crime scene

Intensive field assessments were conducted around the crime scene; Trees were enumerated in 50 x 20 m plots, while 0.5 x 2 m quadrant was used to study herbs, climbers and grasses. Samples were collected at random within each plot, and identified and their relative abundance determined by describing their quantities of representation. Life forms of plants considered in the identification were trees, shrubs, ferns and herbs. The current vegetation of the site sample is includes predominantly an open forest which includes *Andropogon gayanus, Drepanocarpus lunatus, Mimosa pudica, Luffa cylindrica, Mariscus alternifolia, Cassia alata, Spigelia anthelmia, Eleusine indica, Brachiaria deflexa, Saccolepis africana, Emilia coccinea, Scoparia dulcis, Delbergia castaphyllum, Vernonia cinera, Phycus* species, *Ipomea carica, Vernonia amygdalina and Alchornia cordifolia.* The vegetation is also represented with dominance of *Mangifera indica, Terminalia catappa, Elaeis guineensis, Tridax procumbens, Gomphrena celosoides, Cyperus rotundus, Borreria species, Paspalum viginatum, ficus species, Phyllantus species, Azardiractha indica, Euphorbia hirta, Bidens pilosa, Panicum maximum, Digitaria horizontalis, Cynodon dactylon, Ixora parviflora, Triumffeta cordifolia, Synedrella nodiflora, Acalypha ciliata, Commelina benghalensis, Mariscus alternifolis, Paspalum orbiculare, Setaria parviflora, Albizia zygia, Setaria barbata, Parkia biglobosa, Cassia fistula, Ixora parviflora.*

The crime scene was evaluated before anyone entered, which was a key to keeping contamination to a minimum level (Figure 4). Experimental samples were collected from suspect shoes, cloths, nostrils, ears and hair. While the control samples were also collected using "Pinch method" at the common room where the crime occurred and surrounding areas because of the high amount of dirt and dust. This was done by selecting an area about 10 to 50 meters square and walking back and forth collecting pinches of dirt throughout the crime scene. Each pinch of dirt was combined into a single, sterile, plastic bag and then sealed (Figure 5). This idea of combining all pinches of dirt was to prevent the possibility of over- representation of a single pollen type. Research as shown that test using pinch method is needed for each control sample before their combined dirt yields a reliable pollen assemblage of the regional flora. Generally, collection of 10 to 20 pinches of dirt per control sampling location was sufficient to ensure an accurate sample (Figure 6).

