Vegetation history and monsoonal fluctuations during the last 12,500 years BP inferred from pollen record at Lower Subansiri Basin, Assam, Northeast India

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ABSTRACT


A 120 cm sediment profile from 4.5 m deep exposed section of Lower Subansiri River Basin has been pollen analyzed to trace palaeovegetation and climate in relation to monsoonal activity since 12,500 years BP. The study has depicted the existence of tropical mixed tree–savannah type to tropical mixed deciduous type forest under four climatic regimes, viz. cold and dry to warm and relatively dry since 12,500 years BP followed by a palynologically barren zone indicating strong fluvial activity. Four sets of monsoon fluctuations, i.e. relatively low to considerably decline in monsoonal activities have been estimated by using pollen marker taxa during the period. The marker taxa signifying high monsoonal activity are – Dipterocarpaceae, Syzygium cuminii, Arecaceae and Moraceae. Melastoma malabathricum, the only taxa which is marked as low monsoonal activity and dry depositional environment. The consistent occurrences of high land taxa are suggestive of long distance pollen transport from higher elevation via strong wind and water source.

Key–words—Lower Subansiri Basin, Monsoonal activity, Northeast India, Vegetation.
INTRODUCTION

Detailed and systematic study of palynological record has provided valuable insights concerning the changing vegetation scenario and contemporaneous climatic changes in the Indian subcontinent during the Quaternary Period (Meher–Homji & Gupta, 1999). Hitherto, no adequate palynological information is available from northeast India. However, some preliminary works have been carried out in Assam (Gupta, 1971; Bhattacharya & Chanda, 1988, 1992; Bera, 2000, 2003; Bera et al., 2008), Manipur (Roy & Chanda, 1987; Nautiyal & Chauhan, 2009), Mizoram (Chauhan & Mandaokar, 2006; Mandaokar et al., 2008), Tripura (Goswami, 1981; Prasad, 1986, 1988; Prasad & Ramesh, 1983), Arunachal Pradesh (Bhattacharyya et al., 2007), Meghalaya (Gupta & Sharma, 1985; Basumatary & Bera, 2007, 2010), Nagaland (Bera et al., 2010) and Sikkim (Bhattacharya & Chanda, 1986; D’ Costa & Mukharjee, 1986; Sharma & Chauhan, 2001; Chauhan & Sharma, 1996; Mehrotra et al., 2005).

However, the estimation of monsoonal activity by palynodata has been carried out by few workers in India (Swain et al., 1983; Prasad & Enzel, 2006; Demske et al., 2009). Study of the Indian monsoonal activity is critical for understanding regional and global variability as it drives major changes of the tropical Indian Ocean region (Gupta et al., 2003; Ely et al., 1993; Fleitmann et al., 2003; Goodbred & Kuehl, 2000). The changes in the monsoonal activity over South Asia affect the fluvial system and thus flora and fauna of the region (Gupta et al., 2006; Kumaran et al., 2005). Annual precipitation is an important parameter explaining the modern distribution of pollen taxa is clearly evidenced by distinct pollen assemblage, e.g. Glochidion pollen type, Grewia, Schleichera oleosa, Trema orientalis, Lannea type, Maytenus type, Lagerstroemia and Melastomaceae/Combretaceae are receiving annual rainfall 1200 to 2500 mm/yr, Syzygium type, Trema orientalis, Olea dioica, Elaeocarpus, Securinega type, Tetrameles nudiflora, Mallotus type, Moraceae/Urticaceae receiving 2800 to 4500 mm/yr and Poeciloneuron and Syzygium type are receiving exceeding 4500 mm/yr (Barboni & Bonnefille, 2001).

