Morphological study of modern phytolith assemblages in guinea Sahara region of Nigeria

Mohammed Musa Gasma 1, *, Isiyaku Alhaji Musa 2, Habihu Aminu 2, Hamidu Muhammed Askira 2, Saminu Hamisu Aliyu 2 and Jimeshio Joseph Gberindyer 2

1 School of Science, department of Biology, Umar Suleiman College Gashua, P.M.B 02 Gashua, Yobe state.
2 Cocoa Research Institute of Nigeria, P.M.B 5244, Ibadan, Oyo state, Nigeria.

World Journal of Advanced Research and Reviews, 2022, 13(01), 748–753

Publication history: Received on 19 December 2021; revised on 26 January 2022; accepted on 28 January 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.13.1.0082

Abstract

Morphological study of phytolith was carried out from 11 plant species in 10 different plant families in Nigeria. Fresh plant leaves were randomly collected each from family which consists of leaves from 11 species 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, 9 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 serve as baseline data that represent the modern vegetation assemblage of the study area for future paleoenvironmental study and environmental reconstruction.

Keywords: Analysis; Family; Morphology; Morphotypes; Phytolith

1. Introduction

Phytolith is a Greek words (phyto) “plant” and (lithos) “stones” [1,7,17]. Phytolith are amorphous silica structures produced and precipitated in and between the cells of plants tissue [3,6,14,17]. Silica uptake in plant is absorbed when plant take water from the soil and the nutrient it requires for growth. Phytolith absorbed were precipitated throughout the plant in different location by polymerization process [7,14,17,18,20]. The absorption of liquid silica by plant root are usually stored in monosilic acid Si(OH)₄ [5,17]. The extraction of phytolith can be achieved by chemical or ashing technique [8,14].

Phytolith are very small in sizes ranging between 20-200 µm across [14,17]. When plant decay off, the phytoliths incorporated into soil where they remain for millennia. Phytolith morphology is specific and identifiable even though they are highly amorphous [1,14,17]. Past plant vegetation information of the past can be traced through phytolith analysis [4,15]. Phytolith assemblage from soil and lake sediment were used as climatic and vegetation indicators for environmental reconstruction and paleoenvironmental studies [2,3,4,11]

Phytolith study is still controversial since its interpretation is uncertain hitherto as a result of redundancy and multiplicity of its recovery [4,11]. The scientific community are still debating on why phytolith is not considered as an essential element of plant [10]. However, plant reproduction researches revealed that plants growing in less silica medium lack structural support because phytolith protect the plant from biotic and abiotic stress [1,7,14].
Phytolith research revealed the presence of grass family in the past 2,500 years according to [9] and [13] revealed that phytolith are produced more in the leaves than in the inflorescence of grass family. Phytolith assemblage recovered from the soil serve as an indicator of grass in many tropical and temperate regions which is due to the fact that phytolith shape in unique and specific within the Poaceae family [4,16].

Reconstruction of past plant vegetation associated with microfossil from the soil can be achieve through phytolith analysis [2,11,21]. Excavated phytolith from an environment can be compared with the modern reference to help in reconstruction of plant related environments transition over time [6,22]. However, this study aimed to catalogue the present plant vegetation for future paleoenvironment and environmental reconstruction.

### 2. Material and methods

Plant materials were collected from plant leaves and dried at Gasma study area for phytolith analysis (Figure 1). (11) plant species were involved in this study from 10 families. Chemical treatment method of phytolith analysis was accord with Schulze's solution [14]. The sample was placed directly into a centrifuge tube and 10 ml of Schulze’s was added to it. The sample was stirred for proper immersion with the Schulze’s solution [14]. The sample will then be centrifuge and phytolith material will then be extracted and prepared for examination using an Olympus BX41 microscope under 400x [14].

#### 2.1. Study Area

![Figure 1 Gasma study area in Yobe state at 12°52’55.00”N 10°58’29.59”E](image)

### 3. Results

Out of 11 plant leaves collected from 10 plant families for phytolith analysis, 9 species were observed to have cuneiform bulliform phytolith shape, 1 bilobate phytolith shape and 1 globular echinate phytolith shape. Light microscope (LM) was used in the entire examination under 400 x magnifications. Phytolith morphotypes were catalogued according to shapes, sizes and surface texture as shown from Table 1. The study presents the light microscope photomicrograph of phytolith from each species as shown from Figure (23). Various phytolith morphotypes were found in less abundance which includes: cylindrical polylobate, globular, cuneiform, mesophyll long cell, long cell echinate and parallelepiped bulliform phytolith. The surface texture found from this study was verrucate of majority.

