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STUDIES ON POLLEN RAIN VIS-A-VIS VEGETATION RELATIONSHIP IN CHAUDHARI- KA-TAL, RAEBARELI DISTRICT, UTTAR PRADESH

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ABSTRACT

The paper embodies the modern pollen rain-vegetation relationship, based on pollen analysis of 10 surface samples from Chaudhari-Ka-Tal, Raebareli District. The pollen assemblage reveals the dominance of non-arboreals (herbs) and relatively extremely low frequencies of arboreals (trees and shrubs). Among the tree taxa, average frequencies of the major components are, *Madhuca indica* 4.53%, *Holoptelea* 2.39% and *Acacia nilotica* 2.22% and these collectively constitute average 9.14% fraction of the pollen rain, whereas rest of the trees viz., *Terminalia*, *Emblica officinalis*, *Schleichera*, *Bombax ceiba*, *Syzygium* and *Annona* cf. *squamosa* are retrieved very meagerly with average of 4.69% pollen only. The under-representation of all these taxa could be inferred due to their low pollen productivity owing to entomophilous mode of pollination as well as their sparse presence in the local flora. The partial preservation of their pollen in the sediments cannot be denied. In all, the trees taxa constituting a chunk of average 13.8% of the total pollen rain do not reflect their actual composition in the extant vegetation. The grasses average 37% pollen together with good representation of sedges, Cheno/Am, Caryophyllaceae, Brassicaceae, Asteraceae and *Artemisia* in the pollen rain substantiate their actual presence in the herbaceous complex. The frequent encounter of Cerealia along with other culture pollen taxa viz., Cheno/Am, Brassicaceae and *Artemisia* depicts the proximity of the cultivated land to the study site. The consistently high frequencies of *Typha* imply its luxuriant growth all along the swampy margin of the lake and nearby waterlogged areas. Fungal spores viz., *Glomus*, *Nigrospora*, *Tetraploa* and *Curvularia* are recorded in considerable frequencies, indicating the damp condition.

Keywords*:* Pollen rain, Pollen deposition, Vegetation, Chaudhari-Ka-Tal, Raebareli District

INTRODUCTION

Considerable data-grid has been generated on modern pollen rain-vegetation relationships for the tropical evergreen and deciduous forests in South India and Sri Lanka (Bonnefille *et al*., 1999; Anupama *et al*., 2000; Barboni and Bonnefille, 2001), tropical deciduous forests in the foothills of Himalaya (Sharma, 1985; Gupta and Yadav, 1992), northeast India (Basumatary and Bera, 2007), Madhya Pradesh (Chauhan, 1994, 2007) and tropical deciduous scrub vegetation in northwest desert (Singh et al., 1973). These studies have provided significant comparative database on the pollen rain vis-a-vis modern vegetation and have been used as modern analogue for the factual appraisal of past pollen sequences from their respective regions in terms of vegetation succession and coeval climatic conditions during the Quaternary Period. However, the Ganga Plain with immense potential for the Quaternary palaeofloristic and palaeoclimatic studies has not been given adequate attention to unravel the pollen deposition pattern of different plant taxa/plant groups, which is imperative prior to the analysis of sedimentary/ lacustrine deposits from this region. In this perspective, hitherto a maiden study has been executed from Jalesar, Unnao District in the Central Ganga Plain (Trivedi and Chauhan, 2012). In the present paper, an endeavour has been made to bring about more information on this aspect in order to assess the factual extent of representation of various regional and local plant taxa in the modern pollen rain and to reveal their pollen dispersal efficiency as well as the possible factors affecting preservation of pollen/ spores in the sediments through the pollen analysis of surface soil samples gleaned from the milieu of the Chaudhari-Ka-Tal in Raebareli District.

