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POLLEN RAIN VIS-À-VIS VEGETATION RELATIONSHIP IN KIKAR TAL (LAKE), RAEBARELI DISTRICT, UTTAR PRADESH, CENTRAL GANGA PLAIN

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ABSTRACT

Pollen analysis of 10 surface samples from Kikar Tal, Raebareli District reveals the relatively higher frequencies of non-arboreals subduing the arboreals. The consistent records of *Syzygium cumini* with moderate frequencies among the trees, reflects its frequent presence in the flora. However, majority of the trees, *Emblica officinalis*, *Terminalia*, *Acacia nilotica*, *Holoptelea integrifolia*, etc. are under-represented, despite their frequent occurrence. Their irregular record in the pollen rain could be attributed to low pollen-productivity since they are entomophillous as well as partial pollen preservation. Trees constitute small fraction av. 12% pollen only and together with av. 3% shrubs they denote av. 15% arboreal pollen. Amongst the non-arboreals, Poaceae exhibits preponderance followed by Cerealia, Cheno/Am, *Artemisia*, Tubuliflorae, etc. The representation of these taxa corresponds with their composition in the ground flora. Collectively, the non-arboreals encompass a major chunk of av. 85% pollen, depicting the open nature of vegetation. The encounter of Cerealia pollen implies the agrarian practice. The study also furnishes information concerning the prominent pollen/spores in the local milieu, which get deposited on the ground along with rains/dews after emission from the source plants. Their relative abundance assists in ascertaining the specific common pollen/spores in the aerospora relevant to allergic diseases.

Keywords: Pollen rain, Vegetation, Surface samples, Kikar Tal, Raebareli District (U.P.)

INTRODUCTION

Modern pollen surface samples from the known environment provide an important way to establish whether specific type of vegetation have a sufficiently distinctive pollen spectrum to allow their identification in the fossil record, despite interspecific differences in pollen production or post depositional modification (Barboni *et al.,* 2003). A number of studies have been conducted from the Late Quaternary lake-fill sequences appended with chronology to reconstruct the past vegetation dynamics and related palaeoclimatic conditions from the different parts of Indian subcontinent. A lot of work has been executed on modern pollen rain-vegetation relationship from the tropical evergreen lowland forest and deciduous forests in the southern part of the India (Barboni and Bonnefille 2001; Barboni *et al.,* 2003; Anupama *et al.,* 2000; Bonnefille *et al.,* 1999), where attempt has been made to quantify palaeoclimate changes during the monsoon season. In this perspective, a very comprehensive study has been done on the several surface samples analyzed from different vegetation series and the representation of their constituents in the modern pollen rain in contrast to their factual presence in northwest India comprising the regions of Rajasthan and Gujarat (Singh *et al.*, 1972) as well as the factors affecting to the preservation of pollen/spores in the sediments. The comparative database derived on this aspect has been used for the appropriate appraisal of the pollen sequences from lake deposits in terms of past vegetation and climate change in Rajasthan desert during the Quaternary Period (Singh *et al.*, 1974). In addition, sporadic information regarding modern pollen rain-vegetation relationship is also available from the tropical deciduous sal forests in central India (Chauhan, 1994; 2007) and tropical mixed deciduous forests in Northeast India (Basumatary and Bera, 2007) and the foothills of Himalaya (Sharma, 1985; Gupta and Yadav, 1992). These studies have provided valuable comparative database concerning the pollen rain vis-à-vis extant vegetation, which have been used in the modern analogue for the precise assessment of the pollen sequences from the sediment deposits in terms of sequential vegetation succession and climatic events in the above regions during the Late Quaternary Period. However, in this context very little attention has been given to the Ganga Plain which has entirely different floristic setup, despite significant Quaternary palaeoclimate and palaeovegetation records from some of the lakes viz. Sanai Tal, Raebareli district (Sharma *et al.,* 2004); Lahuradewa Lake, Sant Kabir Nagar District (Chauhan *et al.,* 2009; Saxena *et al.,* 2013); Jalesar Tal, (Trivedi *et al.,* 2013) and Basaha Jheel, Unnao Disrict; Kathauta Tal and Karela Jheel, Lucknow District (Chauhan *et al.,* 1990) and collective studies by Chauhan and Chatterjee (2008) from the central Ganga Plain. Recently, some sketchy attempts have been put forward to study modern pollen rain-vegetation studies from Jalesar, Unnao district (Trivedi *et al.,* 2014), Chaudhary-ka-Tal (Saxena *et al.*, 2015; Trivedi *et al*., 2016), Bari Tal, (Trivedi *et al*., 2014), Karela Jheel, Lucknow District (Chauhan *et al*., 2015) Ropan Chhapra Tal, Deoria District (Saxena and Singh, 2016; Trivede *et al*., 2011) from where the Quaternary palaeoclimatic studies on the lake deposits have been pursued. Such studies are imperative as they provide comparative database on pollen rain vis-a-vis vegetation, which serves as modern analogue for the appropriate interpretation of the pollen sequences of lake deposits precisely in terms of vegetation and climate change of the past. In the present paper, an attempt has been made to infer the appropriate extent of representation of pollen of various regional and local plant taxa/groups in the pollen rain compared to their actual presence in the modern vegetation, pollen deposition pattern and dispersal efficiency as well as possible factors affecting preservation of pollen/spores in the sediments through the pollen analysis of surface soil samples from the surroundings of Kikar

Tal, Raebareli District. This study on pollen rain-vegetation interplay will enable us to assess the past vegetation climate change in the region.