Figure 4: Second entrance of the crime scene

Figure 5: Showing the scene of crime

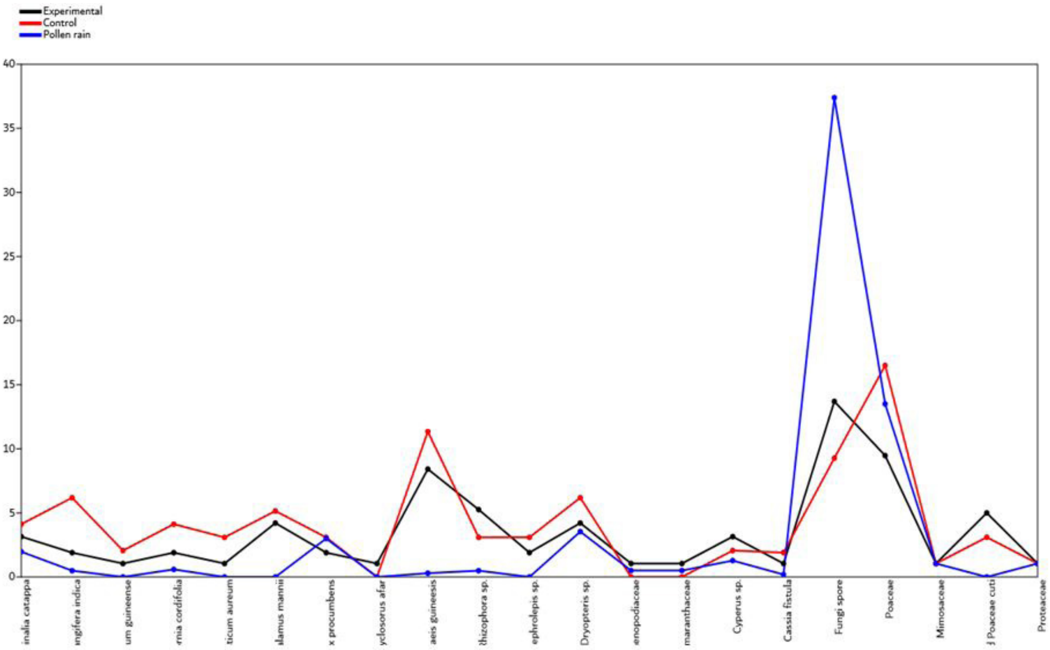

Figure 6: Showing auto correlation of recovered palynomorphs between the crime scene, suspect and pollen rain

Case Background

On the 29th of March 2017 at 6:15pm, a suspect (named withheld) was apprehended by the University of Lagos security unit in connection with a missing gadget in the common room at Mariere hall of residence in the University of Lagos, Akoka. The victim said he was trying to take a rest when he suddenly fell asleep, only to wake up without the presence of his gadget. The suspect claimed that he was not a student that he usually come into the school premises to wash vehicles as a source of livelihood at the faculty of education close to the first entrance of the institution. He also claimed that he was never in the said location at that particular time where the crime was committed. During the process of his arrest, when the suspect was trying to evade arrest a pair of slippers belonging to him was found at the crime scene. He was later taken to Sabo Police Station for further investigation. Also, forensic materials were retrieved from his slippers (sediment), nostrils, ear lobes (wax), and clothes.

Palynological analysis

Samples were subjected to standard palynological treatment, according to [24]. Samples were retrieved from suspects as well as the crime scene in sterilised plastic bags and then stored in tightly closed sterilised containers with a small amount of alcohol (70%) to avoid microbial growth and then frozen. The control and experimental samples were placed into 10 ml test tubes and washed using distilled water by centrifugation and decantation to remove alcohol. 10% potassium hydroxide (KOH) solution was added to the residue, warmed (70 °C) for 15 minutes and stirred occasionally. This step breaks up the matrix (deflocculation) and dissolves humic materials. The residue was washed again using distilled water by centrifugation and decantation. Next, 0.1 ml solution of sodium pyrophosphate was added, stirred and placed in boiling (100 °C) water bath for 20 minutes, centrifuged for 5 minutes and then decanted. The process was repeated twice. Distilled water was then added, stirred, centrifuged and finally decanted. This step is usually required only for soil samples in order to remove clay (fine mineral particles, mainly silica) as a high concentration of clay on prepared slides causes cloudiness and hinders pollen identification. After that 10% hydrochloric acid (HCl) was added to both control and experimental sample. Then leaving it for 24 hours before stirring, centrifuged using distilled water at 3000 r.p.m for 5 minutes and finally the supernatant was decanted. The process was repeated twice. This step removes carbonates which can cause a reaction with the reagent used in the last step which can be potentially dangerous to the user [25]. Forensic materials retrieved from suspects clothing and proboscis were treated with acetolysis mixture (acetic anhydride and concentrated sulfuric acid in v/v = 9:1). Acetolysis removes cellulose, a common plant polysaccharide. The solution was placed in a boiling (100 °C) water bath for 5 minutes, centrifuged and finally decanted. Slides were prepared using the method of [26]. Samples were then stored in 100% glycerin to prevent the palynomorphs from drying out. From stock mixture, samples were collected and mounted on slides and studied under x40 objective lens magnification using an Olympus light microscope.

Taxonomic Identification

Some pollen albums, relevant journals [8,33-35] and pollen reference slide collection in the Palynology and Palaeobotany Laboratory, Department of Botany, University of Lagos was used. Photomicrography of some of the identified palynomorphs was taken with the aid of a Motic 2300 digital camera.

