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Vegetation and environment around Birsinghpur-Pali, Umaria District, Madhya Pradesh during recent past, based on pollen and fungal evidence

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ABSTRACT

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Pollen analysis of 90 cm deep sediment profile from Birsinghpur-Pali, Umaria District has revealed that in the beginning of the pollen sequence (Pollen Zone BP-I) encompassing a time span of approximately 350 to 175 years BP or so the area supported open vegetation largely comprising grasses, members of Asteraceae, Chenopodiaceae, etc. together with scattered trees viz., *Madhuca indica*, *Syzygium*, *Holoptelea*, *Symplocos*, *Emblica officinalis*, *Acacia* and *Grewia* under a warm and less-humid climate than today. Open vegetation is also substantiated by the abundance of fungal spore *Nigrospora* together with *Curvularia*, *Tetraploa*, *Diplocladiella*, Microthyriaceae cf. *Microthyium*, *Cookeina*, etc. since majority of them infect mainly the herbaceous plants. The retrieval of aquatic plants viz., *Potamogeton*, *Typha* and algal remains in low frequencies signifies the presence of a few ponds and small water bodies around the study site. This is also corroborated by the frequent encounter of mycorrhizal fungus; *Glomus*, which inhabits commonly the erosion prone lake bed. Subsequently since 175 years onwards (Pollen Zone BP-II), there was a reduction in the number of trees and they were trivially represented by *Madhuca indica*, *Bombax ceiba*, *Syzygium* and *Grewia* only. The ground flora also dwindled, though it was still dominated by grasses. The fungal diversity also declined, excepting the preponderance of *Nigrospora* and *Cookeina*. This depletion in the overall arboreals (trees & shrubs) and non-arboreals (herbs) elucidates that the deterioration of climate, probably on account of further reduction in precipitation. However, the encounter of crop land weeds such as Chenopodiaceae, Caryophyllaceae, *Cannabis sativa*, etc. suggests intensive human activities in the region.

Key-words: Palynology, Vegetation, Climate, Birsinghpur-Pali, Umaria (M.P.)

INTRODUCTION

Pollen and spores to be recovered in the sediment deposits are important proxy signals to infer the past vegetation and environmental change. They get deposited in the lakes and swamps mainly through water courses and provide the chronicle of sequential change in the vegetation in the region over a long span of time. In Madhya Pradesh, pollen analytical studies of sediment deposits have so far been conducted in eastern (Chauhan 1995, 2000, 2002, 2004, 2005, 2015, Chauhan & Quamar 2010, Chauhan et al. 2013, Yadav et al. 2006), central (Shaw et al. 2007) and southwestern (Chauhan & Quamar 2012a, 2012b) regions, furnishing insights into the changing vegetation scenarios and concurrent climatic alterations they have come across during the Late Quaternary Period in

response to deviating trend of southwest (SW) monsoon. Further, efforts have also been made to understand the temporal and spatial distribution of the prominent forest elements such as Sal (*Shorea robusta*) and teak (*Tectona grandis*) in relation to monsoon fluctuation during the Quaternary Period. In addition, the pollen sequences generated from the different regions of Madhya Pradesh have also enabled to understand the inception of agrarian practice and its later course as well as impact of anthropogenic activities on the natural resource in a definite time frame. In the present paper, an attempt has been made to unravel the vegetation and climatic changes as well as depositional environment of the sediments during the recent past through the meticulous pollen analytical investigation of a shallow sediment profile from Birsinghpur-Pali in Umaria District, Madhya Pradesh.