STUDY AREA

The investigation site-Chaudhari-Ka-Tal is situated about 55km southwest of Lucknow and 2km east of Bachharawan township on Shivgarh road and on the left bank of Sharda Canal between Long. 81°7′ 15.75″ and Lat. 20° 28′36.02″ in Raebareli District. The lake is perennial and very big in expanse, measuring 300m in length and 100m in breadth at its widest (Fig. 1). It is irregular in shape with bumpy surrounding land surface all around and raised embankment on western and southern sides. The western and southern parts adjoining to the lake are under intensive agricultural practice, whereas the eastern and northern parts studded with the lake possess some forest groves and Acacia-scrub vegetation. The lake is fed by the subterranean as well as rain water. However, it remains filled with water for a wider extent during the monsoon season as well as till early winter season and is used for irrigation and fish rearing on commercial scale by the owners. Singhara (*Trapa natans*) is also cultivated in the lake by the local folks on commercial basis. Most of the area encircling the lake is under the cultivation of the conventional crops viz., *Triticum aestivum* (wheat), *Oryza sativa* (paddy), *Cicer aeretinum* (chana), *Phaseolus mungo* and *Sacchhrum offinarum* (sugarcane). Presently, mint (*Mentha piperita*) is grown by the local people as a cash crop. The swampy margin of the lake is profusely overgrown with *Typha latifolia* (elephant grass) and *Ipomoea aquatica*. However, eastern and southern flanks of the lake are occupied by thick mat of *Chara* and *Trapa natans*, especially during post-monsoon season.

CLIMATE

Climate of the region, in general, is humid and largely influenced by southwest monsoon (Chauhan *et al*., 1990).

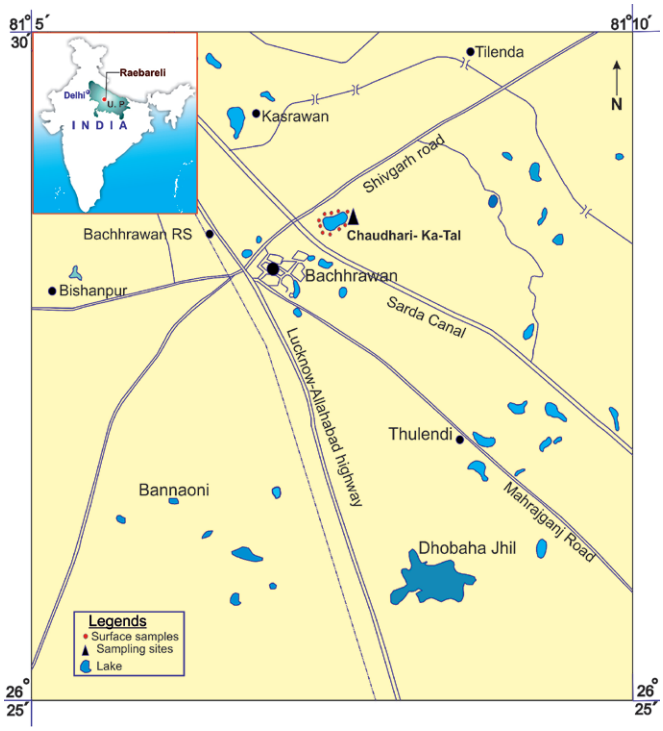


Fig. 1. Map of Chaudhary-Ka-Tal, Raebareli showing site of surface samples.

Winter season from November to February is characterized by average minimum and maximum temperatures of 7.6ºC and 21ºC respectively. The temperature occasionally goes down to 0ºC during the extreme cold months of December and January. Summer season from April to June is marked by hot 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 begins 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 region is 1020-1140 mm. About 75% rainfall occurs during the monsoon season.

VEGETATION

The area in the vicinity of the lake has patchy occurrence of stands or groves of forest interspersed with stretches of open mixed savannah, dominated by grasses (Champion and Seth, 1968). Thus, the landscape imparts a view of open vegetation. The trees viz., *Acacia arabica*, *Acacia nilotica*, *Holoptelea integrifolia*, *Cordia dichotoma*, *Syzygium cumini*, *Madhuca indica*, *Capparis decidua*, *Butea monosperma*, *Symplocos racemosa*, *Ailanthus* excelsa, *Melia azardirach*, *Aegle marmelos*, *Bauhinia variegata*, *Albizia lebbek*, *Flacourtia indica*, *Terminalia arjuna*, *Dalbergia sissoo*, etc. together with thickets of *Ziziphus mauritiana*, *Carissa spinarum*, *Adhatoda vasica*, *Indigofera himalayensis*, *Nyctanthes arbor-tritis*, etc. occur sparingly distributed in the scrub forests. However, 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 pockets. Around the habitations *Adhatoda vasica*, *Ricinus communis* and *Mimosa pudica* are frequent. *Mangifera indica*, *Melia azedirach*, *Tamarindus indica*, *Syzygiumcumini* and *Ficus religiosa* are the common avenue trees.