Lithological Analysis

The lithological analysis was done by washing the sediments with distilled water using a 63 µm sieve. The sediments were oven dried, examined and described with the aid of Grain Size Analyser and Colour Chart, using a stereo binocular microscope and hand-held magnifying lens at X40 magnification.

Soil Salinity and Potential of Hydrogen Test

Five grams of the samples were weighed and dissolved in 50 ml of distilled water to form a suspension. The samples were thoroughly stirred and allowed to stand for six hours to allow the dissolution of ions and salt content of the sediments. A salinity probe (La Motte pH/Conductivity /TDS/Salinity Meter Tracer Pocketester Code 1766) was then used to measure the salinity and pH values of each sample.

Chemical Analysis

Digestion of Samples: Two grams of samples was weighed into a digestion flask, 10ml of nitric acid was added. The mixture was evaporated on a Q-Block digestion for 2 hours. Then it was allowed to cool at room temperature and add up to 25ml mark with mileQ water. It was then filtered with filter paper and funnel into a white plastic bottle ready for Atomic Absorption Spectrophotometer. The analysis was done using- Buck model 210VGP which is designed to measure the concentration of elemental metals in solution.

Results

In this study, a total of 21 palynomorphs (pollen, spores, and fungal spores) were recovered in the analysis (Table 1). The palynological data obtained revealed that a total number of 20 recovered palynomorphs from the forensic materials found at crime scene, while 21 palynomorphs was also recovered from the suspect. The recovered palynomorphs assemblage of both samples includes pollen of *Elaeis guineensis, Mangifera indica, Terminalia catappa, Syzigium guineensis, Cyclosorus afar, Alchornea cordifolia, Acrostichum aureum, Oncocalamus mannii, Pterismanniana, Cyperus papyrus, Albizia zygia and Tridax procumbens.* Some were identified to species level; *Protea* species and *Rhizophora* species Others were identified to family level; which include pollen of Poaceae, Chenopodiaceae and Amaranthaceae. Fungal spore and charred poaceae cuticle were also recovered. There was drastic decline in representation of the recovered palynomorphs for both samples which was recorded in Proteaceae (1.05%), Mimosaceae (1.05%), *Cassia fistula* (1.05, 1.9%), Chenopod/Amaranth (1.05%), *Tridax procumbens* (1.9%), *Acrostichum aureum* (1.05- 4.12%), *Alchornea cordifolia* (1.9-4.12%), *Syzigium guineensis* (1.05-2.06%). Large amounts of fossil pollen with botanical affinities assigned to tropical rain forest plants and fresh water swamp species were recovered in both samples such as *Mangifera indica* (1.9%, 6.18%), *Terminalia catappa* (3.15%, 4.12%), *Oncocalamus mannii* (4.21, 5.15%), *Elaeis guineensis* (8.42%, 11.34%), *Nephrolepis species* (1.9%, 3.09%), *Dryopteris species* (4.21%, 6.18%), Poaceae (9.47%, 16.5%) and Charred Poaceae cuticle (5.6%, 3.1%) (Table 2).

The results of potential of hydrogen and salinity analysis of the recovered sand grains showed a generally acidic setting ranging from 4.40-4.60 for conductivity, while 5.30-5.44 for potential of hydrogen (Table 3). These values fall within the range considered to be conducive for palynomorphs preservation since samples with high alkalinity values limit the preservation of pollen grains and spores, as reported by who suggested high alkalinity as one of the major causes for the paucity of pollen [31]. The lithological analysis revealed an alternation between mudstones and sand (Table 4). The lithological properties are light grey, fine-grained angular and very well sorted sandy bodies indicating the long-distance movement of the deposited sediment. The textural features varied from sub-angular to rounded, moderately well sorted with abundant carbonaceous detritus and ferruginous materials indicating these sand bodies have been deposited under continental environments. The lithological analysis for control and experimental samples for grain colour revealed light brown and dark brown respectively.

