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Modern pollen-vegetation relationship as an adjunct in the interpretation of fossil pollen records in the Chilka Lagoon, Odisha, India

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ABSTRACT

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In the present investigation, an attempt has been made to evaluate modern pollen-vegetation relationship in the surface sediments of the Chilka Lagoon, Odisha. The ecosystem of the Chilka Lagoon has remained unique throughout its existence and the data generated from the analysis of surface sediments can be used for the interpretation of palynological results in terms of past vegetation and climate around the Chilka Lagoon. The palynological investigations exhibited the dominance of midland taxa over the peripheral and fresh water taxa. The modern pollen-vegetation relationship as represented by the pollen spectra reflects the local and nearby vegetation in a consistent way. Core mangrove pollen grains were poorly registered in the pollen spectra as they are either absent or represented in a degraded form in the present vegetation scenario. However, good representation of grasses showed a more or less close coherence with their actual composition in the present vegetation cover.

Key-words—Modern pollen-vegetation, Palynology, Chilka Lagoon, Odisha.

चिल्का लैगून, ओडिशा, भारत में जीवाश्म पराग अभिलेखों की व्याख्या में सहबंध के रूप में आधुनिक पराग-वनस्पति संबंधता

शिल्पा सिंह, बर्खार्ड डब्ल्यू. शार्फ, आशा खंडेलवाल एवं मनमोहन मोहंती

सारांश

श्मौजूदा अन्वेषण में, चिल्का लैगून, ओडिशा के पृष्ठीय अवसादों में आधुनिक पराग-वनस्पति संबंधता मूल्यांकित करने का प्रयास किया गया है। चिल्का लैगून का पारिस्थितिक तंत्र इसकी समूची विद्यमानता में अद्वितीय रहा है तथा पृष्ठीय अवसादों के विश्लेषण से निकला आँकड़ा चिल्का लैगून के चहुंओर गत वनस्पति व जलवायु के परागाणविक परिणामों में विशेष शब्दों से व्याख्या हेतु प्रयुक्त किया जा सकता है। परागाणविक अन्वेषणों ने परिरेखीय व अलवण जल टैक्सा पर मध्यदेशीय टैक्सा की प्रमुखता दिखाई। पराग स्पेक्ट्रा से यथानिरुपित आधुनिक पराग-वनस्पति संबंधता स्थिर रूप में स्थानीय एवं आस-पास की वनस्पति प्रतिबिंबित करती है। पराग स्पेक्ट्रा में क्रोड मैंग्रोव पराग कण अल्पता में दर्ज हैं क्योंकि वे वर्तमान वनस्पति परिदृश्य में या तो हैं नहीं, या कम हैं। फिर भी, वर्तमान वनस्पति आच्छादन ने उनके वास्तविक संघटन के साथ घासों के अच्छे निरूपण ने कम या ज़्यादा संबद्धता दिखाई।

संकेत-शब्द—आधुनिक पराग-वनस्पति, परागाणुविज्ञान, चिल्का लैगून, ओडिशा।

INTRODUCTION

Pollen records of surface (sediment) samples reflect the regional vegetation patterns. Surface pollen data have been widely used for interpretation of fossil pollen records and reconstructions of vegetation and climate in the past. In India, many studies have demonstrated valuable information on modern pollen-vegetation relationship from the foothills of the Himalayas (Sharma, 1973, 1985; Bhattacharyya, 1989; Gupta & Yadav, 1992), tropical deciduous scrub vegetation in Rajasthan (Singh *et al*., 1973), western Uttar Pradesh (Sharma *et al*., 2007), northeastern Madhya Pradesh (Chauhan, 1994; 2008), South India (Anupama *et al*., 2000; Barboni & Bonnefille, 2001), the northeastern part of India (Gupta & Sharma, 1985) and from Little and South Andaman Islands (Singh *et al*., 2010). However, so far, there has been no modern pollen deposition study recorded from Odisha and the present work is the first attempt to fill this gap. This communication deals with the modern deposition of local and regional pollen-spores in relation to the surrounding vegetation in the surface sediments. This has implications for a better understanding of Quaternary vegetational reconstructions of the Chilka Lagoon, Odisha.

