

Late Holocene vegetation and climate of Kusumelli Swamp in Sehore District, Madhya Pradesh, India

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ABSTRACT

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The present study focuses on the palynological analysis of 1 m deep sediment trench profile from Kusumelli Swamp, in Sehore District, Madhya Pradesh, providing information on vegetation and climate in the region since Late Holocene. The pollen sequence reveals that the central Narmada valley supported tree-savannah vegetation between 4,000-3,100 yr BP under cool and dry climate, which was transformed into open mixed deciduous forest between 3,100 to 1,350 yr BP as a consequence of onset of a warmer and wetter climate. From 1,350 yr BP onwards, the association of tree taxa suggests growth of dry deciduous trees with inter-dispersed moist tree taxa and shrubs under climate more or less similar to that of present day.

Key-words: Pollen analysis, Late Holocene, vegetation, climate, Kusumelli Swamp, Sehore District, central Narmada Valley, Madhya Pradesh, India.

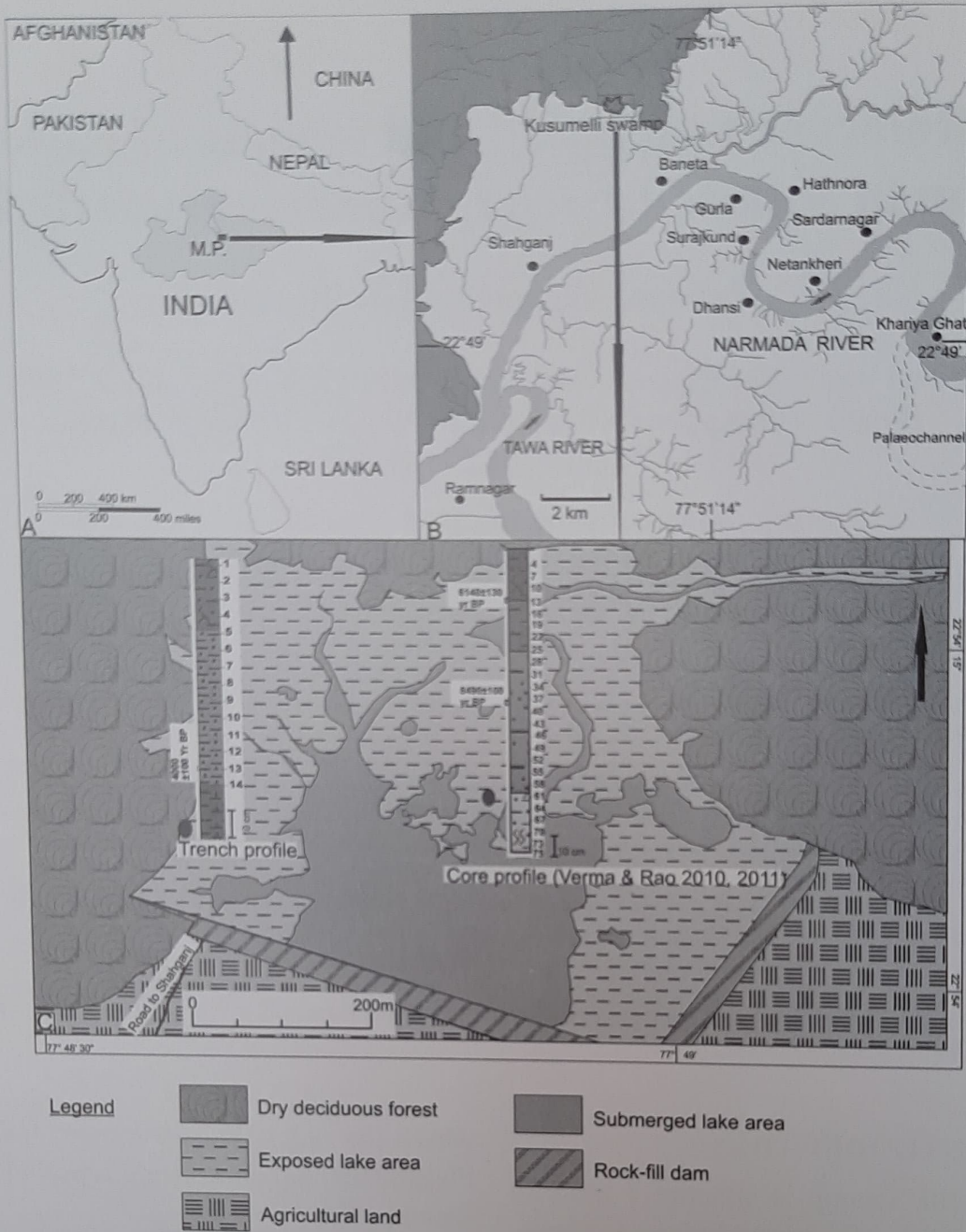
INTRODUCTION

The Kusumelli Swamp is situated 7 km NE of Shahganj, in Sehore District, Madhya Pradesh. It is a perennial swamp (Lat. 22°54'05.5"N, Long. 77°48'39"E), fed by subterranean water, surrounded by dry deciduous forest and agricultural land. Verma and Rao (2010, 2011) published palynological study of a sediment core (11,900 to 5100 yr BP) from this swamp and provided climate and vegetation history. In continuation, an attempt is being made here to infer vegetation and climate changes since last 4,000 years through the pollen analytical investigation of 1 m deep sediment trench profile from the same swamp, about 300 m west of the earlier one (Text-figure 1). The study area lies in the vicinity of a hominin site (Hathnora) in the central Narmada Valley from

where the oldest known human fossil of middle Pleistocene age has been reported (Sonakia & Biswas 1998).

CLIMATE AND VEGETATION