S/N	Parent Plants of Palynomorphs	Family	(Suspect//Ear/Nose/Clothes /Shoe) (experimental)	Crime Scene (Control)	Pollen Rain	Ecological group
1.	*Terminalia catappa*	Combretaceae	1 0 0 2	1 2 1	20	Rain forest
2.	*Mangifera indica*	Anacardiaceae	0 0 1 1	3 2 1	5	Savanna
3.	*Syzigium guineense*	Myrtaceae	1 0 0 0	2 0 0	0	Rain forest
4.	*Nephrolepis biserrata*	Nephrolepidaceae	0 0 0 2	0 3 0	0	Fern spore
5.	*Acrostichum aureum*	Acrostichaceae	0 0 0 1	1 0 2	0	Fern spore
6.	*Tridax procumbens*	Asteraceae	0 0 1 1	0 2 1	0	Open forest
7.	*Elaeis guineensis*	Aracaceae	2 1 1 4	3 5 3	3	Rain forest
8.	*Oncocalamus mannii*	Aracaceae	0 0 2 2	1 2 2	0	Fresh water
9.	*Dryopteris manniana*	Dryopteridaceae	0 0 0 4	2 3 1	36	Fern spore
10.	*Cyclosorus afar*	Thelypteridaceae	0 0 0 1	0 0 0	0	Fern spore
11.	*Rhizophora sp.*	*Rhizophoraceae*	1 0 0 4	1 1 1	5	Mangrove
12.	*Chenopodiaceae*	*Chenopodiaceae*	0 0 0 2	0 0 1	5	Open forest
13.	*Amaranthaceae*	*Amaranthaceae*	0 0 0 2	0 0 0	5	Open forest
14.	*Cyperus papyrus*	*Cyperaceae*	0 0 0 3	0 2 0	13	Fresh water
15.	*Albizia zygia*	Mimosaceae	0 0 0 1	0 1 0	1	Fresh water
16.	*Poaceae*	Poaceae	0 0 0 9	5 8 3	137	Savanna
17.	*Cassia fistula*	Fabaceae	0 0 4 0	0 2 0	2	Rain forest
18.	*Alchornea cordifolia*	Euphorbiaceae	0 0 0 1	1 0 0	6	Fresh water
19.	*Fungi spore*	-	0 3 0 10	3 4 2	380	-
20.	*Charred Poaceae cuticle*	-	0 0 0 5	1 2 0	5	-
21.	*Protea sp.*	Proteaceae	0 0 0 1	1 0 0	1	Savanna

Table 1: Showing Frequency distributionof recovered palynomorphs from the study location

S/N	***Pollen Taxa***	Experimental	Control	
		(Suspect %)	(Crime scene %)	Pollen rain %
1	*Terminalia catappa*	3.15	4.12	1.968
2	*Mangifera indica*	1.9	6.18	0.492
3	*Syzigium guineense*	1.05	2.06	0.0
4	*Alchornia cordifolia*	1.9	4.12	0.590
5	*Acrosticum aureum*	1.05	3.09	0.0
6	*Oncocalamus mannii.*	4.21	5.15	0.0
7	*Tridax procumbens*	1.9	3.09	3.0
8	*Cyclosorus afar*	1.05	0.0	0.0
9	*Elaeis guineensis*	8.42	11.34	0.295
10	*Rhizophora sp.*	5.26	3.09	0.492
11	*Nephrolepis sp.*	1.9	3.09	0.0
12	*Dryopteris sp.*	4.21	6.18	3.54
13	Chenopodiaceae	1.05	0.0	0.5
14	Amaranthaceae	1.05	0.0	0.5
15	*Cyperus sp.*	3.15	2.06	1.28
16	*Cassia fistula*	1.05	1.9	0.19
17	Fungi spore	13.7	9.27	37.4
18	Poaceae	9.47	16.5	13.5
19	Mimosaceae	1.05	1.05	1.05
20	Charred Poaceae cuticle	5.0	3.1	0.0
21	Proteaceae	1.05	1.05	1.05

Table 2: Showing percentage distribution of recovered palynomorphs from the study location