The present area of study located in Dhemaji District, situated in the northeastern corner of Assam, lies between lat. 27º27’ and 27º57’ N and long. 94º18’ and 95º32’ E respectively (Fig. 1). It is bounded in the north by Siang and Papumpare District of Arunachal Pradesh, in the east by the Arunachal Hills, in the west by Subansiri River, North Lakhimpur District and in the south by Brahmaputra River. The Subansiri River (Fig. 2a) is the largest tributary of the mighty Brahmaputra, a Trans–Himalayan river originating from the western part of Mount Pororu (5059 masl) in the Tibetan Himalaya (Goswami et al., 1990). The different geo–ecological zones transversed by the river have distinctive assemblage of topographical, geological, climatological and floral characteristics. After flowing for around 190 km through Tibet and 200 km through Arunachal Himalaya, it enters into the plains of Assam through a gorge near Gerukamukh which is situated in Dhemaji District and flows through North Lakhimpur District and then merges with mighty Brahmaputra River. The riverbed is composed of sand mixed with pebbles and boulders up to Chauldhoaghat (Goswami, 1997). The forest vegetation is tropical mixed deciduous type and the majority of the forest embraces semi–evergreen taxa and mixed deciduous taxa including riparian and swamp taxa (Champion & Seth, 1968). Floristically, due to the excessive deforestation, the forest areas are cleared and secondary monoculture forests have gradually been established. These forests mainly consist of Shorea assamica, Mesua ferrea, Cinnamomum

![Fig. 1—Map showing the study area.](attachment://image.jpg)
bejolghota, Dipterocarpus macrocarpus, Dillenia pentagyna, Lagerstroemia parviflora, Schima wallichii, Aporusa wallichii, Albizia lebbeck, Terminalia myrocarpa and Tetrameles nudiflora (Fig. 2b). The main components of shrubby species are Melastoma malabathricum, Holarrhena antidysenterica, Garcinia lancifolia and Acacia concinna. Palms like Areca, Caryota and Pinanga are also conspicuous. Bamboos such as Bambusa arundinaria, Dendrocalamus hamiltonii and Melocanna bambusoides are common in and around of the study area. The ground flora in deciduous forest is very poor.
and seasonal. Ferns and fern-allies, liverworts and mosses are also seen on old tree trunks, rock, boulders, etc. along the water streams and shady places. The natural reserve forest is highly exposed to large scale deforestation primarily due to fulfill the needs of timber, firewood and ongoing construction of 2000 mw Lower Subansiri Dam by National Hydroelectric Power Corporation (NHPC Ltd). However, the over exploitation of natural forests are resulting in spreading of secondary degrade forest types which support inferior quality of trees and alien weeds.

The climate is generally hot and sultry during summer and moderate during winter. In general, temperature rises maximum upto 37º C during summers and minimum upto 2º C during winters. The relative humidity reaches high up to 90% during rainy season (Forest working plane, 2005, Dhemaji District, Assam). During the months of May to September, there is an average annual rainfall of 3,435 mm. Under the influence of south west monsoons, huge volumes of floodwater start spilling all along the 720 km length of embankments of the River Brahmaputra in Assam, India (Goswami, 1997).

The soil of the region is broadly classified into four groups, namely new alluvial, old alluvial, red loamy and latertitic soil. The new alluvial soil is found in the flood areas subjected to occasional flood and consequently receives annual silt deposit when the flood recedes. Geologically, older and newer alluvium soil covers the area. Piedmont deposits of older alluvium consist of boulders, cobbles, gravel, sand and silt. These are the main repository in the foothill zone. Flood plain area with newer alluvium consists of fluvially derived sediments including gravel, pebble, coarse to medium sand, silt and clay received from the rivers coming from the upper reaches are the main deposits next to the piedmont deposits. The old alluvial soils are developed at higher level and are not subjected to flooding. Red loamy soils have formed on hill slopes under high rainfall conditions. However, soil in the interior forest reserve is deep red clay with alkaline nature (Forest working plan, 2002, Dhemaji District, Assam). The detailed lithostratigraphic succession of the Subansiri River Section has been given (Fig. 3). The upper portion of lithocolumn (A, A, and B) belongs to the older alluvium and rest part (C, D and E) is under the Tipam Group (Middle–Late Miocene) as detected the scattered silicified fossil woods (Karunakaran, 1974). This study communicated the age–constrained pollen record from Lower Subansiri River Basin which is for the first time to trace palaeovegetation and palaeomonsoon activity along with palaeoflood in and around the study area.