STUDY AREA

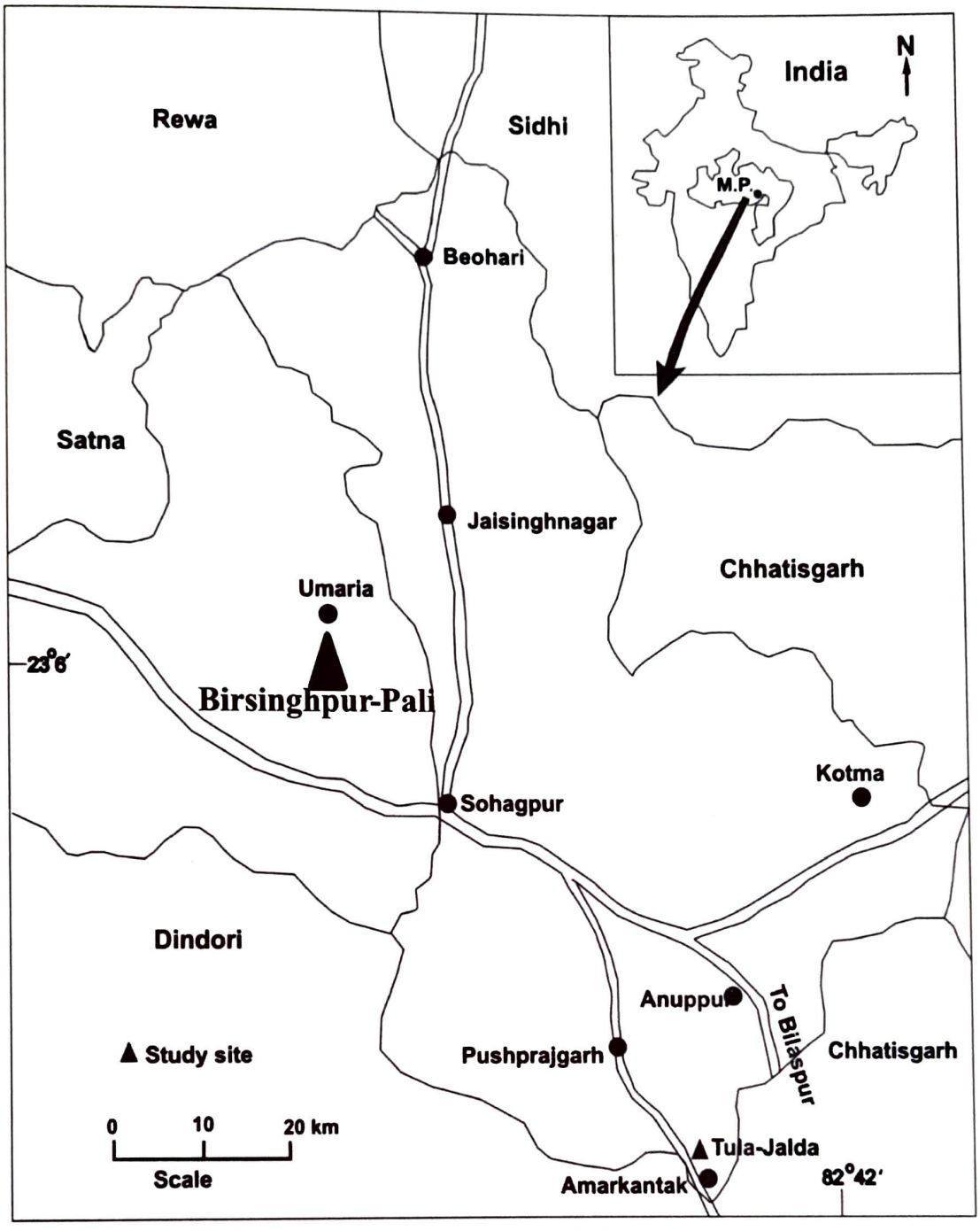
The study area, Birsinghpur-Pali is situated on Shahdol-Katni road about 30km northwest of Shahdol and 80 km south of Katni townships (Text figure 1) between 23°35´16´´ latitude & 81°04´84´´ longitude in Umaria District (M.P.). The investigation site is waterlogged due to subterranean water as well as a brooks flowing nearby. Physiographically; the region, in general, is marked by uneven landscape encompassing the flat land surfaces and hillocks with elevation varying from 360 to 471m msl. However, in certain areas deep gorges formed due to torrential streams and rivers are seen. The southern and northern parts are occupied by the bouldery hillocks with gentle slopes. Most of the area in and around the investigation site is under intensive cultivation by the densely inhabited tribals such as Gond, Bega, Panika and Kol tribals. Wheat (*Triticum aestivum*), barley (*Hordium vulgare*), rice (*Oryza sativa*) and sugarcane (*Saccharum spontaneum*) together with pulses such as arhar (*Cicer arietinum*), groundnut (*Arachis hypogaea*) and mustard oil seed (*Brassica campestris*) are the major conventional crops being cultivated by the local inhabitants. The adjoining hillocks with gentle slopes and flat tops support dense and widely distributed tropical deciduous Sal (*Shorea robusta*) forests.

CLIMATE

The area is characterized by seasonal climatic variability, which is largely influenced by southwest monsoon. The mean annual temperature ranges from 21°C to 31°C. The summer season from April to June is characterized by mean minimum and maximum temperatures of 31°C and 33°C respectively. However, the temperature shoots up to 46°C in the extreme hot month of June. The hot blowing winds known as 'loo' are common from mid-May to mid-June. The winter season from November to mid-February is marked by mean minimum and maximum temperatures of 16.3°C and 21°C respectively. The temperature descends to -1°C during the cold months of December and January. Monsoon season begins in mid-June and continues till mid-September. The average annual rainfall recorded for the region is 1,093 mm. The climate becomes very oppressive from mid-July to mid-September. The region witnesses sporadic rains in January-February due to winter monsoon as well as western disturbance.