STUDY AREA

The Chilka Lagoon (19°28' to 19°54'N; 85°05' to 85°38'E) is one of the largest brackish water lagoons along the east coast of India. It covers Puri, Khurda and Ganjam districts of Odisha State; the major portion of the lagoon lies in Puri District, while a narrow stretch of southern sector lies in the Ganjam District. Chilka Lagoon is a pear-shaped water body (average depth 2.5 m) with a linear maximum length of 64.3 km and with an average width of 20.1 km; the mean width during summers and monsoons are 14.08 and 18.10 km, respectively. The lagoon is spread over an area of 950 km^2 during the summers, which swells up to 1165 km^2 during the monsoons (Siddiqui & Rao, 1995). Based on salinity and depth, Chilka Lagoon has been divided into four ecological sectors (Panigrahi, 2006), viz. Northern Sector, Central Sector, Southern Sector and Outer Channel. The region around Chilka Lagoon experiences a dry, sub-humid, tropical monsoon climate with heavy precipitation occurring between June and September (Subramanian & Uma Devi, 1983). The average annual rainfall is ≈1800 mm. The relative humidity is high and it is generally above 70%.

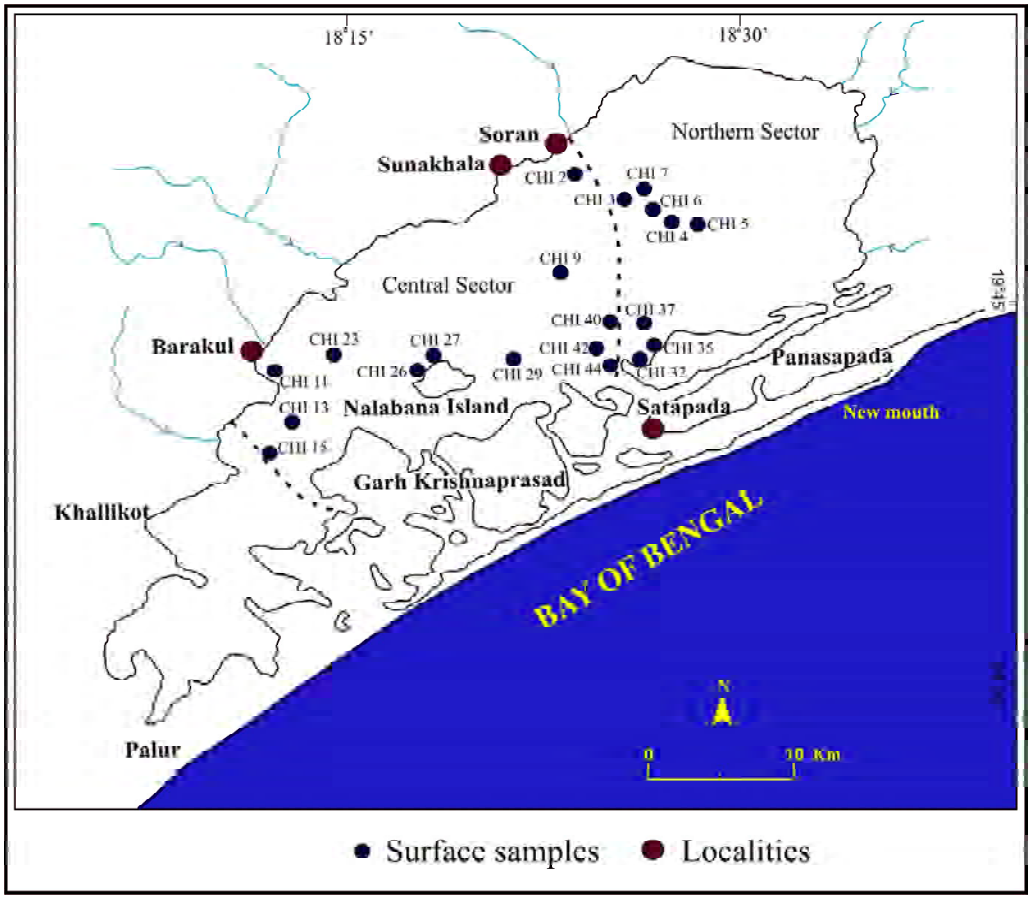


Fig. 1—Map showing the location of sampling sites (surface sediments) from the Northern and the Central sectors of the Chilka Lagoon.

