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MORPHOLOGICAL STUDY OF MODERN PHYTOLITH ASSEMBLAGE IN YOBE STATE NIGERIA

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ABSTRACT

Morphological study of phytolith was carried out from 10 plant species in 10 different plant families in Yobe state Nigeria. Fresh plant leaves were randomly collected each from family which consist of leaves from 10 species and families for phytolith analysis. Schulze's solution was the standard method used to extract phytolith from the sample. The extracted samples were examined with Olympus Bx41 microscope. Phytolith results revealed a wide range of phytolith morphotypes with considerable degree of variability. However, 8 species were reported to have cuneiform bulliform phytolith shape, 1 bilobate phytolith shape and 1 reported globular echinate phytolith shape. Psilate and verrucate surface texture was observed from the study. These results of phytolith analysis could serves as baseline data that represent the modern vegetation assemblage of the

Introduction:

Phytoliths or "plant stone" in Greek are amorphous silica structures produce and precipitate in and between the cells of plant. (An et al., 2015; Bremond et al., 2004; Piperno, 2006; Rashid et al., 2019). The absorption of liquid silica is mainly via plant root and it is stored in the form of monosilicic acid $Si(OH)_4$ (Bowdery, 1999; Rashid et al., 2019). Therein, the monosilicic acid undergo polymerization process and precipitate throughout the plant in different locations (Chowdhury & Datta, 2017; Piperno, 2006; Rashid et al., 2019; Santos et al., 2010; Shillito, 2013).

The debate about whether silica should be considered as essential element for plant is still on (Hunt et al., 2008),

study area for future paleoenvironmental study and environmental reconstruction.

Keywords: *Assemblage, Morphotype, Nigeria, Phytolith*

although a number of studies showed plants grew in silica-free medium failed to thrive. In this regard, phytolith might have roles in plant's defensive mechanism and protect the plant from biotic and abiotic stress (Chowdhury & Datta, 2017; Piperno, 2006; Shakoor & Bhat, 2014).

Phytoliths are very small in size, ranging between 20-200 µm across (Piperno, 2006;Rashid et al., 2019). Even though phytolith are mostly amorphous, certain families of plant could be discerned based on its specific and identifiable phytolith morphology (Piperno, 2006; Rashid et al., 2019; Shakoor & Bhat, 2014). When plant dies, the phytoliths are then incorporated into soil where they could remain for millennia. Phytolith assemblage from soil and lake sediment were used as climatic and vegetation indicators for past environmental reconstruction and paleoenvironmental studies (Alexandre & Brémond, 2009; An et al., 2015; Barboni et al., 2007; Lu et al., 2006). Despite that, phytolith study comes with uncertainty as a result of redundancy and multiplicity in morphology of its recovery in soil. It is noted that many different plants produce the same phytolith shape and some plants produce different phytolith morphotypes from various plant parts (Barboni et al., 2007; Lu et al., 2006). The most notable application of phytolith study is in the Poaceae family due to its unique morphologies. Grass phytolith assemblages recovered from the soil served as strong bio-indicator of past climate condition in many tropical and temperate regions (Barboni et al., 2007; Qiu et al., 2014). According to Fahmy and Magnavita (2006)and Novello and Barboni (2015), phytoliths were produced in high quantity in the leaves than in the inflorescence of grass family. Besides grasses, many plant species also recorded higher concentration of phytolith in leaves (Rovner, 1971; Sharma et al., 2018).

Reconstruction of past plant vegetation in an environment can be carried out by looking at microscopic plant remains in the soil (Alexandre & Brémond, 2009; Lu et al., 2006; Sowunmi, 1973). Phytolith assemblage from a study site can be compared with that of the modern reference to study the plant cover dynamic over time (Bremond et al., 2004; Tsartsidou et al., 2007). Many palynology and phytolith studies in Nigeria were focused in the wetter Niger Delta area in the past. This study aimed to catalogue the present plant vegetation that exists in Yobe state Nigeria for future paleoenvironment and environmental reconstruction.