STUDY AREA

The study site-Kikar Tal is located about 55km southwest of Lucknow city and 2km north-west of Bachharawan between Long. 81°6′ 37.78″ and Lat. 26°28′47″ in Raebareli District at an altitude of 63m amsl (Fig. 1). The lake is perennial in nature and has about 250m^2 aerial expanses. It is circular in outline with gradual slope and 10-12 m wide marshy margin all around. It is fed by the monsoon rainfall and subterranean water. However, during the monsoon season it gets inundated and attains the

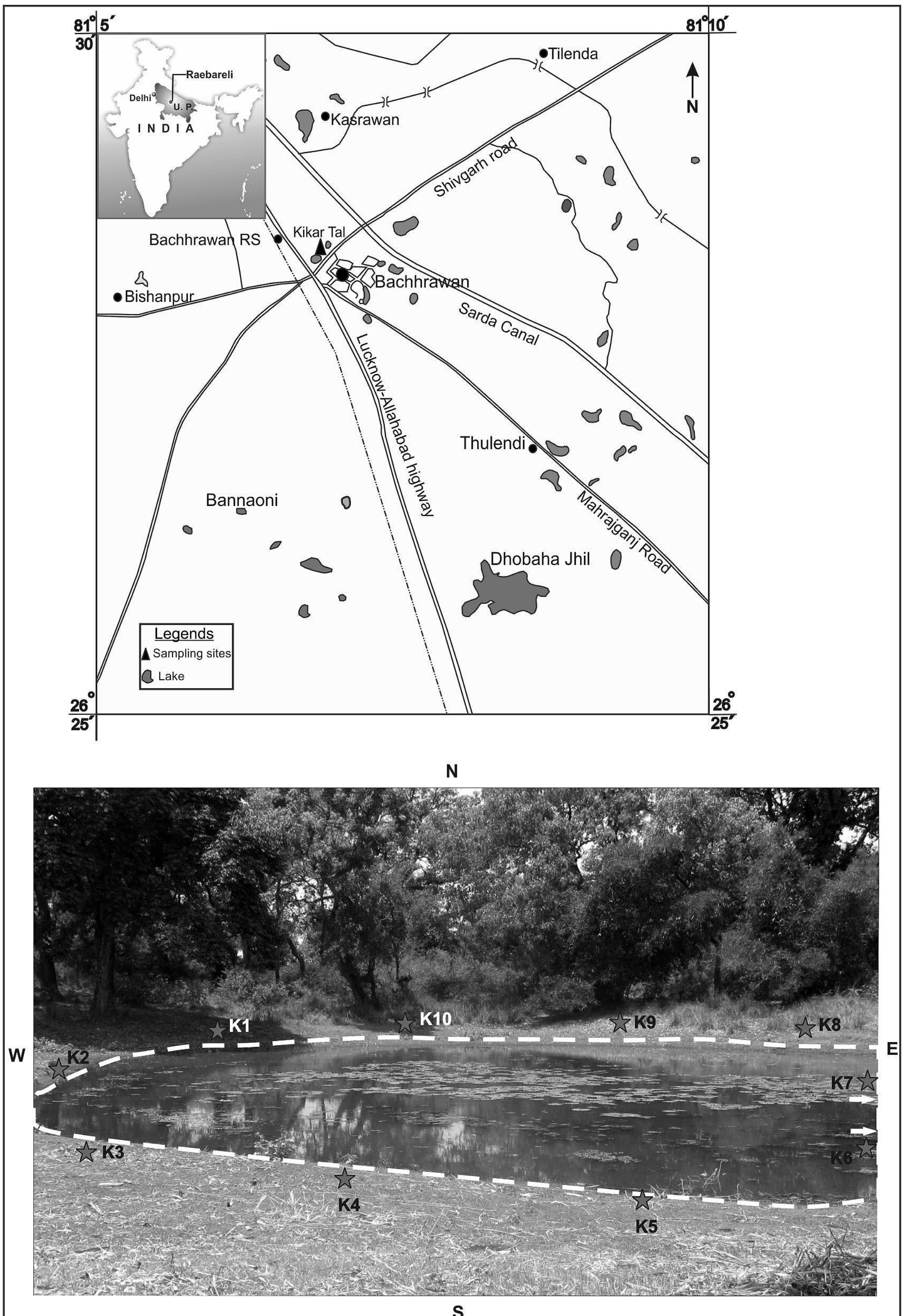

Fig. 1.a). Map showing study site Kikar Tal in Raebareli District, b). Panoramic view of lake and sample locations.

wider extent. Most of the areas around the lake is under extensive agricultural practices, though, the immediate vicinity of the lake supports dense forest stands. The western and northern flanks have forest groves comprising *Syzygium cumini, Cassia fistula, Mangifera indica, Aegle marmelos* and *Madhuca indica,* whereas eastern flank is partly cultivated with open vegetation and southern flank is under intense agricultural activities. Besides, the dried swampy margin of the lake is overgrown with reed-swamp (tall perennial) grasses, *Phragmites karka* and *Typha latifolia,* a semi aquatic element. The adjoining area of the lake is under intensive cultivation of the conventional crops viz., *Triticum aestivum* (wheat), *Oryza sativa* (paddy), together with pulses such as *Cicer aeretinum* (chana), *Phaseolus mungo, Pisum sativum* (pea) and *Sacchhrum officinarum* (sugarcane). Presently, mint (*Mentha piperita*) is grown by the local people as a cash crop.