MATERIAL AND METHODS

During the present investigation, twenty surface (sediment) samples were collected with the help of UWITEC gravity corer from two sectors of the Chilka Lagoon. Of these, eight samples were collected from the Northern Sector and twelve samples were collected from the Central Sector of the lagoon (Fig. 1). The studies from these two sectors were initiated to have a better representation of pollen deposition pattern in the surface sediments as the former is predominantly a freshwater zone, while the latter is brackish in nature. All the samples were chemically treated with 10% KOH solution and 40% HF solution to deflocculate the pollen/spores and to dissolve the silica content of the sediments. Thereafter, the standard technique of acetolysis was followed (Erdtman, 1943). The acetolysed samples were stored in glass-vial tubes containing 50% aqueous solution of Glycerin plus a few drops of Phenol for microscopic examination. The pollen counting and photo documentation were done under an Olympus Microscope (BX61). Pollen identification was executed by comparison with the reference slides available at the Sporothek of BSIP, Herbarium. Published pollen atlases, photographs, keys and other literature were also consulted for identification of the palynomorphs (Thanikaimoni, 1984; 1987; Nayar, 1990).

MODERN POLLEN-VEGETATION RELATIONSHIP

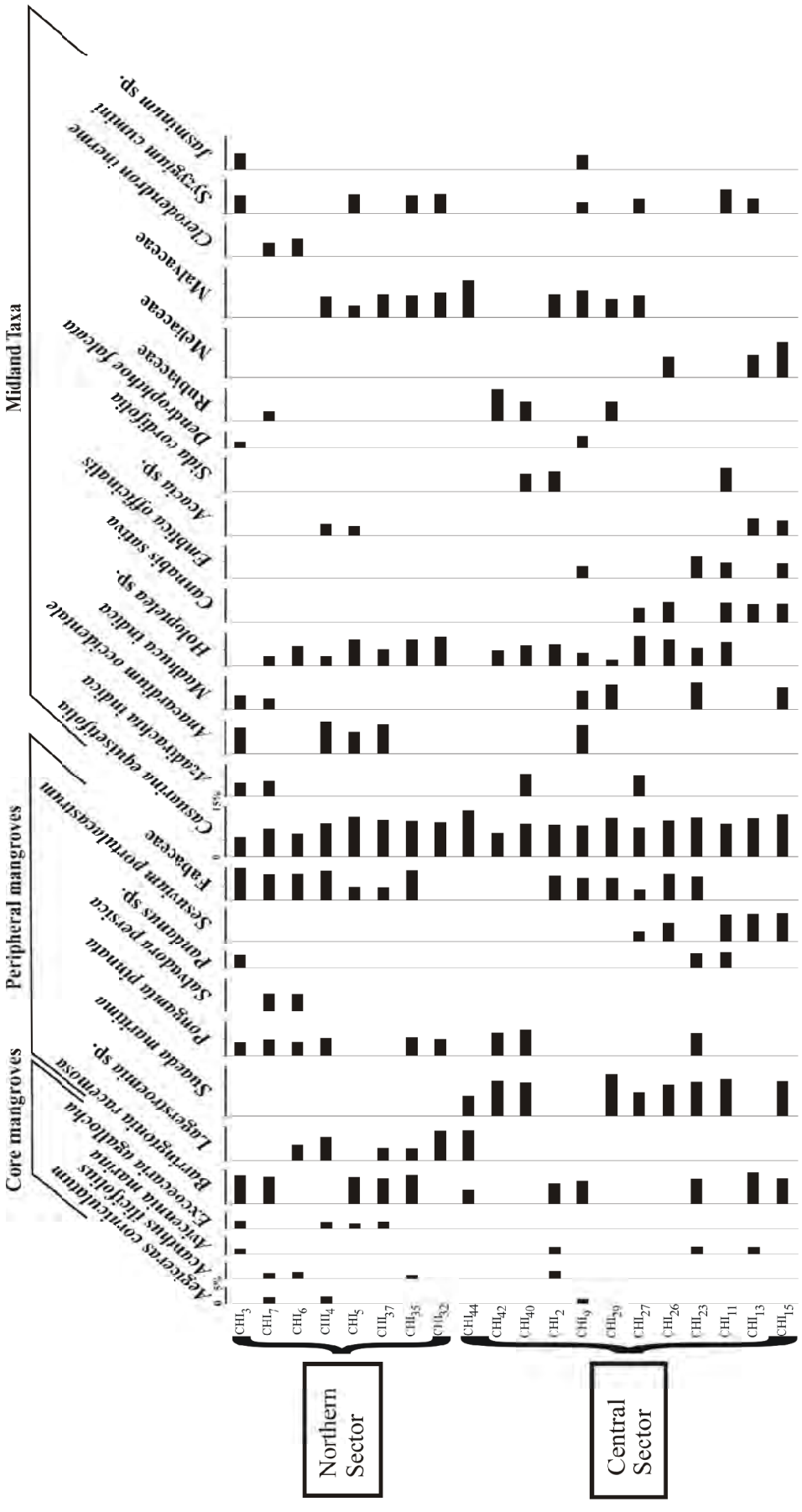
The pollen assemblages recovered from twenty surface (sediment) samples of the Northern and Central sectors are represented in the form of pollen spectra, which was drawn by using Corel software. The percentage frequencies of the recovered pollen taxa have been calculated in terms of total land plant pollen. The plant taxa have been grouped as core mangroves, peripheral mangroves, midland taxa, ubiquitous taxa, freshwater taxa and pteridophytes. The vegetation and results of pollen analysis of both the sectors are dealt separately as below:

1. Northern Sector

It is the shallowest and much wider than other sectors of the lagoon with an average width of about 15 km. The average depth varies from 0.5 m to 1 m. As a consequence of massive freshwater influx from the tributaries of the Mahanadi River, mainly Daya and Bhargavi, it experiences lower salinity values. But, during summers, the Northern Sector exhibits higher salinity because of restricted entry of freshwater and higher resident time of saline water (Panigrahi, 2006).

From the Northern Sector, eight surface samples ($CHI_{3,}$ $CHI_{7,}$ $CHI_{6,}$ $CHI_{4,}$ $CHI_{5,}$ $CHI_{37,}$ CHI_{35} and CHI_{32}) were chemically processed and palynologically investigated (Fig. 2). This sector is predominantly of fresh water zone and inhabited by numerous fresh water aquatic plants. Some of the important aquatic plants present in the Northern Sector are —*Najas faveolata, N. graminea, N. indica, Ceratophyllum demersum, Vallisneria spiralis, Hydrilla verticillata, Potamogeton nodosus, P. pectinatus* and *Halophila ovalis*. Some submerged and free floating plants like *Eichhornia crassipes, Azolla pinnata* sub sp. *asiatica, Salvinia natans, S. cuculata, Pistia stratiotes, Lemna perpusila, Spirodella polyrhiza, Ludwigia adscendens, Ipomoea aquatica, Hygrorhiza aristata, Neptunia olerasia, Utricularia aurea, Nymphaea pubescens, Nymphoides indica, N. hydrophylla, Pragmites karka, Typha angustifolia, Schoenoplectus maritimus, Elaeocharis urticularis, Vallisneria spiralis, Bacopa monniera, Alternanthera philexeroides, Alternanthera paranychoides, Commelina suffruticosa, C. diffusa, Hygrophylla auriculata, Eragrostis nutans, Paspalum distichum, Paspalidium punctatum, Dentella repens, Phylla nodiflora* and *Marsilea minuta* also make important components of aquatic vegetation in this sector.