Materials and Methods

Plant materials were collected from fresh plant leaves in Gasma study area Yobe state Nigeria and dried for phytolith analysis (**Plate 1**), 10 plant species from 10 families were involved in this study. Phytolith analysis was based on the chemical treatment method with the use of Schulze's solution which is a mixture of concentrated nitric acid HNO_3 and potassium chlorate $KClO_3$ (Piperno, 2006). The dried leaf samples were placed into a centrifuge tube and added with 10 ml of Schulze's solution. The centrifuge tubes were then placed in water bath (heated to 90°C). This procedure needed to be repeated every 20 minutes up till all plant materials were no longer visible (Piperno, 2006).To discard the chemicals, samples were then centrifuged at 2000 rpm for 10 minutes. Phytolith material were extracted and mounted on glycerin gel on glass slides and examined using an Olympus BX41 microscope under 400x. The naming of phytolith shapes and surface textures are after ICPN 1.0 (International Code for Phytolith Nomenclature 1.0 (2005)

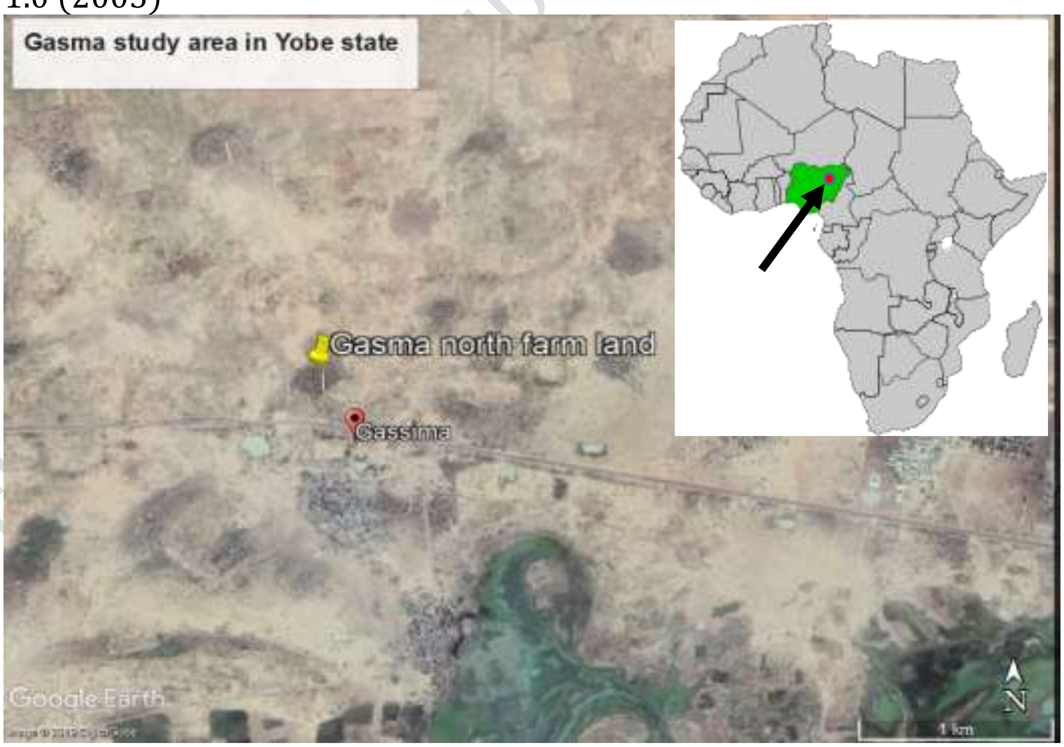

Plate 1: Map showing the phytolith sampling area in Yobe state Nigeria where samples were dried in the Gasma study area, 12°52'55.00"N 10°58'29.59"E.

Results

Out of the leaves collected from 10 plant species for phytolith analysis, 8 species were reported to have cuneiform bulliform phytolith shape, 1 species have bilobate phytolith shape and another one species have globular echinate phytolith shape. Phytolith morphotypes according to shapes, sizes and surface texture are as shown in **Table 1**. Light microscope photomicrograph of phytolith from each of these 10 species are as shown in **Plate 2 & Plate 3**. Other than these major type of phytolith shapes, there were phytolith types from these 10 species found in lower abundance (minor shapes) which included: cylindrical polylobate, globular, cuneiform, mesophyll long cell, long cell echinate and parallepipedal bulliform phytolith. Psilate surface texture was of majority from the observed phytoliths morphotypes.

Table 1: Morphological structure and measurement of phytoliths (µm) of the studied plants