CLIMATE

Climate of the region, in general, is humid and largely influenced by southwest monsoon (Chauhan *et al.,* 1990). Winter season from November to February is characterized by average minimum and maximum temperatures of 7.6ºC and 21ºC respectively. The temperature seldom descends to 0ºC during the severe cold months of December and January. Summer season from April to June is marked by hot blowing winds commonly known as 'loo'. The average minimum and maximum summer temperatures are 27ºC and 32.5ºC respectively. The temperature ascends up to 46ºC in the month of June. Monsoon season commences in the mid-June and continues till mid-September. The weather becomes sultry from mid-July to mid-September. The mean average annual rainfall recorded for the nearest city Lucknow is 1020-1140 mm with about 75% rainfall during the monsoon season.

VEGETATION

The vicinity of the lake is marked by the patchy occurrence of stands or groves of forest interspersed with stretches of herbaceous vegetation, dominated by grasses (Champion and Seth, 1968). Thus, the landscape imparts a view of open vegetation. The trees viz., *Syzygium cumini*, *Madhuca indica*, *Holoptelea integrifolia Acacia arabica*, *A. nilotica*, *Cordia dichotoma*, *Capparis decidua*, *Butea monosperma*, *Symplocos racemosa*, *Ailanthus excelsa*, *Melia azadirachta*, *Aegle marmelos*, *Bauhinia variegata*, *Oroxylum indicum, Schleichera oleosa*, *Moringa oleifera*, *Terminalia arjuna*, *Albizia lebbek*, *Flacourtia indica*, *Terminalia arjuna*, *Dalbergia sissoo*, etc. together with thickets of *Ziziphus mauritiana*, *Carissa spinarum*, *Adhatoda vasica*, *Indigo ferahimalayensis*, *Nyctanthes arbor-tritis*, *Mimosa pudica*, etc. occur sparingly distributed in the scrub forests. However, in the wasteland adjoining to the cultivated fields and along the dry sandy river beds, *Acacia*-scrub forests dominated by *Acacia nilotica* with scattered thickets of *Prosopis spicigera*, *Ziziphus mauritiana*, *Carissa spinarum* and *Abrus precatoris* can be seen in restricted pockets. Around the habitations the shrubby elements viz., *Adhatoda vasica*, *Ricinus communis*, *Calotropis procera* and *Mimosa pudica* are frequent. *Mangifera indica*, *Melia azedirach*, *Tamarindus indica*, *Syzygium cumini*, *Dalbergia sisso, Eucalyptus globules* and *Ficus religiosa* are the prominent avenue trees. *Ziziphus oenoplia*, *Cuscuta reflexa*, and *Abrus precatorius* are the usual climbers on trees. *Butea monosperma* and *Phoenix acaulis* occur commonly in the wasteland around the cultivated land. *Bombax ceiba* is scattered around the villages and in open savannah land. *Barringtonia acutea* and *Syzygium haneyanum* occur occasionally along the stream banks.

The herbaceous vegetation as usual is largely constituted of grasses, *Amaranthus*, *Ajugab racteosa*, *Mazus japonicus*, *Oxalis acetosella, Ageratum conyzoides*, *Vernonia cinerea*, *Sonchus oleraceus*, *Euphorbia hirta*, *E. thymifolia*, *Sida rhombifolia*, *Micromeria biflora*, *Lueca saspera*, *Blumea eriantha*, *Argemone mexicana*, *Lantanacamara*, *Tribulus terrestris*, *Parthenium* sp. etc. Sedges such as *Cyperus rotundus*, *Scirpus mucronatus* and *Fimbristylis miliacea* together with *Polygonum plebeium*, *P. serrulatum*, *Polygala chinensis*, *Ammania baccifera*, *Hydrocotyle sibthorpioides*, *Rotala rotundifolia*, *Hygrophilla auriculata*, *Alternanthera sessilis* and *Chlorophytum* sp. are the major components of the marshy vegetation along the lake margin and banks of streams and rivulets. The aquatic elements including, *Typha latifolia*, *Trapa natans*, *Lemna polyrriza*, *Jussia euperennis*, *Potamogeton japonicas*, *P. cristatum*, *Nymphoides cristata*, *Nelumbo nucifera*, etc. are common in lakes, ponds and ditches. *Eichornea crassipes*, *Trapa natans* and *Chara* sp. form thick and extensive mats on the surface of lentic water bodies throughout the post-monsoon seasons.

MATERIAL AND METHODS

Ten surface soil samples (KT-1 to KT-10) were collected from the surroundings of the Kikar Tal to study modern pollen-rain vegetation relationship and deduce the pollen deposition pattern on different flanks of the lake with their respective vegetation composition. The sampling was executed at 100 m intervals each as it is assumed that the major chunk of pollen gets deposited within 100 m distance or so in open land conditions or cultivated area after emission from the source plants (Luna *et al.,* 2001). The sampling strategy was planned in transect, keeping in view the standard interval of 100 m between the samples to understand the average representation of the prominent forest constituents/plant groups of the regional vegetation in the pollen rain.

10 gm sediment was boiled with 10% aqueous KOH to deflocculate pollen/spores from the sediment and to dissolve the humic acid. This was followed by the treatment of samples with 40% HF in order to remove silica present in the surface sediments. Thereafter, the standard procedure of acetolysis (Erdtman, 1943) using acetolysing mixture (9:1 ratio of acetic anhydride and concentrated sulphuric acid) was followed. Finally, the samples for microscopic examination were prepared in 50% glycerin solution.