S/n	Physical properties	Suspect	Crime scene	Screen opening (mm)
1.	Colour	Light brown	Dark brown	-
2.	Particle size analysis	0.125	0.125	0.177- 0.125
3.	Quartz grain surface texture analysis	Very fine	Fine	-
4.	Grain sorting	Very well-sorted	Very well-sorted	1.1-1.2
5.	Grain shape	Well rounded	Rounded	-

Lithological Analysis
Table 3: Physical properties of sand grains recovered from crime scene and suspect

S/n	Parameters	Control (Crime scene)	Experimental(Suspect)
1.	Conductivity/salinity	4.60	4.40
2.	Potential of hydrogen(PH)	5.44	5.30
3.	**Dionex Analysis (anion)**		
	Parameters	Control(crime scene)	Experimental(suspect)
I.	Total Chloride (mg/L)	141.75	134.65
II.	Nitrate (mg/L)	0.14	0.12
III.	Phosphate (mg/L)	0.78	0.69

Chemical Analysis
Table 4: Showing chemical analysis of sediment recovered from crime scene and suspect

Discussion

This pollen spectrum showed a close relationship in the diversity of plants in samples collected from the crime scene (Control), suspect (sample of interest) and the pollen rain of the study location. Twenty-one different palynomorphs were recovered from both samples; four were identified to family level, one to species level, fourteen to generic level, one fungal spore and one charred Poaceae cuticle. Seventeen similar palynomorphs were represented in both samples collected in the crime scene as well as the forensic materials obtain from the suspect. Also, three dissimilar palynomorphs were recovered. There was a positive correlation between parent plants, pollen rain and pollen representation of the crime scene were observed for *Elaeis guineensis, Cassia fistula, Mangifera indica, Terminalia Catappa, Albizia zygia and Tridax procumbens*. Pollen of *Rhizophora* species was recovered in both samples which indicate that the crime actually occurred in a mangrove environment which extends to the limit of the diurnal tides (Lagoon). Pollen of *Tridax procumbens and Elaeis guineensis* were recovered from both samples indicating open vegetation. Indicated the adaptation of *Acrosticum aureum* which were recovered in both samples to coastal areas associated with mangrove vegetation [32], areas inundated with saline waters, open salt marshes, coastal swamps and areas along estuarine rivers. This strongly supports the contention that the suspect had visited the crime scene and its environment.

While viewing samples with the light microscope, clumps of pollen were recovered in *Cassia fistula* and this is one of the distinct plants found at the crime scene and it was actually flowering as at when the crime was committed. Identified clumps of pollen found on clothing transferred by direct contact from the flower to an object [14]. It is possible that identifying clumps of the same species of pollen may imply that pollen was physically transferred, not aerially dispersed. This suggest that there might have been a direct contact between the suspect and the plant, since the plants is not a prolific producers of pollen grains.

Pollen of Poaceae were also recovered in abundance in both samples, which is confined basically to more open vegetation, dry environments, coastal savannas and river valleys [33]. These features are the recent state of the scene where the crime had occurred. Both forensic materials also yielded palynomorphs (plate 1 and 2) of fresh water swamp forest types; *Oncocalamus* species, *Dryopteris* species, and *Nephrolepis* species. This can be related to proximity of the crime scene to the Lagos lagoon, due to the facts that they mostly occur in marshy to waterlogged habitats. A charred Poaceae cuticle was also abundance in both samples. Reported that this might have resulted from an increased bush burning in their study areas [34]. However, the presence of charred Poaceae cuticles serves as a bio maker used in establishing a link between the suspect and the crime scene with a close range to bush burning activities. Correspondence analysis (CA) is an ordination method for comparing associations containing counts of taxa or counted taxa across associations, CA is the more appropriate analysis. It is a potential tool to visualize the links between the categories of two qualitative variables. Here CA was applied to the percentage frequency data of the 21 palynotaxa retrieved from both the suspect crime scene and pollen rain using the statistical program PAST 2018 (Figure 7). In the CA symmetric plot along axes 1 and 2 (100%), 21 types of palynotaxa formed one group with maximum variance along Axis 1 and Axis 2 as 11.43535% (Experimental), 16.49678% (Control) and 70.26227% (Pollen rain) respectively. while shows the correlation between scene of crime (Figure 7), suspects and pollen rain.