The herbaceous vegetation as usual is largely constituted of grasses, *Amaranthus*, *Ajuga bracteosa*, *Mazus japonicus*, *Oxalis acetosella, Ageratum conyzoides*, *Vernonia cinerea*, *Sonchus oleraceus*, *Euphorbia hirta*, *E. thymifolia*, *Sida rhombifolia*, *Micromeria biflora*, *Luecas aspera*, *Blumea eriantha*, *Argemone mexicana*, *Parthenium* sp. etc. Sedges such as *Cyperus rotundus*, *Scirpus mucronatus* and *Fimbristylis miliacea* together with *Polygonum plebeium*, *Ammania baccifera*, *Rotala rotundifolia*, *Hygrophilla auriculata* and *Alternanthera sessilis* are the major components of the marshy vegetation along the lake margin and banks of streams and rivulets. The aquatic elements including, *Trapa natans*, *Lemna polyrriza*, *Potamogeton 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 METHOD

In all, 10 surface samples (CKT-1 to CKT-10) were collected for the present investigation from the vicinity of Chaudhary-Ka-Tal to study the modern pollen-vegetation relationship. A trench profile from here has also being analysed to reconstruct the past vegetation and climate change. 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 getting discharged from the source plants (Luna et al., 2002). The sampling strategy was planned in linear transect to understand the average representation of the prominent forest constituents/plant groups of the regional vegetation in the pollen rain.

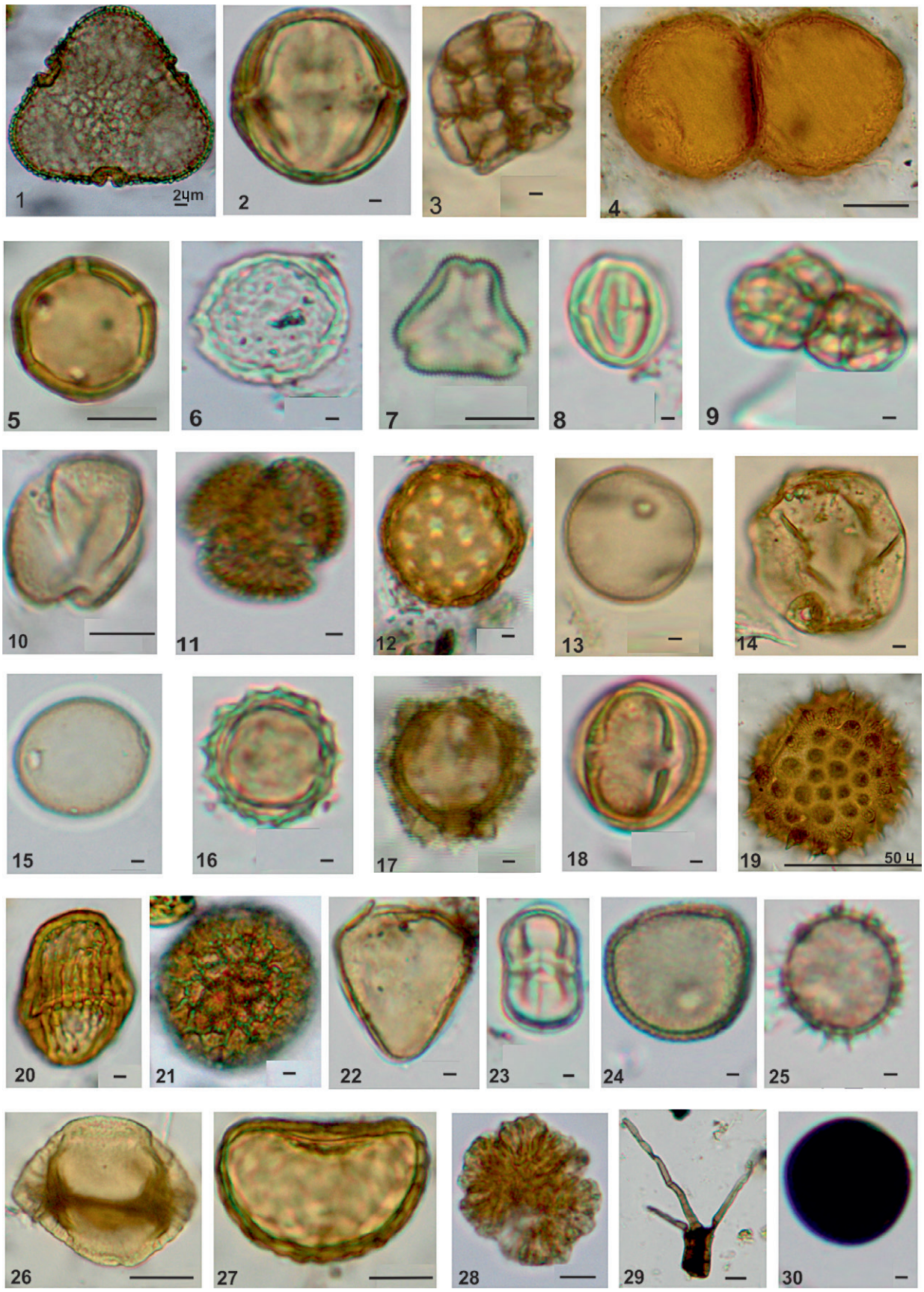
Ten grams of samples were boiled with 10% aqueous KOH and 40% HF in order to remove humus and silica present in the surface sediments respectively. Thereafter, the standard procedure of acetolysis (Erdtman, 1943) using acetolysing mixture (9:1 ratio of acetic anhydride and concentrated sulphuric acid)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