All the samples analyzed were productive in pollen/spore content. The pollen sums range from 200 to 310, depending upon the pollen yield of the samples. Percentage frequencies of the recovered pollen taxa have been calculated in terms of total terrestrial plant pollen (Fig. 2). The pollen of aquatic plants and spores of ferns and other lower cryptogams (algal remains) have been debarred from the pollen sums because of their origin from the local provenances. Their composite frequencies are given in Figure 3. The precise identification of the recovered pollen/spores (Fig. 4/pollen plate) in the sediment was carried out by consulting the reference pollen slides available in the sporothek of BSIP, Herbarium as well as comparing the pollen photographs in the published literatures (Chauhan and Bera 1990; Nayar 1990). The plant taxa classified as trees, shrubs, herbs, ferns and algal remains are arranged in the same sequence in the pollen spectra (Fig. 2).

Pollen rain composition

Out of 10 surface samples analysed, KT-1, KT-2 and KT-3 are from the western flank; KT-4 and KT-5 are from southern flank, KT-6 and KT-7 are from eastern flank and KT-8, KT-9 and KT-10 are from northern flank of the lake. The pollen rain compositions of the samples from different flanks are described as below (Fig. 2).

POLLEN SPECTRA (KT-1, KT-2 & KT-3) from the western flank of the lake with the vast extent of cultivated land and marked by the sparse presence of trees, reveal the dominance of non-arboreals (herbs) and relatively reduced frequencies of arboreals (tree and shrubs). The tree taxa, *Syzygium*, (1.9-6.8%) and *Madhuca indica* (0.6-2.8%) are consistently recorded in moderate values. *Holoptelea integrifolia* (0.6-1.1%), *Emblica officinalis* (1.1-1.3%), *Acacia nilotica* (0.6-1.9%), *Schleichera oleosa* (0.6-1.1%) are present sporadically in low frequencies. Others such as *Bombax ceiba* (0.6%), *Terminalia* (1.7%) and *Adenanthera* (1.7%) Sapotaceae and *Maytenus* (0.6% each) are meagre. The shrubs viz., *Mimosa pudica* (5-6.8%) and Acanthaceae (0.6-4.4%) are recovered consistently with high to moderate values respectively.

The herbaceous vegetation is characterized by the consistent abundance of Poaceae (10.2-25.2%) followed by Brassicaceae (3.8-14.2%), Chenopodiaceae/Amaranthacae (Cheno/Am 6.5-10.7%), *Cannabis sativa* (2.8-6.9%) and Tubuliflorae (4.5-10.1%) with moderate to high values. *Artemisia* (1.1-1.9%), Caryophyllaceae (1.7-1.3%) and *Alternanthera* (1.3%) are met sporadically with deviating frequencies. *Momordica charantia* (1.1%), Liguliflorae (1.9%), Malvaecae (1.3-2.8%), Ranunculaceae (0.6%), *Xanthium strumarium* (0.6-2.5%) and *Tribullus* (1.1%) are encountered in extremely low frequencies. The wetland elements namely Cyperaceae, (3.4-10.4%) and *Polygonum plebeium* (2.5-5.1%) are recorded constantly in moderate to high frequencies, however; *Polygonum serrulatum* (1.3%) is retrieved in one sample only. The aquatic elements, *Typha* (3.1-9.7%), *Potamogeton* (2.3-5.2%) and *Lemna* (1.3-3.1%) show high frequencies, though infrequently, whereas *Nymphoides* (4.5%) and Liliaceae (0.6%) are intermittent with low frequencies. Fern spores (monolete 1.9% & trilete 0.6%) are scanty. The stray pollen of Himalayan element, *Pinus*(0.6%) are also recovered.

POLLEN SPECTRA (KT-4 & KT-5) from the southern part of the lake with sparse forest groves also exhibit high frequencies of non-arboreals over the arboreals. *Syzygium* (2-3.9%), *Holoptelea integrifolia* (2-3.1%) and *Terminalia* (1.6-2%) are the prominent trees as indicated by their steadily low to moderate values. *Acacia nilotica* (1.6%), *Emblica officinalis* (3%), *Adenanthera* (3.1%) and *Maytenus* (1%) show sporadic presence in one sample each. The shrubby elements viz., *Adhatoda vasica* and *Mimosa pudica* (2.3-4.0% each) depict appreciable values compared to Fabaceae (2.3%) and *Linum* (1%), which are encountered scarcely in one sample each.

Among the non-arboreals, Poacaeae (19.5-31%) has excessively high frequencies, whereas the culture pollen taxa viz. Cheno/Am (2.0-7.8%), *Cannabis sativa* (2.3-5%) and Cerealia (2.3-4%) are also recovered in good frequencies. Tubuliflorae (4.7-6.0%) is consistently recorded with high values. Brassicaceae, Liguliflorae (3.19% each) and Malvaceae (2%) are infrequent. The wetland taxa, *Polygonum plebeium* (6.3-10%) and Cyperaceae (6-7%) have constantly high frequencies, whereas *Polygonum serrulatum* (1%) is trivial. Among the aquatic elements, *Typha* (7-11.7%) and *Lemna* (4-6.3%) are retrieved consistently with high values. *Trapa* (1%), *Nymphoides* and *Potamogeton* (2.3% each) denote infrequently low values. Fern trilete spore (2%) and drifted element, *Pinus* (1%) are extremely low.