The pollen spectra from the Northern Sector reflect an overall dominance of peripheral mangroves and midland taxa over the core mangroves (Fig. 2). Amongst peripheral mangroves, the prominent taxa with highest frequencies are *Barringtonia racemosa* (4.1-9.2%), *Pongamia pinnata* (4-7.7%) and *Lagerstroemia* sp. (3.6-8.9%). *Salvadora persica* (5.5-5.6%), *Pandanus* sp. (4-4.7%) and Fabaceae (3.2-9.7%) are encountered in moderate frequencies. Amongst core mangroves, *Excoecaria agallocha* (1.6-2.4%), *Aegiceras corniculatum* (1.5-2.2%), *Acanthus ilicifolius* (1.8-2.4%) and *Avicennia marina* (1.5-2.1%) are recorded in low values. *Casuarina equisetifolia* (5.9-13.8%) is the predominant element among the midland taxa, followed by *Holoptelea* sp. (2-9%), *Anacardium occidentale* (6.4-9.7%), Malvaceae (3.5-9.9%), and *Syzygium cumini* (5.4-5.8%). Pollen of *Azadirachta indica* (4-4.5%), *Madhuca indica* (3.4-4.3%), *Acacia* sp. (2.8-3.4%) and *Jasminum* sp. (5%) are represented in good frequencies, whereas, *Clerodendron inerme* (2.1-2.7%), Rubiaceae (2.9%) and *Dendrophthoe falcata* (1.9%) are characterized by low values. Among the herbaceous taxa, Poaceae (6.4-10.7%), Cheno/Ams (5.3-9.8%) and Cyperaceae (4-8.8%) are predominant. Pollen of Asteraceae (8.5-10.7%) and Caryophyllaceae (4.3-6.8%) are encountered in moderate values. Other taxa, like *Justicia* sp. and Urticaceae are represented in low values. Fresh water element, such as *Potamogeton* sp. (6.7-14.6%) is predominantly recorded, followed by *Typha angustifolia* (5.1-9), *Lemna* sp. (4-7.2%) and *Nymphoides* sp. (3.2-5.3%). Other taxa, such as *Eichhornia* sp. and *Nymphaea* sp. are recorded in low frequencies. Monolete (2.4-6.5%) and trilete (1.8-5.4%) spores are also represented in good frequencies. Drifted taxa and fungal spores are recovered in low frequencies.


Midland Taxa
Peripheral mangroves
Core mangroves
Jussiaeum sp.
Syzygium cumini
Clerodendron inerme
Malvaceae
Meliaceae
Rhizophoraceae
Dendrophthoe falcata
Sida cordifolia
Acacia sp.
Emblica officinalis
Cannabis sativa
Holoptelea sp.
Madhuca indica
Anacardium occidentale
Azadirachta indica
Casuarina equisetifolia
Fabaceae
Sesuvium portulacastrum
Pandanus sp.
Salvadora persica
Pongamia pinnata
Suaeda martima
Lagerstroemia sp.
Barringtonia racemosa
Excoecaria agallocha
Avicennia marina
Acanthus ilicifolius
Acrostichum aureum
0
15%
0
5%
CHI3
CHI7
CHI6
CHI4
CHI5
CHI37
CHI35
CHI32
CHI44
CHI42
CHI40
CHI2
CHI9
CHI29
CHI27
CHI26
CHI23
CHI11
CHI13
CHI15
Northern Sector
Central Sector