All the samples analysed were potential 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. 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

EXPLANATION OF PLATE I

1. ***Bombax ceiba***, 2. ***Madhuca indica***, 3. ***Acacia nilotica*** 4. ***Annona squamosa*** 5. ***Aspidopterys***, 6. ***Holoptelea***, 7. ***Syzygium***, 8. ***Terminalia***, 9. ***Mimosa***, 10. ***Prosopis spicigera***, 11. **Brassicaceae** 12. **Cheno/Am** 12. **Poaceae**, 14. **Cerealia**, 15. ***Cannabis sativa***, 16. **Tubuliflorae**, 17. **Liguliflorae**, 18. ***Artemisia***, 19. **Malvaceae**, 20. ***Polygala chinensis***, 21. ***Polygonum serrulatum***, 22. **Cyperaceae**, 23. ***Polygonum plebeium***, 24. ***Typha***, 25. ***Lemna***, 26 ***Trapa***, 27. **Fern monlete spore** 28. ***Botryococcus***, 29. ***Tetraploa***, 30. ***Nigrospora***.

Plate I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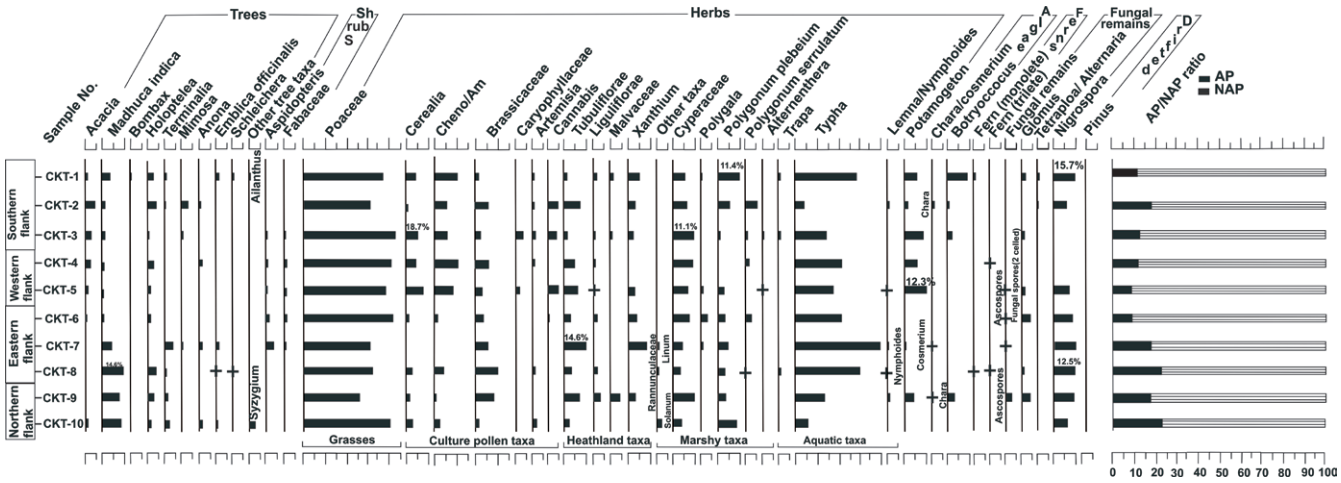