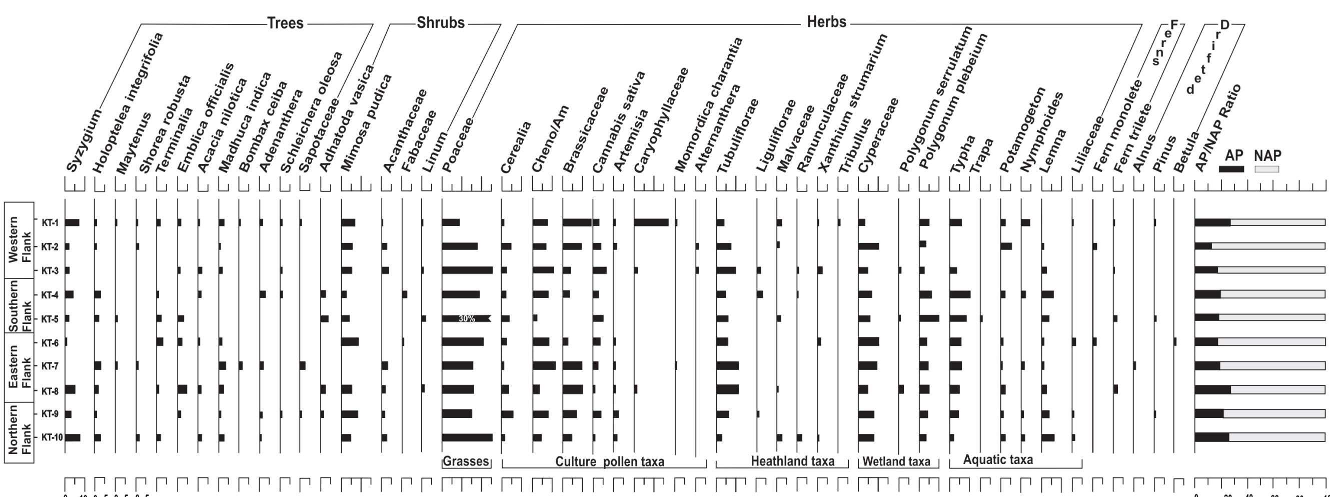

Fig. 2. Pollen spectra from the surface sediments of Kikar Tal (Lake)

EXPLANATION OF PLATE-I

1. ***Madhuca indica,*** 2. ***Bombax ceiba,*** 3. ***Acacia nilotica,*** 4. ***Maytenus*** 5. ***Holoptelea integrifolia***, 6. ***Terminalia***, 7. ***Syzygium cumini***, 8. ***Emblica officinalis,*** 9. Cerealia, 10. Poaceae, 11. Cheno/Am, 12. Caryophyllaceae, 13. ***Alternanthera***, 14. Brassicaceae, 15. ***Cannabissativa***, 16. ***Momordica charantia***, 17. ***Xanthium stumariaum***, 18. Tubuliflorae, 19. Liguliflorae, 20. ***Artemisia***, 21. ***Adhatoda vasica***, 22. Acanthaceae cf. ***Lepidagathis***, 23. Cyperaceae, 24. ***Polygonum plebeium***, 25. ***Typha latifolia***, 26. ***Trapa***, 27. Fern trilete, 28. Fern monolete, 29. ***Pinus***, 30. ***Alnus***, 31. ***Nigrospora.***