The dionex analysis (anion) of the sediment recovered from the suspects and crime scene also shows great similarity in the results obtained from conductivity/salinity, anion content such as total chloride, nitrate and phosphate (Table 4). The atomic absorption spectrometry (cation) parameters such as lead, Copper, Nitrate, Phosphate, shows great variation in their concentration in both

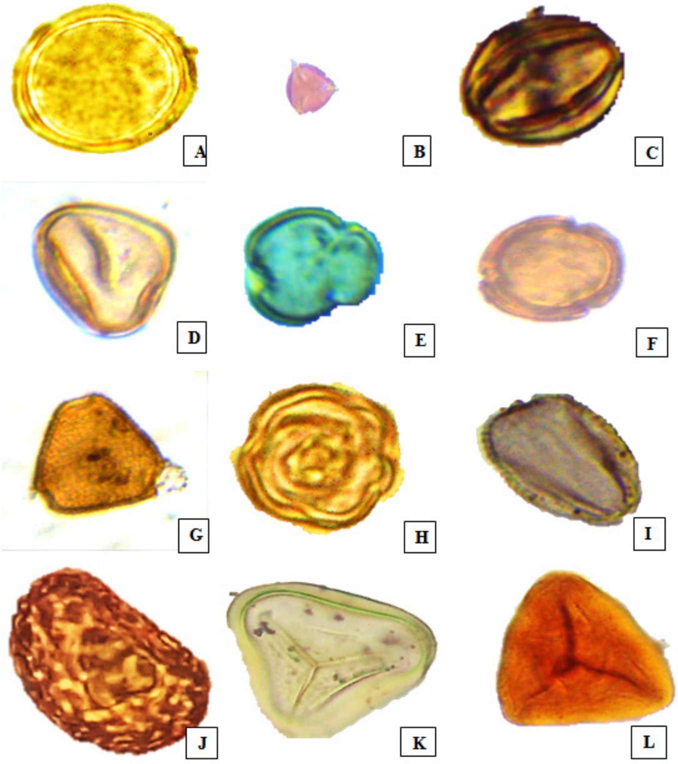

Plate1: Showing recovered palynomorphs (a) Poaceae, Scale bar=5µm; (b) *Cassia fistula*, Scale bar= 5µm; (c) *Alchornia cordifolia*, Scale bar=5µm; (d) *Cyperus papyrus*, Scale bar=5µm (1) (e) *Mangifera indica*, Scale bar=5µm; (f) *Rhizophora* sp., Scale bar=5µm; (g) *Protea* sp., Scale bar=5µm;(h) *Terminalia catappa*, Scale bar=5µm;(I) *Cyperus papyrus*, Scale bar=5µm; (2) (j) *Nephrolepis biserrata*, Scale bar=10µm; (k) Trilete fern, Scale bar=5µm; (l) Pteris sp., Scale bar=5µm.