Fig. 2. Pollen spectra from Chaudhary-Ka-Tal, Raebareli District.

local provenances. The plant taxa (Pollen plate) 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, CKT-1, CKT-2 and CKT-3 are from the southern flank; CKT-4 and CKT-5 eastern flank, CKT-6, CKT-7 and CKT-8 northern flank and CKT-9 and CKT-10 from the western flank of the lake. The pollen rain compositionof the samples from different flanks are described as below (Fig. 2).

POLLEN SPECTRA (CKT-I, CKT-2 and CKT-3) from southern flank of the lake reveals the dominance of non-arboreals and relatively reduced frequencies of arboreals (trees and shrubs). The tree taxa, *Holoptelea* (0.92-4.6%), *Madhuca indica* (1.85-4.6%) and *Acacia nilotica* (1.4-4.6%) are constantly recorded in moderate values. *Terminalia* (0.65-1.42%), *Schleichera*, *Emblica officinalis* (1.42% each) and *Annona* (0.65%) are present sporadically in low frequencies. Fabaceae (1.4-3.9%) is steadily noticed in moderate values. *Mimosa* (0.92-2.8%) occurs sporadically in good values, (mention % as given in other cases) whereas *Aspidopterys* (0.92%) is meagre.

The herbaceous vegetation is characterized by the high frequencies and consistent presence of Poaceae (31.5-43.5%) followed by Cheno/Am (5.2-10%), Tubuliflorae (1.4-7.8%), Cerealia (1.9-6.4%), Brassicaceae (1.42-5.92%), *Xanthium* (1.85-5%) and *Artemisia* (1.3-1.6%). *Cannabis sativa* (2.7-3.9%), Liguliflorae (0.92-2.14%), Malvaceae (1.85-2.14%), Caryophyllaceae (3.7%) and *Alternanthera* (0.92%) are recorded intermittently in moderate to low frequencies. The marshy elements viz., Cyperaceae (0.57-11%) and *Polygonum plebeium* (0.52-11.4%) are retrieved constantly in moderate to high frequencies. *Polygonum serrulatum* (0.92-5.2%) and *Polygala* 90.71%) are occasional in variable frequencies. Among the aquatic elements, *Typha* (3.2-28%) and *Potamogeton* (1.9-8.3%) are encountered in high values. *Lemna* (1.3%) and *Trapa* (2.14%) are recorded in one sample each. Fern monolete spores (1.97%) are stray. The fungal spores, *Nigrospora* (4.6-15%), *Glomus* (1.8-2-14%), *Tetraploa* (0.65-0.71%) and fungal spores (0.92-1.34%) are very frequent to rare. POLLEN SPECTRA (CKT-4 and CKT-5) from western flank of the lake also exhibit relatively much reduced number and frequencies of arboreal pollen as compared to the non-arboreal pollen. However, the tree taxa such as *Acacia nilotica* (1.1-2.5%), *Madhuca indica* and *Bombax ceiba* (1.1-1.6% each), are met with consistently in reduced values. *Annona* (1.6%) is recorded in one sample only. The shrubby elements such as Fabaceae (1.6-2.2%) and *Aspidopterys* (1.6-1.76%) show constantly moderate values.