Plate I

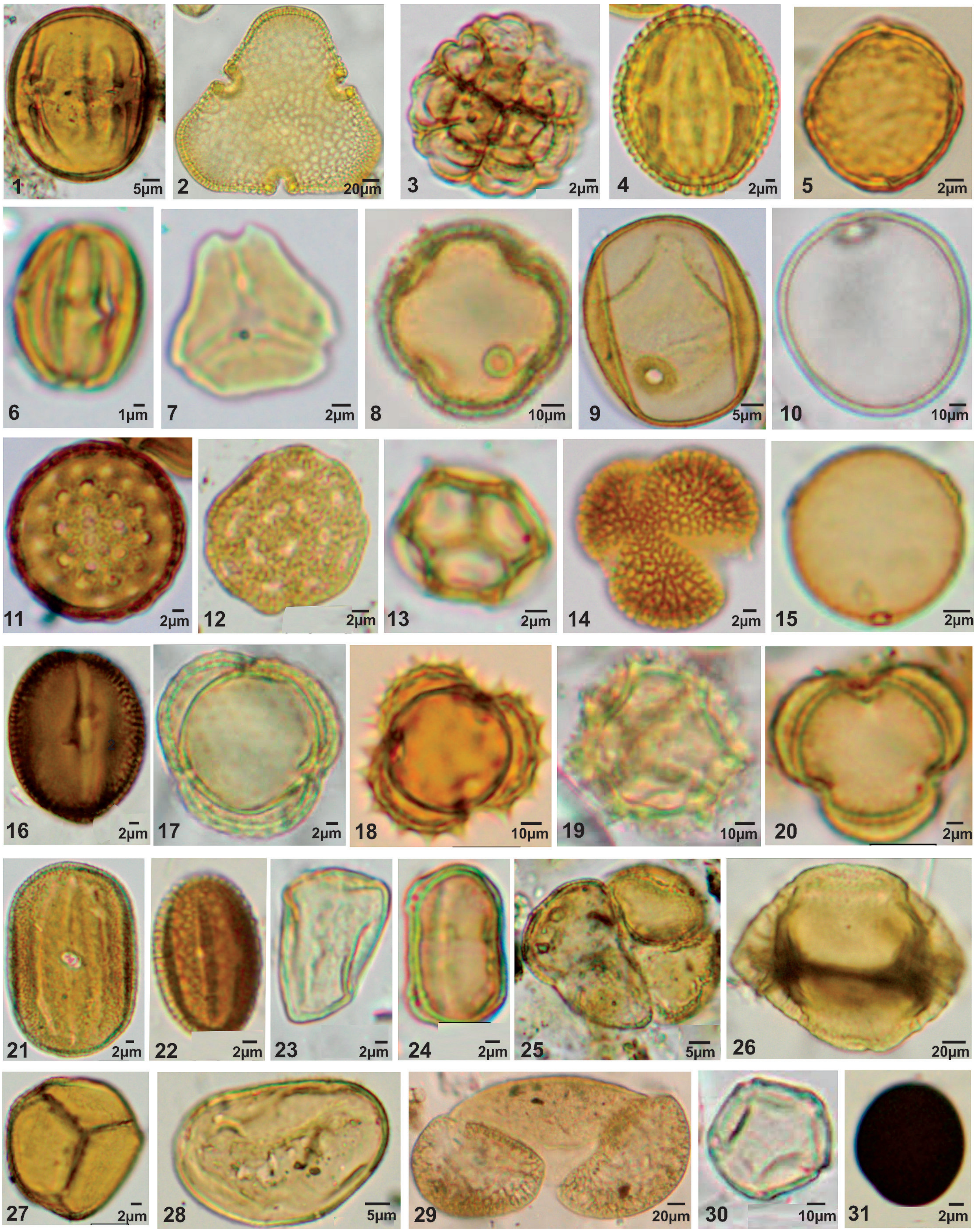
1 5µm
2 20µm
3 2µm
4 2µm
5 2µm
6 1µm
7 2µm
8 10µm
9 5µm
10 10µm
11 2µm
12 2µm
13 2µm
14 2µm
15 2µm
16 2µm
17 2µm
18 10µm
19 10µm
20 2µm
21 2µm
22 2µm
23 2µm
24 2µm
25 5µm
26 20µm
27 2µm
28 5µm
29 20µm
30 10µm
31 2µm

Table 1. Categorization of plants recovered in the surface sediments of Kikar Tal.

Arboreals		Non-arboreals	Others
Trees	**Shrubs**		
Moist elements : (av. rainfall 1200 mm) *Syzygium cumini*, *Madhuca indica*, *Shorea robusta*, Acanthaceae **Dry elements:** (av. rainfall <1000 mm) *Acacia nilotica*, *Holoptelea integrifolia*, *Adenanthera, Emblica officinalis*, *Bombax ceiba*, *Maytenus*, *Schleichera*, Sapotaceae.	*Adhatoda vasica* *Mimosa pudica* Fabaceae, *Linum, Terminalia*.	**Grasses** (Poaceae) **Culture pollen taxa:** Cerealia, Cheno/Am, *Brassica* *Cannabis sativa*, *Artemisia*, *Alternanthera*, Caryophyllaceae. **Heathland taxa:** Tubuliflorae, Liguliflorae, Malvaceae, Ranunculaceae, *Tribullus*, *Xanthoum strumarium*. **Wetland taxa:** Cyperaceae, *Polygonum plebeium*, *P. serrulatum*, Liliaceae. **Aquatic taxa:** *Typha*, *Trapa*, *Potamogeton*, *Nymphiodes,Lemna*.	**Ferns:** Ferns producing monolete spores, Ferns producing trilete spores. **Drifted:** *Pinus*, *Alnus*, *Betula*.

POLLEN SPECTRA (KT-6 & KT-7) from the eastern flank of the lake with scanty trees and extensively cultivated land also portray the dominance of non-arboreals and relatively much reduced numbers and frequencies of arboreals. *Madhuca indica* (1.2-4.6%) is recovered consistently with appreciable frequencies. However, the rest of the trees, *Terminalia* (3%), *Holoptelea integrifolia*, Sapotaceae (2.8% each), *Adenanthera* (1.9%), *Emblica officinalis* (1.8%) and *Acacia nilotica* (1.2%) are sporadic, though in good frequencies. *Maytenus* (0.9%) *Shorea robusta* and *Syzygium* (0.6% each) are scanty. The shrubby elements, *Mimosa pudica* (8.9%) is much frequent in one sample only. Acanthaceae (2.8%), *Linum* (1.9%) and Fabaceae (0.6%) are occasional.

Among the herbaceous taxa, Poaceae (16.7-22%) retained its dominance over others such as Cheno/Am (7.7-11.1%), Brassicaceae (2.4-9.3%), Cerealia (0.9-4.2%) and *Cannabis sativa* (0.8-3.6%) in moderate to high values. *Artemisia* (0.6-0.9%) and *Momordica charantia* (0.9%) are in much reduced values. Tubuliflorae (6.0-12.0%) attains the highest values. *Xanthium strumarium* (1.8%) is present in one sample only. The wetland elements, Cyperaceae (9.3-10.7%) and *Polygonum plebeium* (3.6-4.6%) are encountered steadily with moderate to high values. Liliaceae (1.2%) is intermittent. The aquatic element, *Typha latifolia* (6.5-10.7%) is met in much high frequencies in contrast to *Lemna* (0.9-3.6%) and *Potamogeton* (0.9-1.2%), which are also steadily recorded. *Nymphoides* (1.9%) is scarce. Fern monolete spores (1.8%) together with the Himalayan elements such as *Betula* (1.2%) and *Alnus* (0.9%) are scarce.