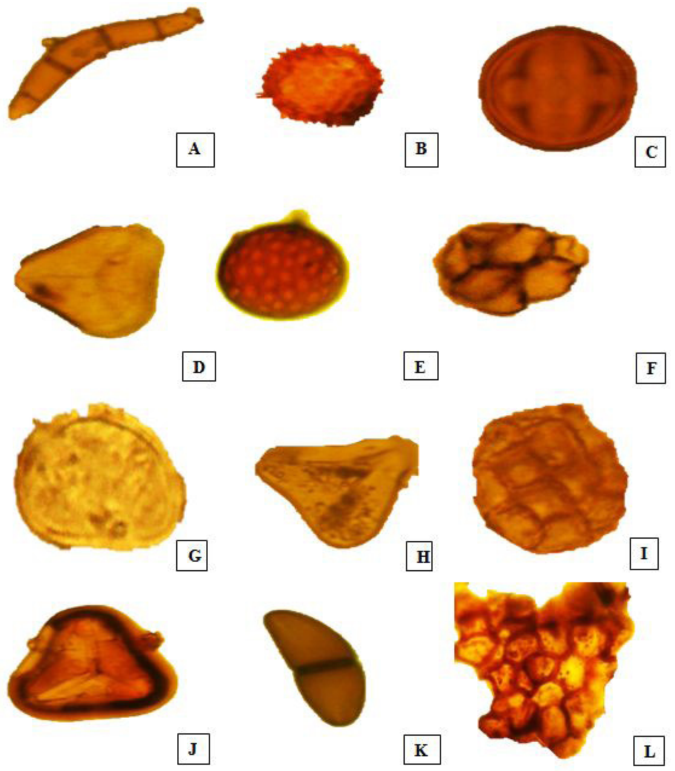

Plate 2: Showing recovered palynomorphs (a)Septate spore, Scale bar=5µm;(b) *Tridax procumbens*, Scale bar=5µm;(c) Combretaceae, Scale bar=5µm;(d) *Elaeis guineensis*, Scale bar=5µm;(e)Chenopod /Amaranth, Scale bar=5µm;(f) Spore indeterminate, Scale bar=5µm;(g) *Cyclosorus afer*, Scale bar=10µm;(h)*Elaeis guineensis* Scale bar=5µm;(i)*Albizia zygia*, Scale bar=5µm;(j)*Pterismannina*, Scale bar=5µm;(k) Fungal spore, Scale bar=5µm; (l) *Charred Poaceae cuticle*, Scale bar=25µ