VEGETATION

The region abounds with tropical moist deciduous Sal forests with *Shorea robusta* being the most prominent ingredients (Champion & Seth 1968). Besides *Shorea robusta* (Sal), *Madhuca indica*, *Syzygium cumini*, *Lagerstroemia parviflora*, *Careya arborea*, *Adina cordifolia*, *Gardenia latifolia*, *Terminalia arjuna*, *Anogeissus latifolia*, etc. are also common constituents of these forests. However, *Madhuca indica* and *Syzygium cumini* can be seen locally in appreciable numbers around the site of investigation. The shrubby vegetation includes mainly *Carissa opaca*, *Woodfordia fruticosa*, *Ziziphus mauritiana*, *Holarrhena antidysenterica*, *Premna mucranata*, *Xeromphis uliginosa*, *X. spinosa*, etc. However, the trees are sparsely distributed around the study site as most of the area there is densely inhabited and under intensive agricultural practice. *Madhuca indica*, *Lagerstroemia*, *Syzygium cumini*, *Diospyros melanoxylon*, *Ecalyptus globulus*, *Bauhinia retusa*, *Mangifera indica* and *Acacia nilotica* are common trees in the vicinity of the investigation site.



Text figure 1. Map showing the study site Birsinghpur-Pali, Umaria District.

The ground flora is predominantly constituted of grasses coupled with *Ageratum conyzoides*, *Mazus japonicus*, *Sida rhombifolia*, *Justicia simplex*, *Chenopodium album*, *Amaranthus spinosa*, *Nepeta indica*, *Micromeria biflora*, *Urena lobata*, *Oldenlandia dichotoma*, *Hyptis suaveolens*, *Crotalaria juncea*, *Desmodium gangetica*, *D. triflorum*, *Zornia gibbosa*, *Flemingia bracteata*, *Aeschynomene indica*, etc. in the terrestrial habitats. *Cyperus corymbosus*, *Scirpus mucronatus*, *Ammania baccifera*, *Rotala rotundifolia*, *Hygrophila auriculata*, *Justicia quinquangularis*, *Hydrocotyle sibthorpiodes* and *Ocimum americanum* occur luxuriantly over the swamps and marshes along the stream bank. *Typha latifolia*, *Nymphoides indica*, *Potamogeton purpurascens*, etc. are the aquatic plants of lakes and ponds. Ferns such as *Dryopteris prolifera*, *Adiantum philippensis* and *Diplazium esculentum* along with lycopods viz., *Selaginella semicordata*, *Lycopodium cernuum* etc. are preponderant in moist and shady habitats.

MATERIAL AND METHODS

A 90 cm deep trench was dug on the less-water logged intact swampy margin at the study site, Birsinghpur-Pali in Umaria District for the present investigation. In all, 9 samples measuring 200 gram were picked up at 10 cm intervals from the trench for pollen analysis. The profile is uniformly composed of shallow clayey-sand deficient in organic matter in variable amount throughout. However, a few rootlets and other plant debris of the vegetation growing over the swamp were noticed in the top part (0-15 cm depth) of the sediment profile. The sediment profile is homogeneously composed of much fragile clayey-sand, constituting the major fraction, with trace of coarse sand in the lowermost horizon. Beyond the depth of 90cm, the sediment deposit is entirely constituted of coarse sand, devoiding organic matter; hence, further sampling was abandoned as the sediment was not feasible for pollen analytical investigation. The overall nature and texture of the sediment deposit implies that sedimentation occurred under a high energy environment. Hence, it is supposed the deposit to be very recent, covering the time span of last 350 years, if the sedimentation rate 1cm/3.7 years at 135-0 cm depth of the earlier analysed sediment core from the nearby Kiktiha Swamp in Shahdol District is taken into consideration (Chauhan & Quamar 2010).

Ten gram samples were boiled in 10% aqueous KOH solution for 5 minutes to deflocculate the pollen and spores from the sediments and to dissolve the humus. The samples were washed thrice with distilled water by decantation in order to remove the alkali. This is followed by treatment of the samples with 40% HF solution to dissolve the silica. Thereafter, the samples were acetolysed (Erdtman 1943) using acetolysing mixture (9:1 ratio of acetic anhydride and concentrated Sulphuric acid, respectively). Finally, the samples were prepared in 50% glycerin solution for microscopic observations. A few drops of phenol were added in the samples to avoid the microbial degradation of pollen/spores.