The climate of Narmada Basin is humid tropical, although at places extremes of heat and cold are often registered. The overall climate of Madhya Pradesh is classified broadly into four seasons; Winter (January–February), Hot summer (March–May), Rainy south western monsoon (June–September) and Post-monsoon (October–December). The mean monthly temperature and precipitation data from AD 1901–1997, available at Hoshangabad climate station (Lat. 22°46'N, Long. 77°46'E) show that May and December–January are the hottest (34.4°C) and coldest



Text-figure 1. A. Map of India showing study area in Madhya Pradesh. B. Location of Kusumelli Swamp near Shahganj (modified after Patnaik et al. 2009). C. Satellite map showing position of trench and core in Kusumelli Swamp, Sehore District, Madhya Pradesh.

(19.1°C) months respectively. About 92.8% of the annual rainfall (1,225.9 mm at Hoshangabad) is received during southwest monsoon seasons and only 7.2% of the annual rainfall takes place during October to May.

The region represents the tropical dry deciduous forests along the Narmada river valley and the edging Vindhyan Range. According to Champion and Seth (1968), the study area is marked by TYPE 5A/C1b dry teak forests and TYPE 5A/C3 southern dry mixed deciduous

forests. Teak (*Tectona grandis*) is a ubiquitous species in the region, with a presence ranging from a sporadic distribution in most parts of the study area to localized teak-dominated patches. Teak and associated taxa such as *Madhuca indica*, *Diospyros melanoxylon*, *Terminalia tomentosa*, *Holoptelea* sp., *Buchanania lanzan*, *Lagerstroemia parviflora*, *Ougeinia dalbergoides*, *Hardwickia binata*, *Miliusa velutina* and *Lannea coromandelica*. *Acacia* spp. and *Ziziphus mauritiana* occur on flat terrain. The undulating terrain and hill slopes have

patches of mixed forest dominated by *Boswellia serrata* and *Anogeissus latifolia*. Species like *Sterculia urens* and *Gardenia latifolia* are found scattered on rocky slopes. Bamboo forests occur in the hill slopes and along streams. Some of the open patches of the study area are covered with tall grasses interspersed with *Butea monosperma* and *Ziziphus mauritiana*. Evergreen tree species like *Terminalia arjuna*, *Syzygium cumini* and *Ixora parviflora* are found in riparian vegetation along channels and river banks.