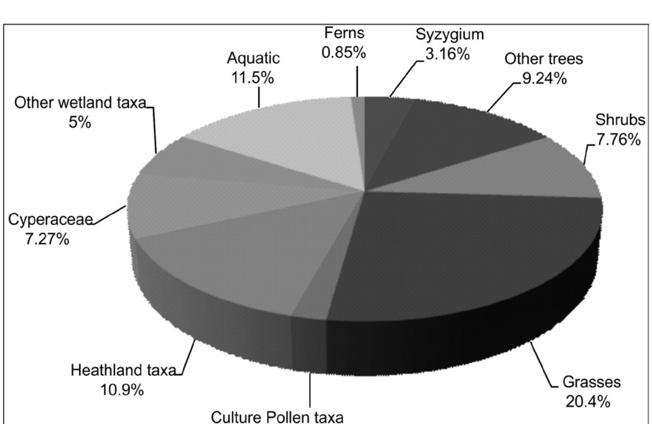

Fig. 3. Composite pollen spectrum showing the different plant groups recovered from the sediments.

POLLEN SPECTRA (KT-8, KT-9 & KT-10) from the northern flank with diversified forest groves show highest values of *Syzygium cumini* (2.4-7.1%). Other trees such as *Holoptelea integrifolia* and *Madhuca indica* (2.7-0.8% each) are also have constantly good frequencies. *Shorea robusta* (0.9-1.6%), *Acacia* (1.7-1.8%), *Terminalia* (0.8-1.8%) and *Emblica officinalis* (1.6-4.2%) are represented infrequently with moderate to low values. *Schleichera oleosa* and Sapotaceae (0.8% each) are meager. The shrubby elements, *Mimosa pudica* (4.4-7.9%) and Acantahceae (1.6-2.7%) are steadily present in substantial values; whereas *Adhatoda vesica* (1.6-2.5%) and *Linum* (1.8%) are noticed with moderate values, though infrequently.

Among the herbaceous elements, Poaceae (15.7-25.7%) maintains dominance over others viz., Brassicaceae (4.4-10.1%), Cheno/Am (2.7-7.1%), Cerealia (1.8-6.3%), *Cannabis sativa* (0.8-3.9%) and *Artemisia* (0.8-2.4%), which are also encountered constantly in moderate values. Caryophyllaceae (0.8-1.7%) is in reduced value. Tubuliflorae (3.5-10.9%) retains its consistently high frequencies among the heathland taxa. Malvaceae (0.8-2.7%) is also better represented, though sporadically, in contrast to Ranunculaceae (1.8%). Liguliflorae (0.8%) and *Xanthium strumarium* (0.9%), which are in variable frequencies in one sample each. The wetland elements, Cyperaceae (5-7.9%) and *Polygonum plebeium* (3.5-5%) have good frequencies. *Polygonum serrulatum* (2.5%) and Liliaceae (0.8%) are recovered intermittently in one sample each only. The aquatic elements viz., *Typha latifolia*, *Potamogeton* (2.7-5% each) and *Lemna* (1.7-6.2%) show high frequencies, whereas *Trapa* (0.8%) is scarce. Fern spores (monolete 0.8-0.9% and trilete 1.7%) are in reduced values. The pollen of *Pinus* (0.8%) is found occasionally.

DISCUSSION

The pollen rain-vegetation relationship study is indispensable prior to the investigation of sediment deposits as it provides the modern analogue to decipher the changing vegetation scenarios and coeval climate change in any region during the past. In this context, an attempt has been executed from Kikar Tal, Raebareli District (U.P), through the pollen analysis of 10 surface samples from the vicinity of this lake from where the analysis of sediment deposit is undertaken. The pollen assemblage in general, has revealed the dominance of non-arboreals (herbs) in contrast to reduced number and low frequencies of arboreals (trees and shrubs). Amongst the trees, *Syzygium cumini, Holoptelea integrifolia* and *Madhuca indica* are prominent, constituting av. 6.35% fraction of the tree pollen. The representation of these taxa corresponds to some extent with their presence in the regional floristics as well as in localized forest grooves. However, *Acacia nilotica, Terminalia, Bombax ceiba, Shorea robusta, Schleichera oleosa, Adenanthera, Maytenus*, Sapotaceae, etc. are extremely sporadic and do not exhibit their actual presence. They form a small chunk of av. 5.83% pollen and collectively all the trees are marked by av. 12.18% pollen only out of the total pollen flux. Despite their sparse presence in the region; they are still under-represented (Fig. 2). This irregular display of most of the trees could be ascribed to either low pollen productivity owing to their entomophilous mode of pollination. Similar inferences have been drawn concerning the ambiguous representation of trees in the modern pollen rain of the tropical deciduous forests from Central India (Chauhan, 1994, 2007) and tropical South Africa (Vincens *et al*., 1997). Besides, the poor dispersal efficiency from the source and selective preservation of pollen in the sediments cannot be denied. Further, a large number of trees occurring in variable proportion in the region are untraceable in the sediments. The microbial degradation of the pollen cannot also be ruled out as a good number of fungal spores such as *Nigrospora*, *Tetraploa*, *Alternaria*, *Glomus*, *Curvularia*, ascospores, etc. have been recovered in the sediments, while examining the samples. Further, it has been observed that the southern and northern flanks of the lake with good forest groves demonstrate the somewhat better representation of trees in their respective spectra with av. values of 12.05% and av. 15.9% pollen respectively, in contrast to western and eastern flanks, which are studded to cultivated land and open vegetation with sprinkle of a few trees for a wider extent. Earlier studies conducted from Jalesar Lake, Unnao District (Trivedi *et al*., 2011; Bari Tal, Lucknow District (Trivedi *et al*., 2014); Karela Jheel, Lucknow District (Chauhan *et al*., 2015), Chaudhary-Ka-tal, Raebareli District (Saxena *et al*., 2015; Trivedi *et al*., 2016) and Kikar Tal (Saxena and Trivedi 2017) from the Central Ganga plain have also brought out the low record of the trees with average 17%, 16%, 20.8% 13.8% pollen in the pollen rain respectively. The record of temperate and subtropical elements such as *Pinus*, *Alnus* and *Betula* in the sediments signifies the transportation of their pollen largely by water courses and partly by winds from the Himalayan region, where they occur abundantly (Chauhan *et al*., 2015). Their presence also suggests the Himalayan connection of regional winds circulation pattern. This is also well evident from the record of pollen of above subtropical and temperate plants in surface and sediment profile samples from central India (Chauhan, 2007; Chauhan *et al*., 2013) and Rajsthan Desert (Yadav *et al*., 2007), depicting their exclusive drifting by the turbulent wind currents from the Himalaya since there are no water channels leading to these regions from the Himalaya.