POLLEN ANALYSIS

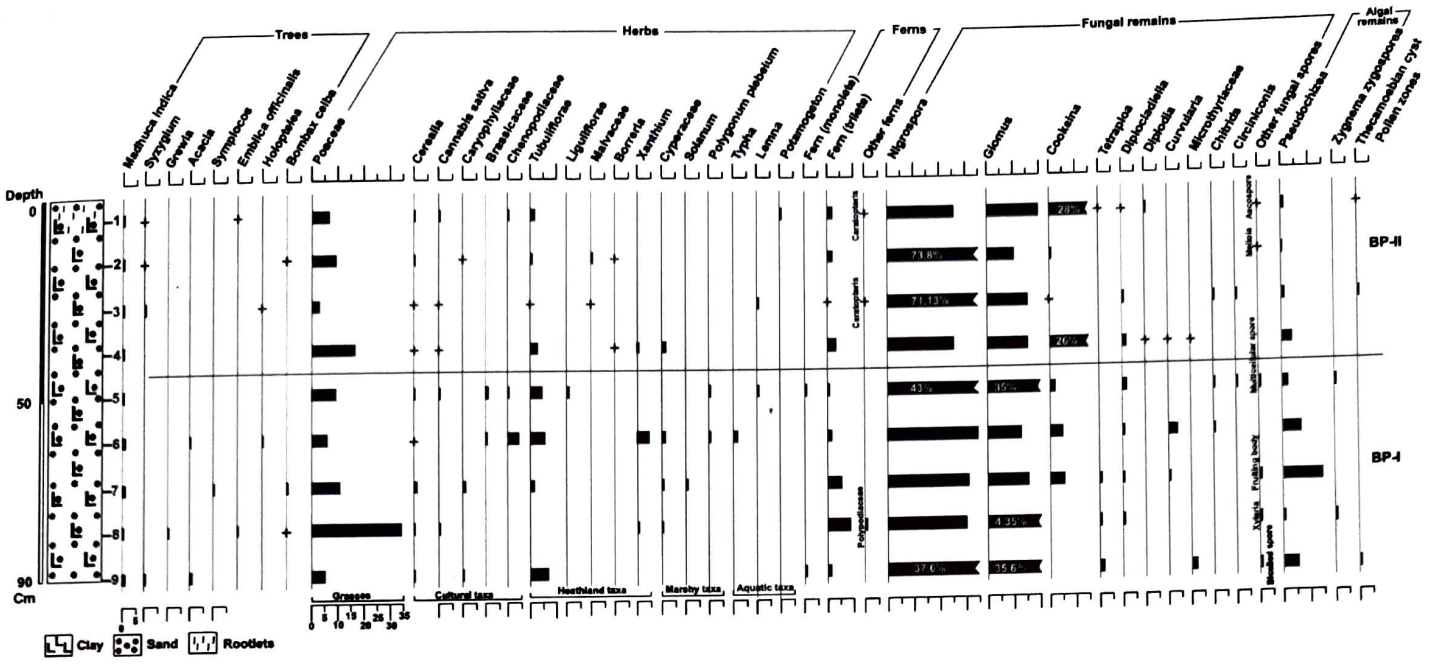
All the samples analysed were found prospective in pollen and spore content. The pollen sums range from 150 to 200, depending upon their yield and comprise the pollen and fern spores recovered. The percentage frequencies of the recovered palynomorphs have been calculated in terms of total plant pollen and fern spores retrieved. The fungal remains/spores have been recorded very preponderantly in the samples; hence, they have been excluded from the pollen sums owing to their origin from the local provenance. The appropriate identification of fossil palynomorphs including pollen, fern spores and algal remains (Plates 1 & 2) in the sediments was carried out by consulting the reference pollen slides available at the sporothek of BSIP Herbarium as well as the pollen/spore photographs in the published literature (Nayar 1990, Chauhan & Bera 1990, Chauhan & Sharma 1991, Singh & Chauhan 2008). The plant taxa categorized as trees, shrubs, herbs, ferns, fungal spores and drifted and have been arranged in the same manner in the pollen diagram (Text figure 2). Further, the non-arboreals have also been sub-grouped as grasses, cultural taxa; heathland, marshy and aquatic herbs for the better understanding of the local vegetation changes and anthropogenic impact in the region. The plant taxa with pollen frequencies of < 0.5% are indicated by '+' sign in the pollen diagram.

Description of pollen diagram:

The pollen diagram from Birsinghpur-Pali has been divided into two pollen zones (BP-I & BP-II), taking into account the fluctuating frequencies of arboreals (trees & shrubs) and non-arboreals (herbs). They are pre-fixed with the initials 'BP' after the name of study site-Birsinghpur-Pali and are numbered from bottom to top (Text figure 2). The pollen/spore composition of the pollen zones is as below:

Pollen Zone BP-I (90-45cm): *Poaceae-Tubuliflorae-Cyperaceae-Madhuca indica-Acacia-Fern (trilete)-Nigrospora-Glomus-Cookeina assemblage*

The pollen assemblage recovered in this zone with time interval of 350 to175 years BP, in general, shows the dominance of non-arboreals (herbs) over the arboreals (trees & shrubs). The trees are few and are represented in extremely low frequencies. Among them *Madhuca indica* (1-2%) is consistently recorded



Text figure 2. Pollen diagram from Birsinghpur-Pali, Umaria District.

throughout with low to moderate values. Other trees such as *Acacia* (1.7%), *Syzygium* (1.5%), *Bombax ceiba* (0.45-1%), *Emblica officinalis*, *Holoptelea* and *Grewia* (1% each) are encountered sporadically in low frequencies.