MATERIAL AND METHOD

Samples were collected from 1 m deep trench profile of Kusumelli Swamp. The lithology mainly consists of 25 cm black carbonaceous clay with rootlets at the top underlain by 55 cm black carbonaceous clay followed by calcareous sandy clay (~20 cm) at the base. A total of 14 samples were collected at every 5 cm for pollen analysis by making 30 cm wide trench. One bulk sample was collected at the depth of 73-75 cm for radiocarbon dating and it has been dated to 4,000±100 yr BP at ¹⁴C Laboratory, Birbal Sahni Institute of Palaeobotany, Lucknow. On the basis of sediment accumulation rate of 1 cm/47 years in the swamp (Verma & Rao 2011), the interpolation of dates, i.e., 3,100, 1,350, 377 yr BP, has been done to date the pollen zone boundaries at 62 cm, 26 cm and 2 cm depth respectively.

The samples were treated with 10% KOH solution and 40% HF in order to remove humus and silica present in the sediments respectively. Thereafter, the conventional method of acetolysis (Erdtman 1943), using acetolysis mixture (9:1, acetic anhydride and conc. H₂SO₄) was followed. The samples were prepared in 50% glycerin solution for microscopic examinations.

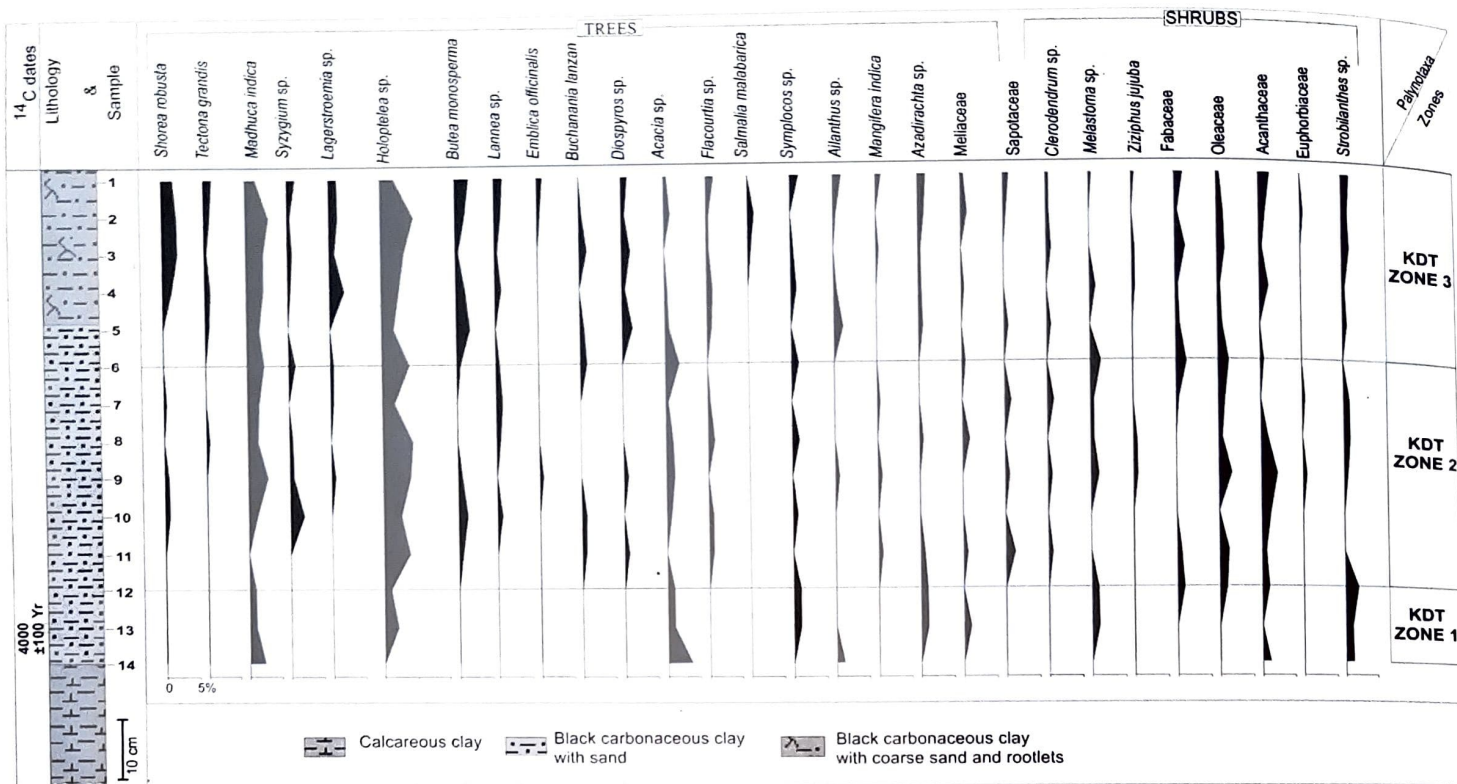
POLLEN ANALYSIS

The number of spores and pollen counted for each sample ranges from 160 to 400, depending upon potential of samples. The percentage frequencies of the recovered pollen taxa including

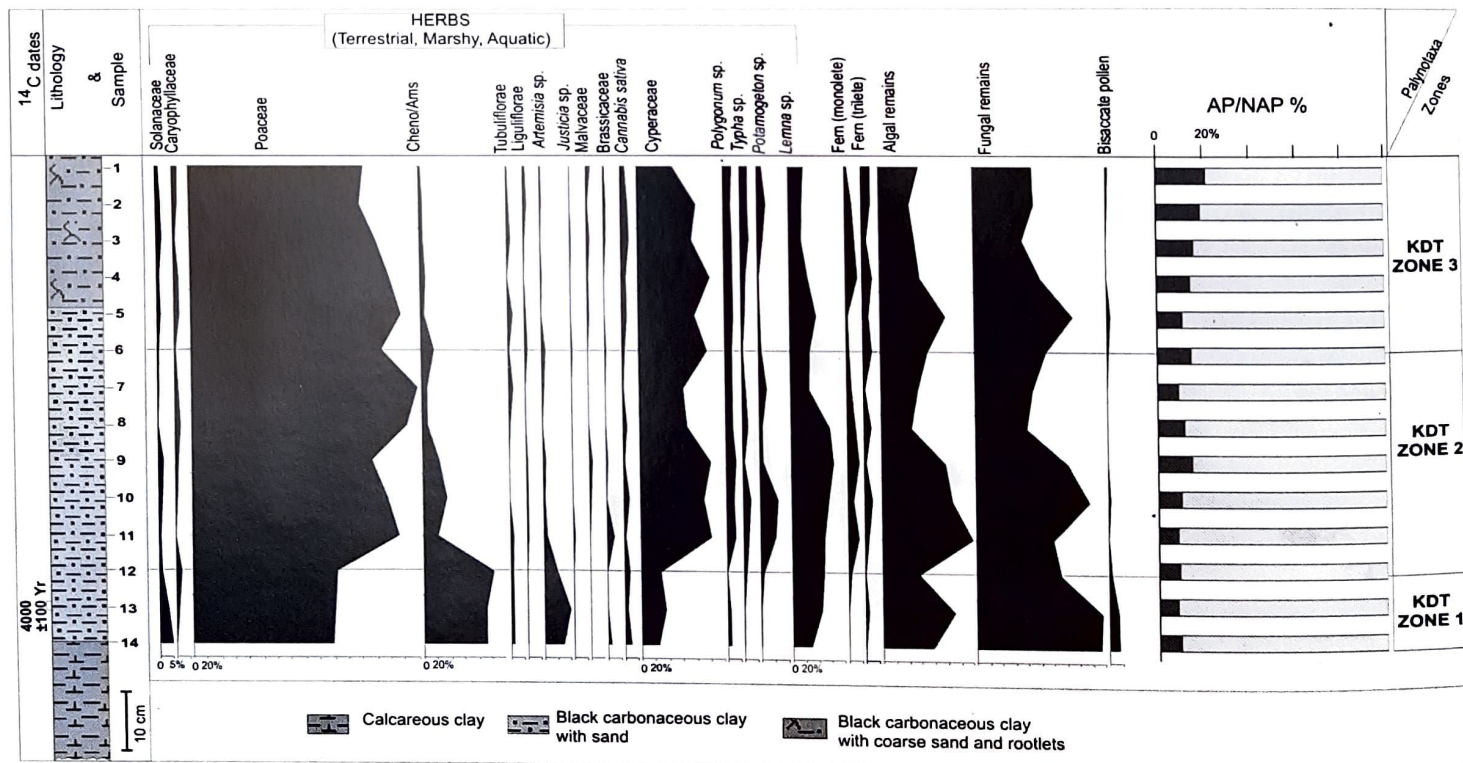
fern spores have been calculated in terms of total terrestrial plant pollen. The palynomorphs are grouped in the following order: trees, shrubs, herbs, ferns and algal and fungal remains. Based on the relative fluctuation in the arboreal and non-arboreal pollen, the pollen diagram of Kusumelli Swamp profile has been divided into three pollen zones, i.e. KDT 1 to KDT 3 (Text-Figures 2, 3).