The non-arboreals as usual are characterized by the high frequencies of Poaceae (39-41%) followed by Cheno/Am (7.6-11.6%), Cerealia (5-8.2%), Tubuliflorae (2.5-6.4%)), Brassicaceae (2.9-5.8%) also in appreciable frequencies. Liguliflorae (0.8-0.9%), Caryophyllaceae, *Cannabis sativa* (1.76 % each), *Artemisia* (1.66%), *Xanthium* (3.5%) and *Alternanthera* (0.58%) are retrieved infrequently. The marshy vegetation is marked by high values of Cyperaceae (7-9.1%) and *Polygonum plebeium* (4.7-5%) have higher frequencies in this flanktoo. The aquatic elements, *Typha* (17.6-22%) and *Potamogeton* (6.6-12.2%) have much increased values, whereas *Trapa* (1.63%) and *Lemna* (0.58%) are feeble. Fern trilete spores 0.58%) are trivial. Fungal spores, *Glomus* (1.76%), *Curvularia* (2.9%), *Nigrospora* (5.8%) and 2-celled fungal spores (0.66%) are also recorded, though in fluctuating values.

POLLEN SPECTRA (CKT-6, CKT-7 and CKT-8) from eastern flank of lake demonstrate the enhanced diversity of arboreal pollen. *Madhuca indica* (1.48-14.6%) attained highest values, whereas *Acacia nilotica* (1.08-1.98%) is also steadily present in relatively lower frequencies. *Holoptelea* (2.2-4.34%), *Terminalia* (1.08-3.97%) and *Emblica officinalis* (0.54-1.32%) are in moderate values, though sporadically. Others such as *Annona* (1.98%), *Bombax ceiba* (0.74%) and *Schleichera* (0.54%) are scanty. The 7 meagre shrubby taxa, Fabaceae (1.62-2.22%) and *Aspidopterys* (2.96-3.97%) are represented with moderate frequencies.

Among the terrestrial herbs, Poaceae (32.4-43.7%), Cheno/Am (6.6-11.9%) and Brassicaceae (3.7-10.8%) and Tubuliflorae (3.2-14.5%) are marked by their constantly much higher frequencies. Others viz., Cerealia (2.2-3.8%) has reduced values. *Xanthium* (3.7-7.9%) attains the highest frequency. *Artemisia* (1.08%), Liguliflorae (1-2.2%) and Ranunculaceae (1.08%) are scanty. The marshy elements, Cyperaceae (3.8-8.14%) and *Polygonum plebeium* (3.2-6.66%) maintain the high values. *Polygala chinensis* (1.9-3.7%) and *Polgonum serrulatum*

(0.54-2.96%) has low to moderate values. *Typha* (22.2-39%) is recovered with highest frequencies so far, whereas *Potamogeton* (0.66%), *Lemna* (0.66-0.74%), *Trapa* (1.63%) and *Nymphoides* (0.54%) are trivial. Fern spores (monolete 0.54% and trilete 0.54-0.70%) are feeble. Fungal spores such as *Nigrospora* (6.6-12.5%), *Glomus* (4.4%), *Alternaria* (1.32%) ascospores and bi-celled spores (0.66% each) are in deviating frequencies.

POLLEN SPECTRA (CKT-9 and CKT-10) from northern flank are characterized by the relatively lowest diversity of both arboreals and non-arboreals as compared to other flanks. The tree taxa, *Madhuca indica* (7.2-7.8%) followed *Terminalia* (2.7-2.8%), Acacia (1.6-3.7%) and *Holoptelea* (2.1-3.3%) are constantly recorded in increased values. *Syzygium* (2.8%), *Bombax ceiba* (2.12%) and *Emblica officinalis* (1.41%) are encountered with low to moderate value, despite their sporadic presence. Fabaceae (1.4-3.9%) is the only representative of shrubby vegetation.

Among the non-arboreals, Poaceae (26.8-41.1%) retains its dominance over other herbaceous elements. Cheno/Am (4-12.8%), Brassicaceae (2.1-7.8%), Tubuliflorae (3.5-6.7%) and Cerealia (2.2-2.8%) are met with consistently with moderate to high values too. Malvaceae (4.4%), *Xanthium* (3.9%), *Justicia* (2.12%), *Artemisia* and Liguliflorae (2.2% each) are sporadic and have the higher frequency in contrast to other flanks. Cyperaceae (4.2-10%) and *Polygonum plebeium* (3.9-8.5%) are in moderate to high frequencies as seen in other flanks. *Solanum* (2.8%) is recorded in one sample only. *Typha* (6.3-13.4%) is recovered steadily with high frequencies. *Potamogeton* (4.46%) and *Lemna* (1.6%) are occasional with moderate frequencies. Fern trilete spores (0.7%) are scarce. The fungal spores, *Glomus* (1-4.4%), *Nigrospora* (4.2-10%) and ascospores (3.3%) are frequent, whereas bi-celled spores (0.55%) are found occasionally.