No.	SPECIES NAME	COMMON NAME	FAMILY	LENGTH MEAN±SD	WIDTH MEAN±SD	*MAJOR SHAPE	*MINOR SHAPE
1.	*Abelmoschus esculentus*	Okra	Malvaceae	32.4±10.27	21.2±5.15	CBF	PPB
2.	*Acacia nilotica*	Gum arabic tree	Fabaceae	27.1±7.77	17.7±4.89	CBF	CFM
3	*Allium cepa*	Common onion	Liliaceae	25.0±7.48	19.0±6.23	CBF	GBL, PPB
4	*Anacardium occidentale*	Cashew	Anacardiaceae	27.0±7.33	18.7±7.35	CBF	PPB
5	*Azadirachta indica*	Neem tree	Meliaceae	27.7±6.10	19.2±5.03	CBF	PPB
6	*Balanites aegyptiaca*	Desert date	Zygophyllaceae	38.1±7.57	26.5±8.38	CBF	MLC, PPB
7	*Borassus aethiopium*	Palmyra palm	Arecaceae	21.4±4.29	20.2±3.71	GBE	PPB
8	*Calotropis pocera*	Rubber tree	Apocynaceae	28.9±7.92	21.7±6.84	CBF	PPB
9	*Citrus limon*	Lemon	Rutaceae	26.0±8.29	15.5±4.97	CBF	PPB
10	*Pennisetum glaucum*	Millet	Poaceae	20.4±4.25	10.9±1.73	BLT	LCE, CDP

*__CBF__ = Cuneiform bulliform cell, **CFM** = Cuneiform, **BLT** = Bilobate short cell, **GBL**= Globular cell, **GBE**= Globular echinate, **CDP** = Cylindrical polylobate, **LCE** = Long cell echinate, **MLC** = Mesophyll long cell, **PPB** = Parallepipedal bulliform phytolith.

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Below are photomicrographs (Plate 2 and Plate 3) of phytolith (major and minor shapes) of plant species as recorded in **Table 1.**