#### 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*  L. | Okra        | Malvaceae | 32.4±10.27     | 21.2±5.15     | CBF          | PPB          |
| 2.  | *Acacia nilotica* L.      | Gum arabic tree | Fabaceae | 27.1±7.77      | 17.7±4.89     | CBF          | CFM          |
| 3.  | *Allium cepa* L.          | Common onion | Liliaceae | 25.0±7.48      | 19.0±6.23     | CBF          | GBL, PPB     |
| No. | Species                                   | Major Shape                      | Minor Shape                      | CBF    | MLC  | PPB  | GBE   | GBL  | CDP  | LCE | CBF   | BLT  | LCE  | CDP  |
|-----|------------------------------------------|----------------------------------|----------------------------------|--------|------|------|-------|------|------|-----|-------|------|------|------|
| 4   | *Anacardium occidentale* L.               | Cashew                           | Anacardiaceae                    | 27.0±7.33 | 18.7±7.35 | CBF | PPB |
| 5   | *Azadirachta indica* L.                   | Neem tree                        | Meliaceae                        | 27.7±6.10 | 19.2±5.03 | CBF | PPB |
| 6   | *Balanitesaegyptiaca* L.                  | Desert date                      | Zygophyllaceae                   | 38.1±7.57 | 26.5±8.38 | CBF | MLC | PPB |
| 7   | *Borassusaethiopium*                     | Palmyra palm                     | Arecaceae                        | 21.4±4.29 | 20.2±3.71 | GBE | PPB |
| 8   | *Cola acuminata* L.                       | Cola nut                         | Malvaceae                        | 28.7±5.10 | 19.7±6.35 | CBF | PPB | GBL |
| 9   | *Calotropispocera*                        | Rubber tree                      | Apocynaceae                      | 28.9±7.92 | 21.7±6.84 | CBF | PPB |
| 10  | *Citrus limon* L.                         | Lemon                            | Rutaceae                         | 26.0±8.29 | 15.5±4.97 | CBF | PPB |
| 11  | *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 = Parallelepiped bulliform phytolith.

Below is LM photomicrograph of phytolith major and minor shapes of plant species investigated as recorded in Table 1?

![LM photomicrograph of phytolith](image)

**Figure 2** LM photomicrograph of *Abelmoschus esculentus* L. phytolith shape (12) cuneiform bulliform phytolith in major shape and (3) parallelepiped bulliform phytolith in minor shape. *Acacia nilotica* L. phytolith shape (4, 56) cuneiform bulliform phytolith in major shape and (7) cuneiform phytolith in minor shape. *Allium cepa* L. phytolith shape (8) cuneiform bulliform phytolith in major shape, (9) parallelepiped bulliform phytolith and (10) globular phytolith in minor shape. *Anacardium occidentale* L. phytolith shape (11,12) cuneiform bulliform phytolith in major shape and (13) parallelepiped bulliform phytolith in minor shape. *Azadirachta indica* L. phytolith shape (14,15) cuneiform bulliform phytolith in major shape and (16) parallelepiped bulliform phytolith in minor shape.
Figure 3 Balanites aegyptiaca L. phytolith shape (1718) cuneiform bulliform phytolith in major shape, (19) parallelepipedal bulliform phytolith and (20) mesophyll long cell phytolith in minor shape. Borassus egypticaphytolith shape (21, 22) globular echinate in major shape and (24) parallelepipedal bulliform phytolith in minor shape. Calotropis procera phytolith shape (2526) cuneiform bulliform phytolith in major shape and (27) parallelepipedal bulliform phytolith in minor shape. Citrus limon L. phytolith shape (28,29) cuneiform bulliform phytolith in major shape and (30) parallelepipedal 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. Cola acuminata L. phytolith shapes (35,36) cuneiform bulliform (37) parallelepipedal bulliform in minor shape.

4. Discussion

Plant from wet habitat produce large phytolith due to the availability of water content that influence phytolith size [5,17]. Phytolith studies is associated with redundancy and multiplicity [4]. Previous studies further affirmed that some plant produce large phytolith while others very few [20,22]. Phytolith identification was accorded with international code for phytolith identification system [12].

Phytolith researches revealed a wide range of variability and concluded that phytolith shapes cannot serve as a distinguishing factor to plant families. Since there is no taxonomic shape given to a specific plant except the Poaceae family known to have bilobate phytolith shape [4,14,17]. Plant research showed that phytolith abundance in fruit and
seed is higher than in plant leaves (Shakoor Bhat, 2014). Phytolith study revealed that variation in phytolith shape may be caused as a result of multiplicity of plant samples taking for phytolith analysis [4,17].

[16], [17] and [19] revealed that bilobate phytolith shape are the distinguishing characteristics of Poaceae family, rondel, polypode 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 [3]. Globular phytolith, globular granulate, and globular echinate phytolith were characterized by palms trees from Areceae family and gives best account of the satellite tree cover [4]. [1] revealed the presence of cuneiform bulliform phytolith shape in broad leaf plant. Other phytolith shapes may also be available and reported as minority shapes [1]. Cuneiform bulliform phytolith are the representatives of both monocotyledon and dicotyledon plant [8,17]. Cuneiform bulliform cell and parallelepipedal bulliform cell phytoliths are produced in Panicoideae and Oryzoideae found in the warm humid climate of China [3,11]. Some plants produced huge amount of phytoliths, resulting in over-representation of the vegetation [3].