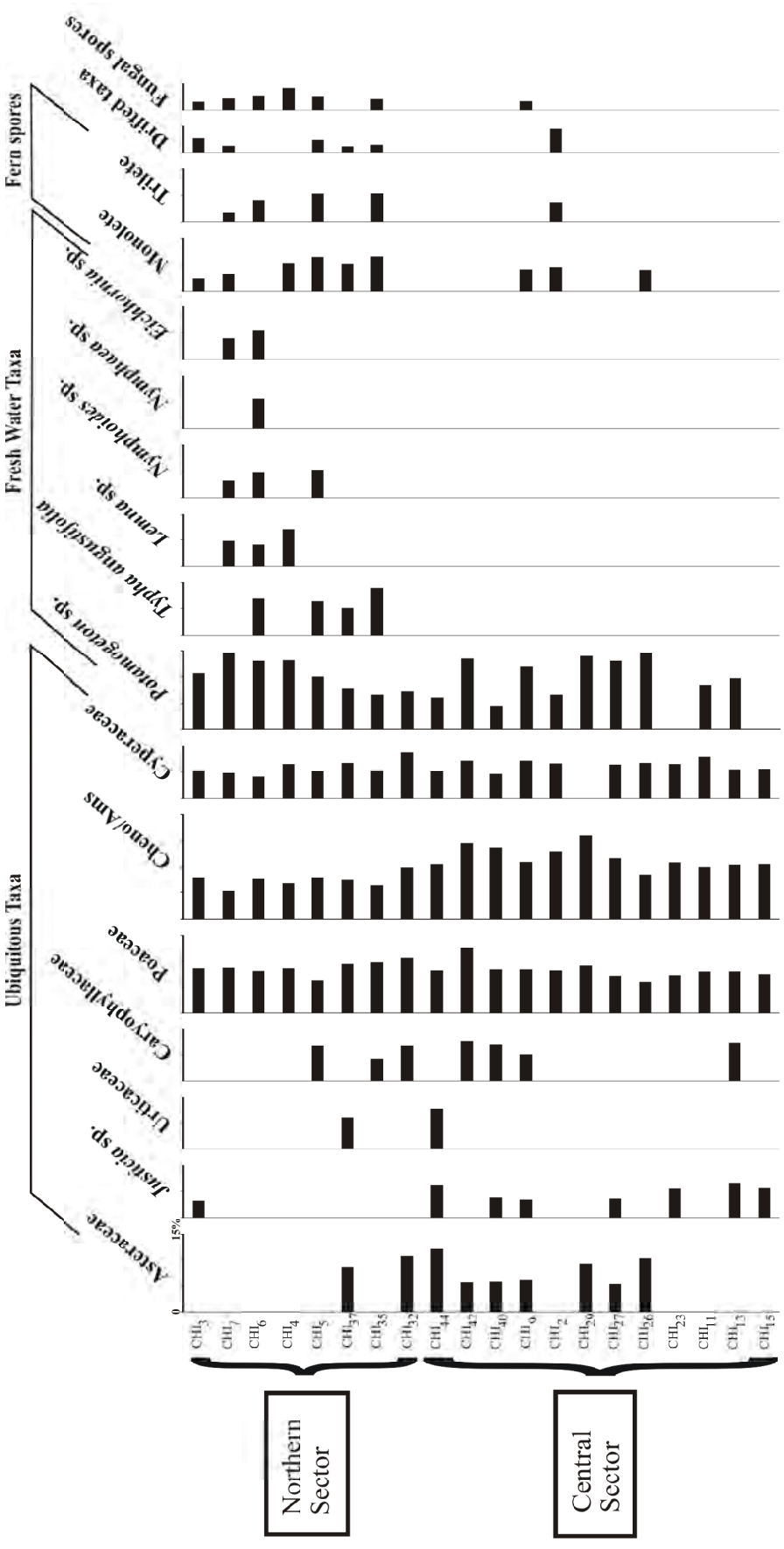


Fig. 2—Pollen spectra of surface (sediment) samples showing modern pollen-vegetation relationship from the Northern and the Central sectors of the Chilka Lagoon.

2. Central Sector

It lies between the Northern and Southern sectors. It is smaller in size, deeper than the Northern Sector, with an average depth of 1.5 m to 2 m in summers. The deepest area of this sector is near Kalijai Island where the average depth in summers is about 3 m (the bottom is muddy). It shows a fluctuation of salinity according to seasons (pre monsoon 13-30 ppt, monsoon 5-9 ppt, post monsoon 6-12 ppt) and is almost brackish in nature.

Twelve surface samples ($CHI_{44,}$ $CHI_{42,}$ $CHI_{40,}$ $CHI_{9,}$ $CHI_{2,}$ $CHI_{29,}$ $CHI_{27,}$ $CHI_{26,}$ $CHI_{23,}$ $CHI_{11,}$ CHI_{13} and CHI_{15}) were chemically processed and palynologically investigated from the Central Sector (Fig. 2). Some of the important aquatic species are — *Najas graminae, N. indica, Potamogeton pectinatus, Phragmites karka, Arundo donax, Schoenoplectus maritimus, Salichornia brachiata, Suaeda maritima, Sesuvium portulacustrum, Heliotropium curassivicum* (salt marsh), *Alloteropsis cimicina, Chenopodium album, Cynodon dactylon, Paspalum vaginatum, Panicum psilopodium* and *Saccharum spontaneum.*