MATERIAL AND METHOD

A 4.5 m deep exposed Subansiri River Section was examined for interpretation of palaeovegetation, climate and monsoonal activity. The upper 1.7 m exposed section has been sampled at 10 cm intervals for palynological studies. However, below 2.8 m depth a Tertiary zone (Tipam Group, Middle–Late Miocene in age) was detected as evidenced by the scattered silicified fossil woods (Mehrotra et al., 2011). The collected soil samples were chemically processed using standard acetolysis method (Erdtman, 1953), 175–310 pollen grains per sample were identified and later counted. The four samples collected from the depths of 120, 100, 70 and 40 cm (base to top) of sedimentary soil profiles were carbon dated at Birbal Sahni Institute of Palaeobotany, Lucknow, India. The percentage of pollen taxa has been calculated with respect to the total pollen count. The pollen diagram is grouped on the basis of various characteristic plant taxa, viz. arboreal taxa (tree and shrub), nonarboreal taxa (terrestrial, marshy and aquatics) and high land taxa (conifers and other broad leaved taxa) respectively in the palynoassemblage (Pl. 1).

RESULTS

Four pollen zones have been recognized in this pollen diagram based on the pollen assemblage recovered from the sedimentary soil profile. Each pollen zone is prefixed by S

PLATE 1

Palynoassemblage recovered from sedimentary profile from Lower Subansiri River Basin, Assam.

1. Dipterocarpaceae
2. Lagerstroemia sp.
3. Syzygium cumunii
4. Acacia catechu
5. Moraceae
6. Dillenia pentagyna
7. Salmalia malabaricum
8. Areaceae
9. Sapotaceae
10. Mesiua ferrea
11. Terminalia bellerica
12. Strobilenthes sp.
13. Melastoma malabathricum
14. Polygonum serralatum
15. Impatiens sp.
16. Tubuliflora
17. Artemisia sp.
18. Chenopodiaceae
19. Justicia simplex
20. Cerealia
21. Poaceae
22. Cyperaceae
23. Pinus sp.
24. Betula sp.
25. Alnus sp.
27. Typha sp.
28. Lycopodium sp.
29. Davallia sp.
30. Microothyriaceae
after the name of the locality Subansiri from where the soil profile has been pollen analyzed (Faegri & Iversen, 1964). These pollen zones are described separately below (Fig. 4).

**Pollen zone S–I (120–100 cm)**—Grasses–Cyperaceae–Tubuliflorae–Solanaceae–Nymphaea–Salmalia–Sapotaceae assemblage: This pollen zone is extending from a depth of 120 cm (12,500 ± 170 years BP) to 100 cm (7,960 ± 170 years BP) has a time span of 4,540 years. The lithocolumn is characterized by silty clay with little sand and pebble. This pollen zone is characterized by the predominance of nonarboreal taxa (76.5%) over arboreal taxa (10.8%) and the high land taxa (12.7%) respectively. Among nonarboreal taxa, grasses (wild and cerealia type) are dominant (21.4% and 8.3%), Tubuliflorae (7.2%), Liguliflorae (5.6%), Malvaceae (3.0%), Artemisia (2.9%), Lamiaceae (2.1%), Euphorbiaceae (1.9%), Convolvulaceae (1.6%), Acanthaceae (1.1%), Impatiens, Chenopodiaceae/Amaranthaceae, Apiaceae, Caryophyllaceae and Brassicaceae are recorded as other prominent terrestrial nonarboreals at lower values. However, marshy taxa like Cyperaceae (8.8%), Polygonum (3.4%) and Onagraceae (3.2%) are encountered at moderate value. The prominent aquatic taxa like Nymphoides (1.3%), Nymphaea (1.1%), Potamogeton and Typha are recorded scarcely. Combretaceae (1.9%) associated with Mesua ferrea (1.3%) and Schima (1.1%) are represented as major tree taxa, however, Arecaceae, Adina, Salmalia malabarica, Ilex, Dipterocarpaceae, Moraceae and Emblica officinalis are sporadic. The shrubby elements such as Oleaceae, Melastoma malabathricum and Fabaceae are also encountered scarcely. The extra–regional taxa like Pinus (4.3%), Betula (2.9%), Alnus (2.6%) and Quercus (1.1%) are registered consistently in moderate value. However, Corylus, Ulmus and Ericaceae are sporadic.