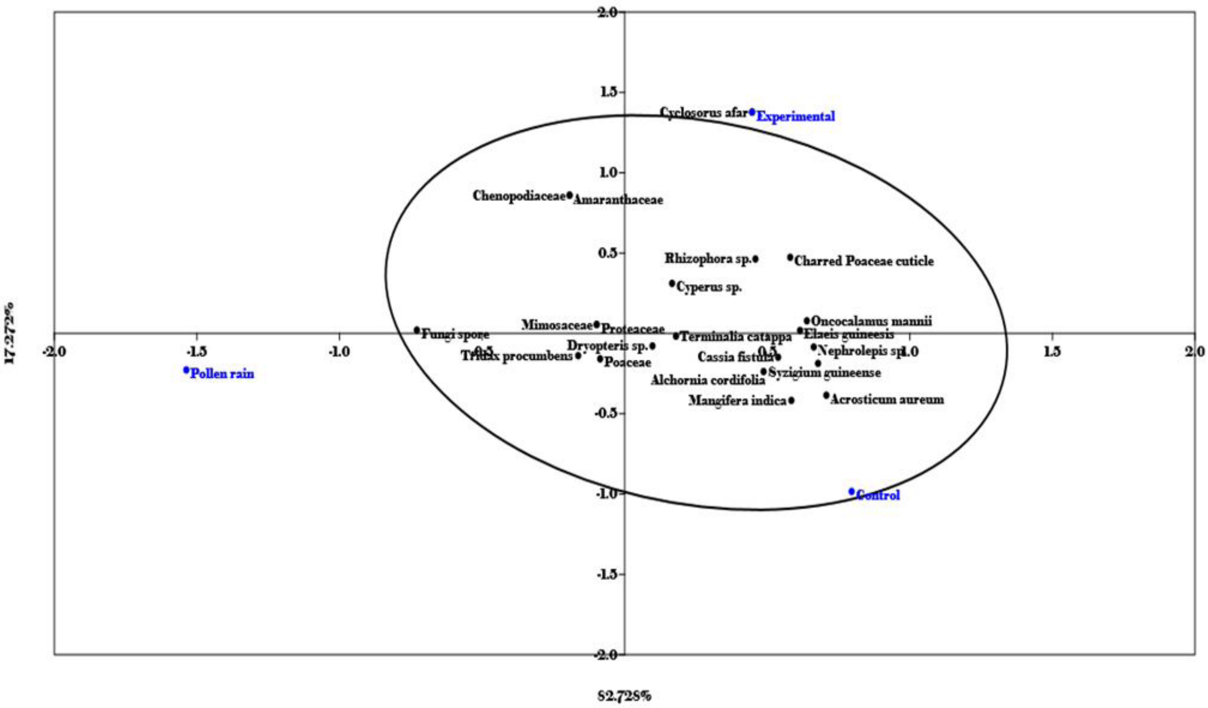

Figure 7: Correspondence analysis symmetric plot of 21 palynotaxa, control and experimental samples along axis 1 and axis

samples, while the Zinc content was on the high side probably due to the bush burning activities in the past or the closeness of crime scene to the central research laboratory in terms of laboratory effluent discharge (Table 5). Using paired t-test, it was observed that the results obtained for the control and experimental samples for all parameters were not significantly different from each other. The t-value was less than 1 or equal to 0.361, this shows a similarity of 95% confidence limit. The results obtained were compared to the soil guide line value for residential area using Contaminated Land Exposure Assessment (2009), such as chromium (130Mg/Kg), Nickel (130Mg/Kg), (450Mg/Kg). The value was below the range for residential area which indicates that there is no contamination of the sediments obtained.

S/n	Atomic Absorption Spectrometry (cation)		
	Parameters	Control(crime scene)	Experimental(suspect)
I.	Lead (mg/Kg)	35.54	16.10
II.	Zinc (mg/Kg)	16,932.00	2,089.80
III.	Copper (mg/Kg)	5.38	1.63
IV.	Chromium (mg/Kg)	1.75	8.13
V.	Nickel (mg/L)	4.04	2.24
VI.	Iron (mg/L)	70.14	28.06

Heavy Metals Chemical Analysis

Table 5: Showing chemical analysis of sediment recovered from crime scene and suspect

The lithological analysis of soil sample recovered from the crime scene shows boundless similarity with the forensic materials obtained from the suspect shoes and clothing, ranging from the colour of the sediments obtained which is light brown and dark brown. The particle size of both samples obtained using sieve analysis were 0.177- 0.125, indicating find sand grain and also less flow of velocity needed to erode, transport and deposit the sand grains. Since the sediment obtained from both samples were of the same size, this indicates that both sediments was sorted out during longer transportation by water over time. The sediments were well sorted indicating that the sand grains are of the same size. There is every indication that before the crime occurred, that there might have been a reworked by wind or water due to the proximity of the crime scene to the Lagoon. The grain shape of the sediments obtained from the crime scene is rounded while that of the suspect is well rounded; this is an indication that the grains have been moved around (i.e. the longer the length of time or distance they have moved the more spherical they become) by the suspect in the process of evading arrest by the University of Lagos security unit. The conclusion reached is therefore that "the pollen evidence, biochemical and lithological evidence *strongly support* the contention that the suspect had been at the crime scene owing to the strong correlation between the samples obtained.

Conclusion

The present study established that ear wax, and nostrils can act as excellent trap for pollen grains, spores and other particulates organic matter and thus may be considered for their potential use as a forensic tool in legal cases. It not only proves that this material as good pollen trap but also demonstrates that it is possible to prove or disprove alibis of suspect/victim from different vegetation zones as each region has a unique pollen print and thus pollen grains from these materials might be useful in crime resolution.

Forensic palynology should be used in line with other forms of evidence and allow for an appropriate amount of evidentiary weight on such evidences [35]. Forensic palynology provides evidences of comparison and correlation [35]. Highlighted the difficulties in presenting forensic palynology as evidence to court due to the intricacy of some evidences [36]. Palynological evidences needs to be clearly and simply explained emphasizing differences or similarities in pollen assemblages in relation to vegetation or species with which court might be familiar or, as in the Hall case, emphasize the unique association that is unlikely to be a chance result [36,37].

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