The pollen assemblages of the Central Sector are characterized by a high representation of midland taxa followed by peripheral mangroves and core mangroves. Among the midland taxa, *Casuarina equisetifolia* (7.2-13.8%) is predominantly represented. Other taxa such as Meliaceae (6.1-10.5%), Malvaceae (5.5-9.9%), Rubiaceae (5.8-9.6%) *Madhuca indica* (5.6-8.1%), *Azadirachta indica* (6.5-7%) and *Sida cordifolia* (5.4-7.1%) are recorded in high frequencies. Pollen of *Holoptelea* sp. (2-9%), *Cannabis sativa* (4.3-6.1%), *Syzygium cumini* (3.3-7.1%), *Acacia* sp. (4.5-5.1%) and Anacardiaceae (8.3%) are also represented moderately. The pollen frequencies of peripheral mangroves are also high, characterized by significant percentages of *Suaeda maritima* (6.2-12.6%) followed by *Pongamia pinnata* (6.6-7.7%), *Barringtonia racemosa* (4.1-9.2%), *Sesuvium portulacastrum* (2.9-8.3%) and Fabaceae (3.2-8%); whereas, *Pandanus* sp. (4.1-4.7%) and *Lagerstroemia* sp. (8.9%) are recorded in good values. Amongst core mangroves, *Avicennia marina* (2-2.1%), *Acanthus ilicifolius* (2.4%) and *Aegiceras corniculatum* (1.5%) are represented by low values. Herbaceous taxa are recorded in high percentages, among which Cheno/Ams (8.5%-15.9%) are represented by high values followed by Poaceae (6.1-12.7%), Asteraceae (5.4-12%), Cyperaceae (4.6-7.9%), Caryophyllaceae (5.1-7.7%), *Justicia* sp. (3.4-6.6%) and Urticaceae (7.8%). Fresh water elements are represented only by *Potamogeton* sp. (4.6-14.5%). Fern spores (monoletes and triletes) are encountered in good values. Drifted taxa and fungal spores are recovered in low frequencies.

DISCUSSION AND CONCLUSIONS

The study of modern pollen-vegetation relationship from the two sectors of Chilka Lagoon indicates that the pollen/spore deposition pattern reflects the existing local and surrounding vegetation of the area. The results from the pollen analyses of surface (sediment) samples reveal an overall dominance of midland taxa over the peripheral and fresh water taxa. Among the midland taxa, *Casuarina equisetifolia* is the only taxon that dominated with high frequencies from both the sectors, specially from the Central Sector. Abundance of *Casuarina equisetifolia* pollen indicates anthropogenic activities in the vicinity of the lagoon, as it has been planted recently. However, *Holoptelea* sp., *Madhuca indica, Anacardium occidentale* and Malvaceae are also represented with moderate values. Other important taxa, such as, *Syzygium cumini, Acacia* sp., Meliaceae, *Cannabis sativa* and *Azadirachta indica* are recorded in appreciable proportion. Among peripheral mangroves, *Suaeda maritima* shows the highest frequencies and this taxon is only recovered from the Central Sector, the Northern Sector is devoid of this taxon. *Barringtonia racemosa, Pongamia pinnata, Sesuvium portulacastrum, Lagerstroemia* sp. and Fabaceae are also characterized by their good representation, exclusively from the Northern Sector, except *Sesuvium portulacastrum,* which is recovered from the Central Sector. The pollen of *Pandanus* sp. and *Salvadora persica* are lowly represented from both the Northern and Central sectors. Core mangroves pollen are also lowly represented. Herbaceous taxa are significantly represented. Pollen of Cheno/Ams are represented abundantly. Frequencies of Poaceae, Cyperaceae and Asteraceae are found in good values, but Caryophyllaceae, *Justicia* sp. and Urticaceae are represented in low values. Abundance of fresh water elements, especially *Potamogeton* sp., are recorded from the Northern Sector and gradually start declining in the Central Sector. The results reflect the present day vegetation of the Northern Sector, which is exclusively a fresh water zone. Fern spores (monoletes and triletes) exhibit their presence in both the sectors.

Thus, the modern pollen-vegetation relationship has greatly helped in understanding the representation of present day vegetation mosaic in the pollen record, which would be useful in tracing the past vegetational changes vis-à-vis climatic fluctuations in and around the Chilka Lagoon.

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