Among the non-arboreals, Poaceae (10-35%) is characterized by its steady presence with appreciable frequencies. Tubuliflorae (0.88-5.5%) and Cerealia (0.5-1.76%) are also recorded in good frequencies. Others such as *Cannabis sativa* (0.5-0.66%), *Xanthium strumarium* (0.5-3.87%), Chenopodicaceae (0.5-3.87%), Brassicaceae (0.5-0.77%) and Caryophyllaceae (0.5-1.76%) are met with sporadically. Liguliflorae (0.5%) is recovered in one sample only. The wetland taxa viz., Cyperaceae (0.88-1.98%) and *Polygonum plebeium* (0.5-0.77%) are better represented compared to and *Solanum* (0.88%), which is stray. The aquatic elements such as *Typha* (3.87%) and *Lemna* (0.5%) are meagerly present in one sample each. Fern trilete spores (0.5-8.6%) are steadily encountered throughout. Fern monolete spore (0.5-1%) and Polypodiaceae (1.32%) noticed very sporadically.

The algal remains *Pseudoschizea* (1.32-14.6%) is very frequent, whereas *Zygnema* (0.5-0.66%) together with thecamoebian cyst (1%) are lowly present.

The fungal spores assemblage demonstrates the abundance of *Nigrospora* (29.76-43%) followed by *Glomus* (17.8-43.5%). *Cookeina* (1.5-6.1%), *Diplocladeilla* (0.77-2%) and *Tetraploa* (0.66-2.09%) are met with sporadically. *Curvularia* (0.88-3.87%) and Chitrids (0.77-1.4%) are sporadic. Microthyriaceae cf. *Microthyrium* (1.5%), *Xylaria* (0.66%) and *Circiniconis* (0.5%) are occasional.

Pollen Zone BP-II (45-0cm): *Poaceae-Tubuliflorae-Cannabis sativa-Fern (trilete)-Madhuca indica-Nigrospora-Glomus-Cookeina-Diplocladiella assemblage*

This pollen zone with a time bracket of 175 years BP to present demonstrates the decline in the number and frequencies of both arboreals and non-arboreals. *Madhuca indica* (0.69-1.44%) retains its steady presence among the trees, though with reduced frequencies than seen in the preceding half. *Syzygium* (0.36-0.69%) shows some improved values. However, others are few and are feebly represented by *Bombax ceiba*, *Emblica officinalis* and *Grewia* (0.48% each) with extremely low values.

Poaceae (2.08-15.5%) is constantly recorded with relatively low values than in the preceding pollen zone together with by Tubuliflorae (0.34-3.39%). The cultural taxa viz., Cerealia (0.48-0.69%), Caryophyllaceae