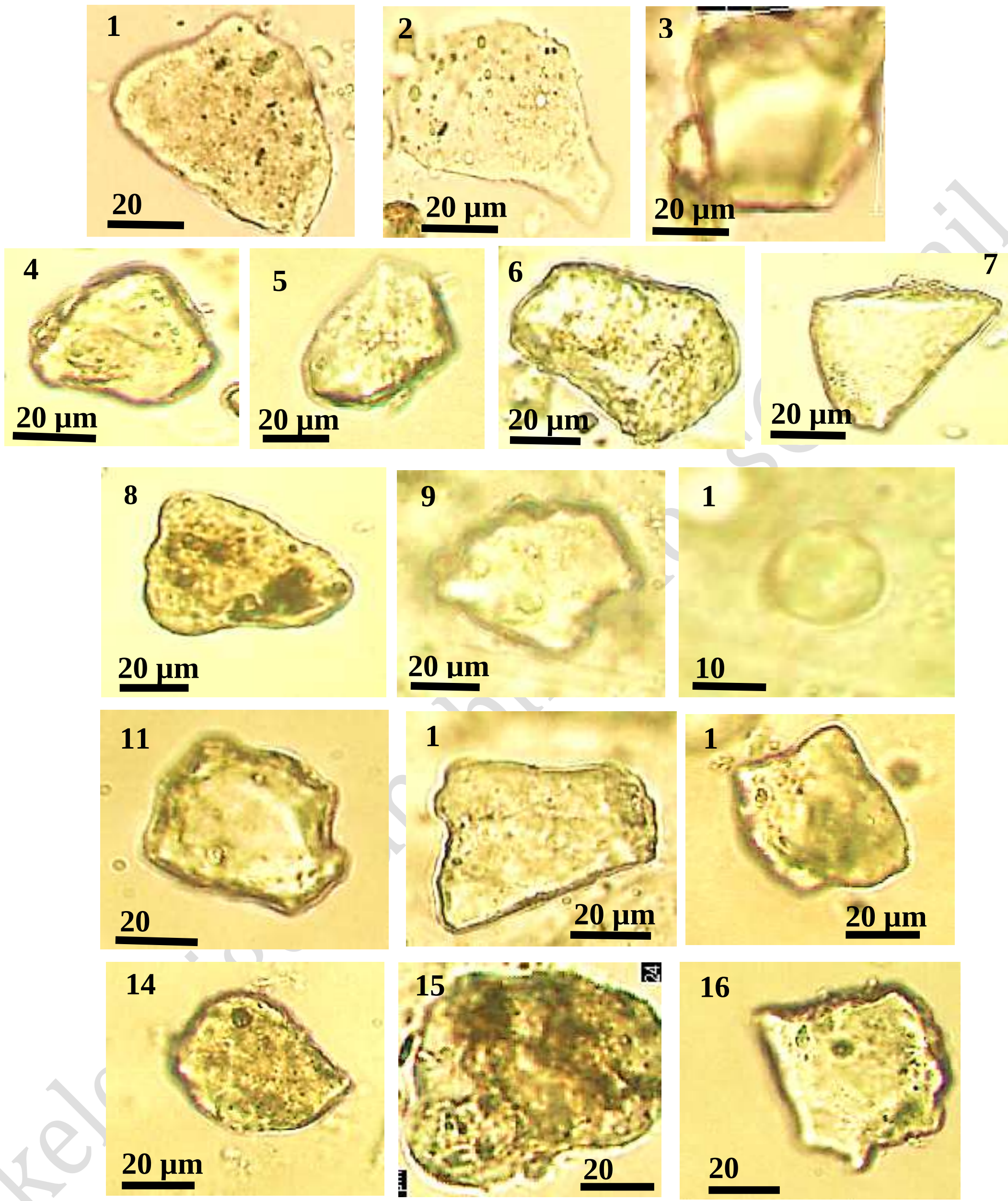

Plate 2: Photomicrograph of *Abelmoschus esculentus* phytolith shape (1 & 2) cuneiform bulliform phytolith in major shape and (3) parallepipedal bulliform phytolith in minor shape. *Acacia nilotica* phytolith shape (4, 5 & 6) cuneiform bulliform phytolith in major shape and (7) cuneiform phytolith in minor shape. *Allium cepa* phytolith shape (8) cuneiform

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bulliform phytolith in major shape, (9) parallepipedal bulliform phytolith and (10) globular phytolith in minor shape. *Anacardium occidentale* phytolith shape (11 & 12) cuneiform bulliform phytolith in major shape and (13) parallepipedal bulliform phytolith in minor shape. *Azadirachta indica* phytolith shape (14 & 15) cuneiform bulliform phytolith in major shape and (16) parallepipedal bulliform phytolith in minor shape.