The ground vegetation as usual is dominated by grasses encompassing av. 21% pollen of the total pollen rain in the region. However, the consistent recovery of Cerealia and other culture pollen taxa such as Cheno/Am, *Cannabis sativa*, Brassicaceae, *Artemisia*, etc. with a cumbersome av. 21.6% suggests the extensive cultivation and human interference in the area adjoining to the lake as well as much open nature of the vegetation. The pollen rain data from western and eastern flanks of the lake demonstrates the relatively higher frequencies of culture pollen taxa, because the adjoining areas are under intensive cultivation and densely inhabited. Interestingly, the considerable record of Tubuliflorae (Asteraceae) throughout signals that the open vegetation is under the impact of much pastoral activity, since the plants of this sub-family escape the grazing and browsing as they are unpalatable to cattle and goats, hence more pollen in the sediments (Vincens *et al*., 1997). The terrestrial heathland taxa constitute av. 11% pollen. The presence of intermittent marshes and wetland in the region is confirmed by the frequent pollen of sedges and *Polygonum plebeium* along with poor presence of Liliaceae with av. 12.27% pollen. Thus, from the above stated account on the pollen rain it is inferred that non-arboreals constitute the largest fraction of average 85% pollen of the pollen influx, which again attest the open nature of the overall vegetation of the region. The representation of the non-arboreals is in concordance with the results from other sites such as Jalesar, Unnao District (Trivedi *et al*., 2011), Chaudhary-ka-Tal, Raebareli District (Saxena *et al*., 2015); Karela Jheel (Chauhan *et al*., 2015) and Bari Tal, Lucknow District (Trivedi *et al*., 2014) from the Central Ganga Plain.

Thus, the overall dominance of non-arboreals and relatively reduced number and frequencies of arboreals (trees & shrubs) in the assemblage retrieved depicts the much open nature of vegetation around the study site. Trees are few and among them the consistent record of *Syzygium cumini* with av. 3% pollen corresponds to some extent with its presence in the regional floristics (Fig. 3). However, *Madhuca indica* and *Acacia nilotica*, which are also common in the region along with other trees viz., *Emblica officinalis*, *Holoptelea integrifolia*, *Terminalia*, *Bombax ceiba*, etc. are extremely sporadic, albeit their sparse occurrence in the region, representing a trivial amount of av. 9% pollen only. The under-represented of most of the trees could be ascribed to their low pollen productivity as well as selective preservation of pollen in the sediments. In all, trees are represented by a small fraction of av. 12% pollen and together with av., 3% shrubby elements; they constitute av. 15% arboreal pollen only. Among the non-arboreals (herbs) the preponderance of grasses coupled with appreciable encounter of culture pollen; heathland and wetland taxa portray truly their composition in the ground flora. They constitute the largest chunk of av. 85% pollen. Further, the frequent encounter of Cerealia and other culture pollen taxa elucidates the intensive agrarian practice and other human activities in the vicinity of the lake. The consistent record of aquatic elements, particularly *Typha latifolia* and *Lemna* suggests the frequent presence of good numbers of ponds/lakes interspersed in the open vegetation. This comparative database on pollen rain vis-à-vis vegetation serves as a modern analogue for the appropriate appraisal of the pollen sequence from the sediment deposits in terms of past vegetation and climate change in the region. Further, the overall representation of trees signifies the existing climate in the region as dealt elsewhere in the text.

In addition, the careful examination of pollen/spores in the surface soils facilitates in discerning the various plant species/ groups contributing to the regional aerospora. Since after emission of pollen from the flowers and spores from the fungal fruiting bodies, they remain suspended in the atmosphere and subsequently get settled down along with dews and rains. This information provides awareness among the people regarding the major pollen/spores in the local atmosphere so that the preventive measures to be taken against the allergic diseases caused by them.

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