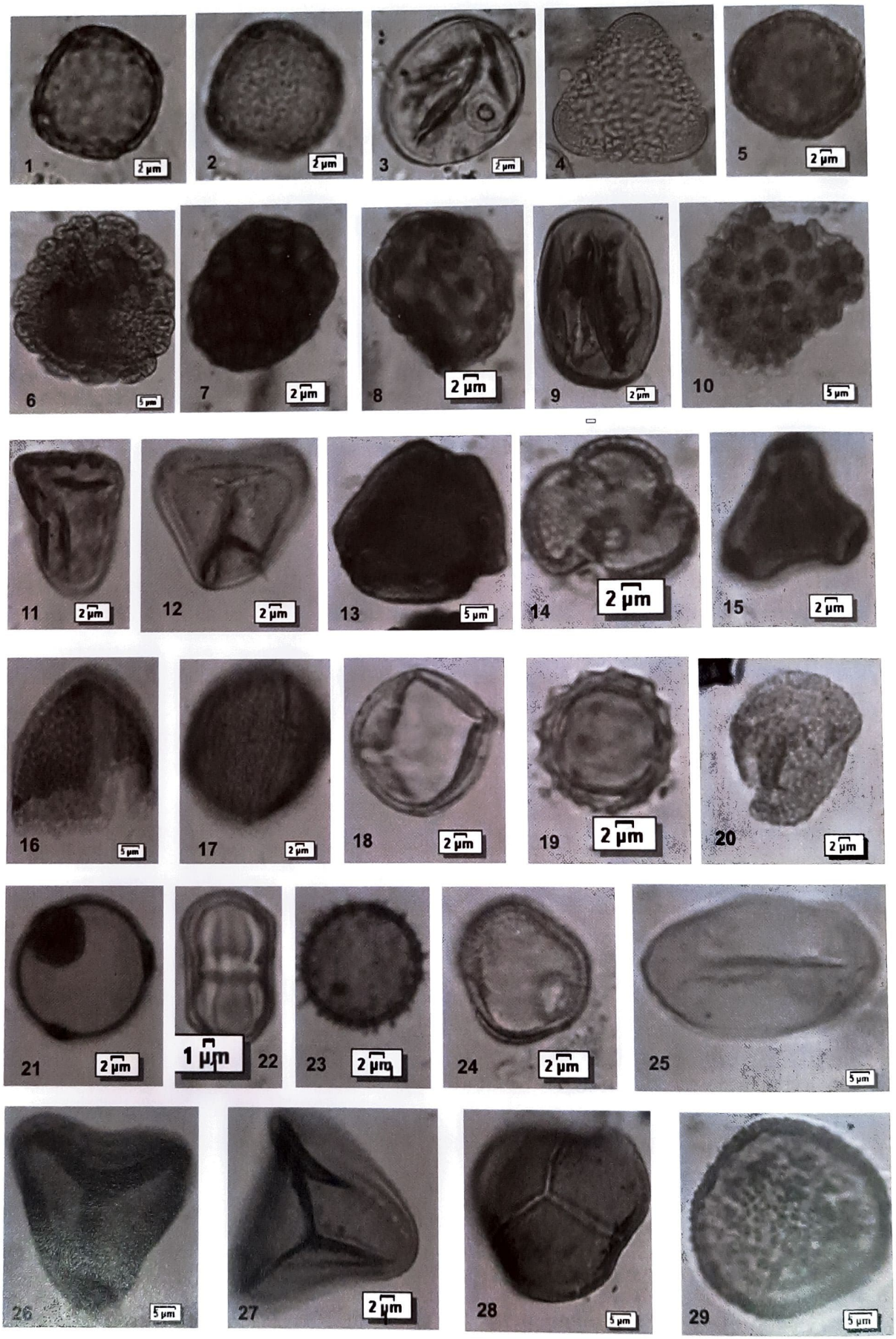


Plate 1

1 & 2. *Holoptelea*, 3. Poaceae, 4. *Bombax ceiba*, 5. *Emblica officinalis*, 6. *Borreria*, *Chrozophora*, 7. *Acacia*, 8. Chenopodiaceae, 9. *Madhuca indica*, 10. Malvaceae, 11. Cyperaceae, 13. *Symplocos*, 14. Brassicaceae, 15. *Syzygium*, 16 & 17. *Grewia*, 18. *Solanum*, 19. Tubuliflorae, 20. Caryophyllaceae, 21. *Cannabis sativa*, 22. *Polygonum plebeium*, 23. *Lemna*, 24. *Typha*, 25. Fern (monolete spore), 12 & 26-28. Fern (trilete spores), 29. Lycopod spore.