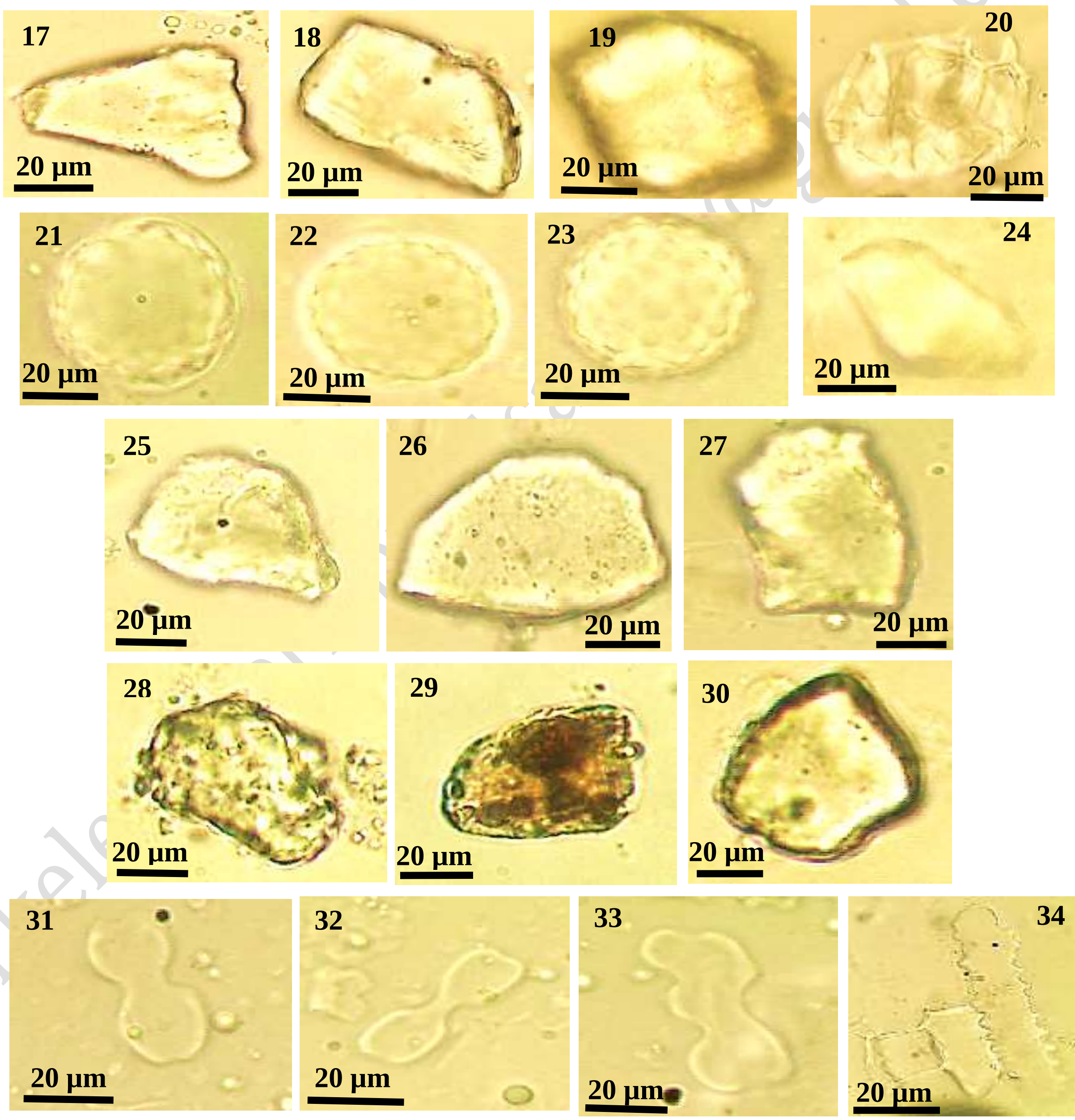

Plate 3: *Balanites aegyptiaca* phytolith shape (17 & 18) cuneiform bulliform phytolith in major shape, (19) parallepipedal bulliform phytolith and (20) mesophyll long cell phytolith in minor shape. *Borassus egyptica* phytolith shape (21, 22 & 23) globular echinate in major shape and (24) parallepipedal bulliform phytolith in minor shape. *Calotropis procera* phytolith shape (25 & 26) cuneiform bulliform phytolith in major shape and (27) parallepipedal bulliform phytolith in minor shape. *Citrus limon* phytolith shape (28 & 29) cuneiform bulliform phytolith in major shape and (30) parallepipedal bulliform phytolith in minor shape. *Pennisetum glaucum* phytolith shape (31 & 32) bilobate phytolith in major shape, (33) cylindrical polylobate phytolith and (34) long cell echinate phytolith in minor shape.

Discussion

To date, phytolith studies revealed a common short-coming of having too much redundancy and multiplicity in morphotypes, making it challenging to discern plant taxa base on phytolith shapes alone. In general, most of the broad-leaf species, irrespective of sites where they were found, have majority of its phytolith in cuneiform bulliform shape. Exception is on species from the Poaceae family which are known to have bilobate phytolith shape (Barboni et al., 2007; Piperno, 2006; Rashid et al., 2019).

Another factor that has influence on the size of phytolith is the growing condition of plants. It was found that plant grown in wet habitat produced larger phytolith (Bowdery, 1999; Rashid et al., 2019). Phytolith research is faced with a lot of problems which include redundancy and multiplicity(Barboni et al., 2007). Previous studies further affirmed that some plant produce large phytolith while others very few (Shillito, 2013; Tsartsidou et al., 2007). Phytolith identification was accorded with international code for phytolith identification system where phytolith morphotypes were catalogued based on its shapes, size and texture ornamentation (Madella et al., 2005).

Qiu et al. (2014), Rashid et al. (2019) and Sharma et al. (2019) revealed from their study that Poaceae family almost produced bilobate phytolith shape, rondel, polylobate and long cell echinate shape. Another study however, affirmed the fact that bilobate shape phytolith is one of the distinguishing characteristics of Poaceae family which is adapted to the warm humid temperature (An et al.,2015).Globular phytolith, globular granulate, and globular echinate phytolith were characterized by palms trees from Arecaceae family and gives best account of the satellite tree cover(Barboni et al., 2007). Shakoor & Bhat (2014) revealed that broad leaf plant produced mostly cuneiform bulliform phytolith shape. Other phytolith shapes may also be produce in less abundance reported as minority shapes (Shakoor & Bhat, 2014). Cuneiform bulliform phytolith are the representatives of both monocotyledon and dicotyledon plant (Croft et al., 2018; Rashid et al., 2019). Cuneiform bulliform cell and parallepipedal bulliform cell phytoliths are produced in Panicoideae and Oryzoideae found in the warm humid climate of China (An et al., 2015; Lu et al., 2006). Some plants produced huge amount of phytoliths, resulting in over-representation of the vegetation (An et al., 2015).

Conclusion

Phytolith morphology was catalogued based on morphotypes of its shapes, sizes and texture ornamentation. There is no any specific shape of phytolith for plant family except the grass family which are mostly known for bilobate phytolith shape. This study however, affirmed that bilobate phytolith shape represent the Poaceae family. Eight (8) species were reported to have cuneiform bulliform phytolith shape and 1 bilobate phytolith shape and 1 globular echinate phytolith shape. The minor phytolith shapes observed were found in less abundance and were reported as minority. The study is compiled with multiplicity and redundancy making the interpretation of phytolith data very difficult as a result.

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