Pollen zone KDT 1: This pollen zone, with a temporal range of 4,000 to 3,100 yr BP, exhibits low diversity of arboreal taxa in contrast to non-arboreals. Arboreal pollen taxa are represented by *Acacia* sp. (1-3.6%), *Madhuca indica* (1-2.4%), *Holoptelea* sp. (0-2.2%), *Terminalia* sp. and *Ailanthus* sp. (0-1.2% each), *Symplocos* sp., *Azadirachta* sp. and Meliaceae (1% each). Shrubs, viz. *Melastoma* sp., members of Acanthaceae and Oleaceae (1% each) are sporadically recorded. The zone is dominated by grasses (49-51.5%), followed by Chenopodiaceae /Amaranthaceae (22-25.8%) and *Artemisia* sp. (5-10%), while other herbs are meagerly present. The marshy element, such as Cyperaceae (6-9%), has relatively much higher values than *Polygonum plebeium* (~1%) which is scanty. Among aquatic elements, *Lemna* sp. (7.2-12.4%) is recorded in moderate to high values, whereas *Typha* sp. and *Potamogeton* sp. (~1% each) are extremely sporadic. The ferns are meagerly represented whereas algal and fungal remains are dominant.

Pollen zone KDT 2: This pollen zone encompassing the time-lag of 3,100 to 1,350 yr BP is marked by the re-emergence of both moist and dry deciduous trees (with sporadic and minor frequencies) such as *Tectona grandis*, *Shorea robusta*, *Lagerstroemia* sp., *Diospyros* sp., *Lannea coromandelica*, *Buchanania lanzan*, *Flacourtia* sp., *Mangifera indica*, *Azadirachta* sp., *Emblia officinalis*, Meliaceae (~1% each), *Syzygium* sp., *Butea monosperma* and *Acacia* (~2% each) whereas *Terminalia* sp. (0.5-2%), *Madhuca indica* (0-3.1%) and *Holoptelea* sp. (1.8-4.8%) attain higher values. In addition, low frequency of Chenopodiaceae/Amaranthaceae (1.3-8.5%)



Text-figure 2. Pollen diagram showing arboreal pollen from Kusumelli Swamp, Sehore district, Madhya Pradesh.



Text-figure 3. Pollen diagram showing non-arboreal pollen/spores from Kusumelli Swamp, Sehore district, Madhya Pradesh.

and *Artemisia* sp. (0-1.6%) with high frequencies of grasses (64-80.5%) and sedges (15.8-25.5%) are also observed. The aquatic elements and fern spores show average values of 3.8% and 2.2%

respectively.

Pollen zone KDT 3: This zone, with time bracket of 1,350 to 377 yr BP, shows increased frequencies of dry deciduous trees, viz. *Tectona*