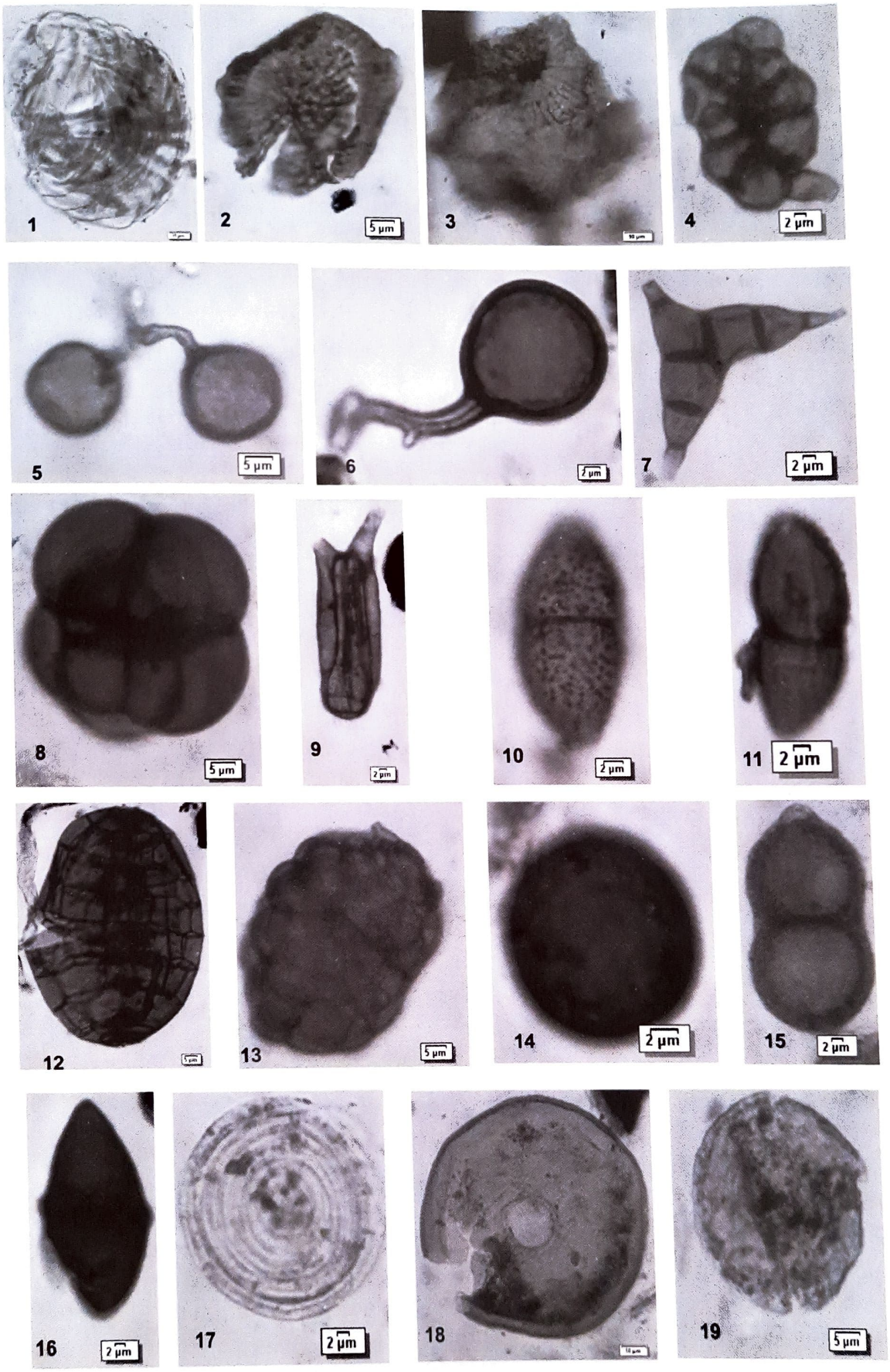


Plate 2

1. *Ceratopteris*, 2. Microthyriaceae cf. *Microthyium*, 3. Microthyriaceae Type-I bodies, 4. Cleistothicium, 5 & 6. *Glomus*, 7. *Diplocladiella*, 8. Multicellular fungal spore Type-I, 9. *Tetraploa*, 10 & 11. Ascospore Type-I, 12. Multicellular fungal spore Type-II, 13. Multicellular fungal spore Type-III, 14. *Nigrospora*, 16. *Xylaria*, 16. Ascospore Type-II 17. *Pseudoschizea*, 18. Thecamoebian cyst, 19. Unidentified Type-II.

(0.36%) and *Cannabis sativa* (0.34-0.96%) are better represented with reduced frequencies. The heathland taxon, *Xanthium strumarium* (0.97%) is scarce, while Malvaceae (0.34-1.47%) and *Borreria* (0.36%) appear scantily for the first time. The marshy taxon; Cyperaceae (1.45%), the only representative of marshy vegetation, is encountered in one sample only. The aquatic elements viz., *Lemna* and *Potamogeton* (0.69% each) are rare. The algal remain, *Pseudochizea* (1-5%) also decline sharply in this pollen zone. Fern trilete spores (0.34-5%) have reduced values in contrast to preceding pollen zone. However, *Ceratopteris* (0.34%) is met with for the first time in this zone.

The fungal remains, *Nigrospora* (25.2-73.8%) and *Glomus* (9.5-20.7%) are consistently present in relatively low frequencies compared to preceding pollen zone. *Cookeina* (0.34-285) is also met with increased values. *Diplocladeilla* (0.48-2.42%), *Circiniconis* (0.69%), *Tetraploa*, *Curvularia* and Microthyriaceae cf. *Microthyrium* (0.48% each) are very infrequent. *Meliola* (0.36%) and *Diplodia* (0.48-0.98%) are noticed scantily for the first time. In addition, Ascospores (0.48-0.66%), bi-celled (0.73-1.50), four-celled (0.96%), multi-celled spores (0.5%) and multicellular fruiting body (0.88%) are also recorded meagerly.