**Pollen zone S–II (100–70 cm)**—Grasses–Bambusoi- deae–Caryophyllaceae–Impatiens–Onagraceae–Nymphaea–Potamogeton–Dipterocarpaceae–Terminalia–Lagerstroemia–Ilex–Careya assemblage: This pollen zone extending from a depth of 100 cm (7,960 ± 110 years BP) to 70 cm (6,421 ± 90 years BP) has a time span of 1,539 years. The lithocolumn is characterized by silty clay with little sand. This pollen zone is characterized by the dominance of nonarboreals (61.3%) over arboreals (24.1%) and the high land taxa (14.6%) respectively. Among nonarboreals, grasses (wild and cerealia type) are dominant (11.4% and 8.4%). Tubuliflorae (5.1%), Liguliflorae (4.0%), Artemisia (2.7%), Malvaceae (2.0%), Euphorbiaceae (1.1%), Lamiaceae, Impatiens and Convolvulaceae (1.0% each), Acanthaceae (0.8%), Chenopodiaceae/Amaranthaceae, Caryophyllaceae and Brassicaceae (0.7% each) and Apiaceae (0.4%) are recorded as other terrestrial nonarboreals at good to moderate values. Similarly, marshy taxa like Cyperaceae (6.8%), Onagraceae (3.8%) and Poly-
gonum (3.1%) are recorded at good values. Among the aquatic taxa, Nymphoides (2.4%), Nymphaea and Typha (1.5% each) and Potamogeton (1.2%) are moderately recorded. Among major trees, Combretaceae is represented as major constituent (2.4%) followed by Arecales (2.0%), Dipterocarpaceae (1.9%), Emblica officinalis (1.7%), Moraceae and Salmalia malabaricum (1.6% each), Schima (1.5%), Ilx (1.2%) and Adina (1.0%) respectively. However, Mesua ferrea, Dillenia, Sapotaceae, Lagerstroemia, Syzygium, Meliaceae and Seme-carpus are sporadic. Fabaceae (1.9%) and Oleaceae (1.1%) are moderately recorded. Melastoma malabaricum and Strobilentes are exhibited scarcely. The high land taxa like Pinus (4.6%), Betula (3.1%), Alnus (2.8%), Corylus (1.2%), Quercus and Ericaceae (1.1% each) are recorded moderately. Ulmus is sporadic.

Pollen zone S–III (70–40 cm)—Grasses–Tubuliflorae–Artemisia–Potamogeton–Dipterocarpaceae–Terminalia–Melastoma assemblage: This pollen zone extending from a depth of 70 cm (6,421 ± 90 years BP) to 40 cm (4,270 ± 70 years BP) has a time span of 2,151 years. The lithocolumn is characterized by 30 cm silty clay. This pollen zone is characterized by the predominance of nonarboreals (49.7%) over arboreals (33.7%) along with high land taxa (16.6%). Among nonarboreal taxa, grasses (wild and cereal type) are dominated at the value of 6.2% and 9.5% respectively. Other terrestrial herbs like Tubuliflorae (3.0%), Liguliflorae (2.9%), Artemisia (1.9%), Impatiens (1.8%) and Malvaceae (1.2%) are recorded moderately. However, Caryophyllaceae, Convolvulaceae, Euphorbiaceae, Chenopodiaceae/Amaranthaceae, Brassicaceae, Apiaceae, Lamiaceae and Acanthaceae are recorded in sporadic frequency. Amongst, the marshy taxa, Cyperaceae (4.7%), Onagraceae (3.3%) and Polygonon (1.6%) are represented uniformly. The major aquatic taxa like, Nymphoides (2.5%), Nymphaea (2.2%), Potamogeton and Typha (2.0% each) are recorded consistently at moderate value. Dipterocarpaceae is represented as major tree constituent (4.2%) followed by Salmalia malabaricum (2.5%), Emblica officinalis (2.1%), Syzygium and Dillenia (2.0% each), Combretaceae (1.9%), Moraceae and Sapotaceae (1.7% each), Ilex (1.6%), Semecarpus (1.5%), Arecales and Lagerstroemia (1.3% each), Adina (1.2%) and Melia (1.0%). Mesua and Schima are sporadic. Melastoma malabaricum is represented as lone shrubby element at the value of 1.8% accompanied by Oleaceae (1.7%), Fabaceae (1.5%) and Strobilentes (1.0%) respectively in lower value. Pinus (4.5%), Betula (3.0%), Alnus (2.8%), Corylus (2.0%), Ulmus and Ericaceae (1.5% each) and Quercus (1.3%) are recovered moderately.