grandis (1.4-2.4%), *Holoptelea* sp. (2.1-5%), *Madhuca indica* (1.7-3.6%), *Butea monosperma* (0.4-2.1%), *Diospyros* sp., *Flacourtia* sp., *Buchanania lanzan*, *Terminalia* sp., *Lannea coromandelica* (0.5-1.2% each) and *Embllica officinalis* (1%). The moist deciduous elements also burgeoned, such as *Shorea robusta* (0.9-1.2%), *Salmaalina* (0.9%), *Lagerstroemia* sp. (0.8 -2.3%), *Syzygium* sp. (0.5-1.2%), etc. The associated shrubs show more or less similar frequencies as in the earlier zone. The accompanying Chenopodiaceae/ Amaranthaceae (0.8-2.3%) and grasses (62-71.2%) are reduced, whereas other herbs such as members of Solanaceae, Caryophyllaceae, Tubuliflorae, Liguiliflorae, Malvaceae, Brassicaceae and *Artemisia* sp., *Justicia* sp. and *Cannabis sativa* are recorded with an average of 1%. The sedges (Cyperaceae 12.8-26%) and other aquatics (average 2.8%) show fluctuating frequencies. The ferns and algal-fungal remains are also recorded copiously.

RESULTS AND DISCUSSION

The Kusumelli Swamp has already been investigated for early to Middle Holocene vegetation and climate change records from central Narmada Valley (Verma & Rao 2010, 2011). The core samples from deeper central part of swamp exhibited presence of mixed moist deciduous forest in the area suggesting maximum vegetational concentration and diversity during 11 to 8 ka yr BP under warm and humid climate. Subsequently the tree savannah type of vegetation developed in between 8 to 7 ka yr BP, under relatively cool and dry climate. After that, existence of dry to moist deciduous forest have been recorded during 7 to 5 ka yr BP under warm and humid climatic condition (Verma & Rao 2010, 2011).

In continuation of the previous studies, 1 m deep trench profile has been investigated to get the vegetation vis-a-vis climate changes in region between 4000 yr BP to present. The pollen/spore assemblage recovered from present profile from Kusumelli Swamp reveals that around 4000 yr BP the region supported tree-savannahs,

which chiefly comprised grasses, members of Asteraceae, Chenopodiaceae/Amaranthaceae and Malvaceae along with sparsely distributed trees, viz. *Holoptelea* sp., *Symplocos* sp. and *Terminalia* sp. under cool and dry climate progressing towards an amelioration trend.

Subsequently, around 3,100 to 1,350 yr BP, both the moist and dry deciduous trees such as *Tectona grandis*, *Shorea robusta*, *Lagerstroemia* sp., *Diospyros* sp., *Lannea coromandelica*, *Buchanania lanzan*, *Flacourtia* sp., *Mangifera indica*, *Azadirachta* sp., *Embllica officinalis*, Meliaceae, *Syzygium* sp., *Butea monosperma* and *Acacia* sp. appeared which increased the total diversity of flora. In addition, *Terminalia* sp., *Madhuca indica* sp. and *Holoptelea* sp. also portray the increased frequencies. The floristic composition envisages that tree savannahs were transformed into open mixed deciduous forests. The depletion in Chenopodiaceae/Amaranthaceae, accompanied by profound occurrence of grasses, exhibits amelioration of climate, which became warmer and wetter with improved SW monsoon from 3,100 to 1,350 yr BP.

From 1,350 onwards, the floristic composition shows improving trends of vegetation enhancement towards edifice of dry deciduous forests. The recuperated growth of dry deciduous trees, such as, *Tectona grandis*, *Holoptelea* sp., *Madhuca indica*, *Butea monosperma*, *Diospyros* sp., *Flacourtia* sp., *Buchanania lanzan*, *Terminalia* sp., *Lannea coromandelica* and *Embllica officinalis* with inter-dispersed moist trees and shrubs suggest that climate gradually changed to more warm and humid coupled with active inception of south west monsoon, i.e. more or less similar to the climatic condition prevailing today.

CONCLUSION

Three phases of change in vegetation and climate have been demarcated since 4,000 yr BP in Kusumelli Swamp, central Narmada Valley, Madhya Pradesh. Pollen zone KDT 1 (4,000 to 3,100 yr BP) suggests cool and dry climate. Pollen zone KDT 2 (3,100 to 1,350 yr BP) exhibits

evidence of warming with invigoration of SW monsoon, which influenced augmentation of mixed deciduous forest. Pollen zone KDT 3 (1,350 yr BP to present) suggests change of vegetation to dry deciduous forest under more or less similar to present day climatic conditions.

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