5. Conclusion

Phytolith shapes were catalogued according to shapes, sizes and texture ornamentation. This study affirmed that phytolith shape will not serve as distinguishing characteristics of plant species as such there is no shape given to particular species except the grass family known for bilobate phytolith shape. Eight (9) 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 quantity reported as minority. The study is compiled with multiplicity and redundancy making the interpretation of phytolith data very difficult as a result.

Compliance with ethical standards

Acknowledgments

The author is deeply indebted Umar Suleiman College of Education Gashua and Cocoa Research Institute Ibadan for their support in the pursuance of his research work.

Disclosure of conflict of interest

There is no conflict of interest in this publication.

References

[1] Shakoor S, Bhat MA. Morphological diversity of phytolith types in some Chloridoid grasses of Punjab. *International Journal of Botany and Research (IJBR)*. 2014;4(1): 1–10.

[2] Alexandre A, Brémond L. Comment on the paper in Quaternary International: “Methodological concerns for analysis of phytolith assemblages: Does count size matter?” (C.A.E. Strömberg). *Quaternary International*. 2009;193(1–2): 141–142.

[3] An X, Lu H, Chu G. Surface soil phytoliths as vegetation and altitude indicators: a study from the southern Himalaya. *Scientific Reports*. 5 October 2015; 15523.

[4] Barboni D, Bremond L, Bonnefille R. Comparative study of modern phytolith assemblages from inter-tropical Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 2007;246(2–4): 454–470.

[5] Bowdery D. *Phytoliths from tropical sediments report from Southeast Asia and Papua New Guinea*. 1999.

[6] Bremond L, Alexandre A, Vela E, Guiot J. Advantages and disadvantages of phytolith analysis for the reconstruction of Mediterranean vegetation: an assessment based on modern phytolith, pollen and botanical data (Luberon, France). *Review of Palaeobotany and Palynology*. 2004;129(4): 213–228.

[7] Chowdhury AK, Datta BK. Diversity, distribution and frequency based attributes of Phytoliths in some Panicum spp. of Tripura, North East India. *Bioscience Discovery*. 2017;2(8): 224–234.

[8] Croft DA, Su DF, Simpson SW. *Methods in Palaeoecology*. Cham: Springer International Publishing. 2018.

[9] Fahmy AG-E-D, Magnavita C. Phytoliths in a Silo: Micro-botanical evidence from Zilum (Lake Chad Basin), NE Nigeria (C. 500 Cal BC). *Journal of Biological Sciences*. 2006;6(5): 824–832.
Hunt JW, Dean AP, Webster RE, Johnson GN, Ennos AR. A novel mechanism by which silica defends grasses against herbivory. *Annals of Botany*. 2008;102(4):653–656.

Lu H-Y, Wu N-Q, Yang X-D, Jiang H, Liu K, Liu T-S. Phytoliths as quantitative indicators for the reconstruction of past environmental conditions in China I: phytolith-based transfer functions. *Quaternary Science Reviews*. 2006;25(9–10): 945–959.

Madella M, Alexandre A, Ball T. International code for phytolith nomenclature 1.0. *Annals of Botany*. 2005;96(2):253–260.

Novello A, Barboni D. Grass inflorescence phytoliths of useful species and wild cereals from sub-Saharan Africa. *Journal of Archaeological Science*. 2015;59:10–22.

Piperno DR. *Phytoliths: A Comprehensible Guide for Archaeologists and Paleoecologists*. USA: Rowman and Littlefield publishing groups inc. 2006.

Piperno DR, Pearsall DM. *The Silica Bodies of Tropical American Grasses: Morphology, Taxonomy, and Implications for Grass Systematics and Fossil Phytolith Identification*. Smithsonian Contributions to Botany. Washington, D.C: Smithsonian Institution Press. 1998.

Qiu Z, Jiang H, Ding J, Hu Y, Shang X. Pollen and phytolith evidence for rice cultivation and vegetation change during the mid-late Holocene at the Jiangli site, Suzhou, East China. *PLoS ONE*. 2014;9(1):1–12.

Rashid I, Mir SH, Zurro D, Dar RA, Reshi ZA. Phytoliths as proxies of the past. *Earth-Science Reviews*. June 2019; 194:234–250.

Santos GM, Alexandre A, Coe HHG, Reyerson PE, Southon JR, De Carvalho CN. *The phytolith 14c puzzle: A tale of background determinations and accuracy tests*. Radiocarbon. 2010; 52.

Sharma R, Kumar V, Kumar R. Distribution of phytoliths in plants: a review. *Geology, Ecology, and Landscapes*. 2019; 3(2):123–148.

Shillito LM. Grains of truth or transparent blindfolds? A review of current debates in archaeological phytolith analysis. *Vegetation History and Archaeobotany*. 2013;22(1):71–82.

Sowunmi MA. Pollen grains of Nigerian plants. *Grana*. 1973;13(3):145–186.

Tsartsidou G, Lev-Yadun S, Albert RM, Miller-Rosen A, Efstratiou N, Weiner S. The phytolith archaeological record: strengths and weaknesses evaluated based on a quantitative modern reference collection from Greece. *Journal of Archaeological Science*. 2007;34(8):1262–1275.