DISCUSSION

Pollen analytical investigation of 90 cm deep trench profile from Bisinghpur-Pali, Umaria District has brought out some significant information concerning vegetation and climate change in the region during recent past, based on pollen and spores retrieved in the sediments. The pollen assemblage recovered reveals that during 350 to 175 years BP the vicinity of the study site supported open vegetation comprising the dominance of grasses followed by Tubuliflorae and sporadic presence of other terrestrial heathland herbs such as *Xanthium strumarium*, Malvaceae, etc. A few trees such as *Madhuca indica*, *Syzygium*, *Grewia*, *Emblica officinalis*, *Holoptelea*, *Acacia* and *Symplocos* occurred scatteredly distributed upon the open herbaceous complex. However, the consistent encounter of *Madhuca indica*, though in low frequency, in contrast to other trees depicts its frequent presence in the region as it is conserved by the local inhabitants for its multifaceted use. In general, the sparse arboreal (trees & shrubs) vegetation implies that the region experience a warm and less-humid climatic condition during the recent past, encompassing the early phase of the pollen sequence (Pollen Zone BP-I). From the uniform texture and loose nature of the sediments throughout the trench profile it is inferred that the fast deposition of sediments largely under the pluvial environment, covering the shorter span of time of about last 350 years or so since the onset of sedimentation. The ground vegetation was largely composed of grasses and other herbaceous elements. The existence of open grassland vegetation is also well corroborated by the preponderance of fungal spore, *Nigrospora* and record of *Tetraploa*, *Diplodia* and *Curvularia*, *Circiniconis*, *Cookeina*, etc. in variable frequencies since they are usual pathogens of grasses and other herbaceous elements. Their record in the sediments also suggests the accumulation of good amount of litters and decomposed organic matter in the region during the period of sediment accumulation. The sporadic encounter of wetland elements such as sedges (Cyperaceae) and *Solanum* coupled with the aquatic taxa such as *Typha*, *Lemna* and *Potamogeton* as well as frequent record of algal remains, *Pseudoschizea* coupled with *Zygnema* and thecamoebian cysts implies the intermittent presence of the marshes with ponds and ditches interspersed with the open vegetation around the study site. Interestingly, the abundance of mycorrhizal fungus, *Glomus* deduces the frequent presence of saline-alkaline marshy lands and lakes, ponds and ditches with erosion prone margins in the vicinity of study site since it propagate well in such habitats (Raghuwanshi & Upadhyay 2010). The consistent retrieval of Cerealia along with other culture pollen taxa denotes that the region was under cereal-based agricultural practice. The area adjoining to the investigation site was also under some other kind of human activity. This is evidenced from the retrieval of cropland weeds viz., *Cannabis sativa*, Caryophyllaceae, Brassicaceae and Chenopodiaceae, which grow frequently in the proximity of cultivated land and the human settlement.

However, in the subsequent phase covering the time span of 175 years BP to present (Pollen Zone BP-II), the trees declined sharply and were represented by sporadic occurrence of *Madhuca indica*, *Bombax ceiba*, *Syzygium* and *Emblica officinalis* only, reflecting the further deterioration of climatic condition, which did not favour the propagation of trees. Likewise, the ground flora also turned sparser than before. The scanty record of wetland elements of sedges and aquatic taxa in contrast to earlier phase also substantiates the prevalence of such climatic conditions in the region during this phase. This degradation of the overall vegetation could also be consequence of augmentation of anthropogenic impact in the region during the recent past. The agrarian activities sustained at low intensity, as reflected by the relatively reduced frequencies of Cerealia and other concomitant cropland weeds than before.

CONCLUSION

Based on the pollen/spore evidence retrieved through the investigation of 90 cm deep trench profile from Birsinghpur-Pali, Umaria District, the following inferences have been drawn pertaining to the vegetation and climate changes in the northeastern Madhya Pradesh during the recent past covering the time period of last 350 years or so.

The pollen analytical studies have deduced that during the early part (Pollen Zone BP-I) encircling the interval of 350 to 175 years BP, the vicinity of the study site supported the open vegetation largely dominated by grasses and members of Asteraceae (Tubuliflorae) with scarcely distributed few trees under a region of warm and less-humid climatic condition.

The recovery of plentiful fungal remains such as *Nigrospora*, *Tetraploa*, *Cookeina*, *Diplodia*, etc. also validates the existence of open grassland vegetation in the ambience of study site, since majority of them are pathogens of grasses and other herbaceous elements. The abundance of mycorrhizal fungus, *Glomus* denotes the area was interspersed with marshy land, ponds, ditches and other kind of water bodies as this fungus thrives well on the erosion prone lake margin.

The area was under human habitation, which is evidenced from the record of Cerealia and other culture/ concomitant cropland weeds such as *Cannabis sativa*, Chenopodiaceae, Caryophyllaceae, etc.

Since 175 years BP to present (Pollen Zone BP-II), the decline in the trees coupled with grasses and other herbaceous elements signifies the deterioration of climate most likely due to reduced monsoon precipitation. The degradation of overall vegetation could also be attributed to the increasing human impact in the region during the recent past.

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