Pollen zone S–IV (40–0 cm)—Grasses–Xanthium–Brassicaceae–Solanaceae–Potamogeton–Dipterocarpaceae–Albizia–Syzygium–Melastoma assemblage: This pollen zone is dated back to 4,270 ± 70 years BP at the depth of 40 cm. This part of lithocolumn has 10 cm clay at the base overlain by 30 cm of silty clay with rootlets. This pollen zone is characterized by the predominance of nonarboreals (64.2%) over arboreals (23.1%) and the high land taxa (12.7%). Among nonarboreals, grasses (wild type and cereal type) are domi-

Fig. 5—Vegetation composition and climate implication of Lower Subansiri River Basin, Assam.
nant (11.3% and 14.5%) associated with Tubuliflorae (5.7%), Liguliflorae (3.6%), Artemisia (2.8%), Malvaceae (2.4%), Euphorbiaceae and Brassicaceae (1.5% each), Caryophyllaceae (1.4%), Lamiaceae, Convolvulaceae, Acanthaceae and Chenopodiaceae/Amaranthaceae (1.3% each) and Apiaceae (1.0%) are recovered moderately. Impatiens is sporadic. Marshy taxa like Cyperaceae (5.7%) and Onagraceae (1.8%) are recorded moderately. Polygonum is registered in sporadic frequency. Aquatics like Nymphaea (5.7%) and Nymphoides (1.1%) are encountered at lower value. However, Potamogeton and Typha are sporadic. Dipterocarpaceae is represented as major constituent (3.0%) followed by Syzygium (1.3%), Combretaceae and Ilex (1.2% each), Salmalia malabaricum, Dillenia and Sapotaceae (1.0% each). Other associated taxa like Emblica officinalis, Arecaceae, Adina, Lagerstroemia, Moraceae, Schima and Mesua ferrea are sporadic. Melastoma malabathricum is represented as lone shrubby element (4.0%) accompanied by Oleaceae (1.4%) and Fabaceae (1.1%) in low values. The high land taxa like Pinus (3.1%), Betula (2.5%), Alnus (2.4%), Quercus, Ulmus and Corylus (1.3% each) are recovered consistently at moderate values. Ericaceae is sporadic.

**DISCUSSION**

The changing frequencies of various arboreal and non-ARBORAL palynomorph assemblage within soil profile with absolute radiocarbon dates collectively reflect the succession of forest vegetation and corresponding climates within fluctuating monsoonal activity in the study area over a long span of time. Changing assemblage of the aquatic plants at different levels in the pollen sequence significantly infers the lake–level fluctuations/hydrological status of lakes/swamps, which is very much affected by the rainfall regime. Furthermore, the appearance as well as marked alterations in the cerealia pollen along with cultural pollen taxa is taken for the precise understanding of incipient agricultural practice and its subsequent pace in a definite time frame.

During the first phase (12,500–7,960 years BP), the tree–savannah type of vegetation grew in the region under cold and dry climate as is evident by the higher value of terrestrial nonarboreal elements, viz. grasses, Tubuliflorae, Liguliflorae and Apiaceae along with scattered open mixed deciduous and semievergreen elements like Combretaceae, Lauraceae, Salmalia malabaricum, Lagerstroemia and Ilex together with stray presence of Dipterocarpaceae. The occurrence of Potamogeton, Nymphaea and Nymphoides suggests the existence of perennial waterlogged condition during this phase. The high land taxa comprised of conifers (Pinus) and broad leaved elements (Alnus, Corylus and Ulmus) are growing in higher reaches of Arunachal Himalaya proves wind activity. The stable presence of the taxa, viz. Tsuga and Ericaceae suggests water flowing conditions from high altitude during this period.

Subsequently during the second phase (7,960–6,421 years BP), the mixed deciduous forest got enriched with the
immigration of some more tropical deciduous arboreals like *Semecarpus anacardium*, *Emblica officinalis* and *Dillenia pentagna*. Dipterocarpaceae got colonized as is evident by a relative rise in its frequency. Sharp declining trends in frequency of most of the terrestrial nonarboreal taxa have been observed. However, both marshy and aquatics especially Onagraceae, *Impatiens* and *Potamogeton* increased their value than the preceding phase. This vegetation change clearly depicts the formation of deciduous mixed forest along with vast stretches of swampy areas with wider perennial water logged conditions. The high land taxa (conifers and broad leave taxa) show continuously stable occurrence in the palynoassemblage in the sediment. The overall pollen assemblage suggests the onset of warm and humid climatic condition during this period. Pastoral activity is marked by the presence in traces of cereals and culture pollen taxa in the palynoassemblage.

During the third phase (6,421–4,270 years BP), the mixed deciduous forest got more enriched with dense tropical mixed deciduous arboreals as compared to the preceding phase. The arboreal taxa are same as the preceding phase but with their higher density, viz. Dipterocarpaceae, *Syzygium cumunii*, Arecaceae and Moraceae. The semievergreen taxa such as *Mesua ferrea* and Combretaceae are consistent as the preceding phase. The high land taxa are registered in persistent frequency. The frequencies of aquatic taxa are increased than the preceding phase and supporting good southeast monsoon. The overall pollen assemblage is suggestive of the warm and humid climatic condition during this phase.

During the fourth phase (4,270 years BP onwards), mostly the semievergreen and deciduous arboreals such as *Mesua ferrea*, Dipterocarpaceae, Arecaceae and *Syzygium cumunii* have decreased whereas, the terrestrial nonarboreal taxa have increased as compared to those present during the preceding phase. The decreased values of most of the aquatic pollens indicate decreased water logged conditions as well as weakened southeast monsoon than the preceding phase. Sudden decline in Onagraceae and *Impatiens* are also indicator of low precipitation. The shrubby taxa *Melastoma malabathricum* shows its peak during this phase suggesting the declining monsoonal activity and dryness during the phase. The sudden increase of Cerealia, Brassicaceae, Chenopodiaceae, Apiaceae and *Xanthium* implies high pastoral activity by the new settlers in and around the study area. The consistent presence of high land taxa supports long distance pollen transport along with high wind activity. The overall scenario is suggestive of the deteriorated mixed deciduous forest under warm and relatively dry climatic condition during this phase (Fig. 5).

Based on the investigations in lakes Didwana, Sambar and Lunkaransar (Singh et al., 1974, 1990), identified the following ecologically sensitive pollens, (i) *Artemisia*, an element of the > 50 cm annual rainfall regime, (ii) *Oldenlandia*, which is indicative of higher precipitation as it is found in sub humid and humid regions of NW India, (iii) *Typha*, a fresh water swamp taxon and (iv) *Syzygium cumunii*, indicative of > 850 mm average annual rainfall.

In this paper we have considered the marker pollen taxa to estimate monsoonal activity. The plant taxa Dipterocarpaceae, *Syzygium cumunii*, Arecaceae, Moraceae, *Impatiens* and aquatic taxa (*Nymphoides, Nymphaea, Potamogeton* and *Typha*) are considered as the high monsoonal marker pollen taxa and *Melastoma malabathricum* as the low monsoonal activity marker taxa to estimate the monsoonal activity (Singh et al., 1990; Barboni & Bonnefille, 2001), (Fig. 6). Results indicate that there was a fluctuation of monsoonal activity during the recent past. During the period 12,500 to 7,960 years BP, the monsoonal activity was relatively low as evidenced by low frequency of the high monsoonal activity marker taxa (Fig. 4). However, between 7,960 to 6,421 years BP, the monsoonal activity is increased than the preceding period as evidenced by increased frequency of marker pollen taxa in the pollen assemblage. From 6,421 to 4,270 years BP, the monsoonal activity is considerably higher than the preceding phase as marked by the high frequency of marker taxa, viz. Dipterocarpaceae, *Syzygium cumunii*, Arecaceae and Moraceae. Accordingly, during 4,270 years BP to present, the monsoonal activity relatively declined as suggested by the dominance of *Melastoma malabathricum* (sharply increased). The other marker taxa, viz. Dipterocarpaceae, *Syzygium cumunii*, Arecaceae and *Impatiens* also show lower percentage in the palynoassemblage thereby strongly supporting the weakened monsoonal activity.

It is quite important to note that since around 2,000 years BP, the monsoonal activity is strengthened in Indian Subcontinent, Arabian Sea and western Tibet (Phadtare, 2000). The carbon and oxygen isotopic records from the stalagmite in Xiangshui Cave, Guilin suggest that the Asian Monsoon was relatively stronger from 6,000 to 3,800 years BP and gradually weakening during the interval. However, since 3,800 years BP onwards, there is a relatively weak Asian Monsoon (Zhang et al., 2004). The South Asian monsoon in Holocene records reveal substantial regional differences (Staubwasser, 2006). More investigation with multiproxy palaeoclimate data are needed to find the precise and regional understanding of the palaeoclimate and vegetation in and around the study area.

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