DISCUSSION

The study of pollen rain-vegetation relationship is a pre-requisite prior to analysis of sedimentary deposits because it provides the modern analogue for the appropriate assessment of changing vegetation scenarios and contemporary climate variability during the past. Hence, to generate the comparative database on this aspect in order to understand the pollen deposition pattern of various regional and local plant taxa/plant groups, the investigation of surface sediments was executed from Chaudhari-Ka-Tal in Raebareli District, from where a sediment profile by Saxena *et al*. (2015) for the reconstruction of past vegetation and climate change was studied. The pollen rain study conducted on 10 surface samples collected from different flanks of Chaudhary-Ka-Tal in Raebareli District (Fig. 2) has indicated the dominance of non-arboreals (herbs) and relatively low number and frequencies of arboreals (trees and shrubs). Among the trees, *Madhuca indica* with average 4.53% pollen followed by *Holoptelea* and *Acacia* with average 2.39% and 2.22% pollen are consistently represented and collectively constitute a fraction of 9.14% pollen. The representation of these taxa exhibits coherence to some extent with their presence in the regional vegetation. The rest of the trees such as *Terminalia*, *Emblica officinalis*, *Annona*, *Syzygium*, *Bombax ceiba*, *Schleichera* and *Alianthus* are sporadically present in low frequencies and are represented by as low as average 4.69% pollen only, irrespective to their factual presence in the local flora, though occurring sparsely. In all, the trees are marked by a small chunk of average 13.84% proportion of the total pollen rain. The under-representation of most of the tree taxa in the pollen rain could be attributed to their low pollen productivity since majority of the tropical trees depict a strong tendency of insect pollination (Chauhan, 2008). Similar observations have also been made concerning the erratic interplay of tropical trees in the pollen rain from the Central Ganga Plain (Trivedi and Chauhan, 2011) and Madhya Pradesh (Chauhan, 1994, 2008) as well as from tropical forests from South Africa (Vincens *et al*., 1997). The selective preservation of their pollen as well as microbial degradation cannot be overlooked since a large number of fungal spores viz., *Nigrospora*, *Tetraploa*, *Glomus,* etc. have also been recovered substantially in the sediments. The scanty shrubby vegetation is truly indicated by the intermittent pollen of a few taxa viz., Fabaceae, *Aspidopterys* and *Mimosa*, representing average 3.7% pollen only. Thus, the total average 17% pollen including trees and shrubs denotes the arboreal vegetation, which also symbolizes the existing climatic condition in the region. Further, the maximum influx of tree pollen in terms of quantity and diversity has been recorded in the northern and eastern flanks since there occur relatively more forest groves in contrast to southern and western sides, where most of the area is under intensive cultivation. Among the non-arboreals constantly high frequencies of Poaceae (grasses) with average 37% pollen is the most dominant. However, the frequent presence of Cerealia and other concomitant cropland weeds such as Cheno/Am, Brassicaceae and *Artemisia* coupled with *Cannabis sativa* and Caryophyllaceae, though sporadically, reflects that most of the area in the vicinity of the lake is under intensive agrarian practice and some other kinds of anthropogenic activities. Additionally, the appreciably high frequencies of heathland elements of Asteraceae (Tubuliflorae and Liguliflorae) provide the evidence for increasing pastoral activities since they are unpalatable to cattle and goats, hence more pollen in the sediments. The good encounter of sedges (Cyperaceae), *Polygonum plebeium* and *Alternanthera* in fluctuating moderate to high frequencies demonstrates the prevalence of marshy condition along the lake margin. In general, the representation of non-arboreal terrestrial pollen assemblage implies a close coherence with the ground flora in the region. Furthermore, the preponderance of *Typha*, a semi-aquatic element and wetland elements of sedges correspond with their profuse growth along the lake margin. In addition, the retrieval of *Potamogeton* together with *Trapa*, despite its low-pollen production, suggests the proximity of lake and other water-bodies, wherefrom their pollen get trapped in the surface sediments. The pronounced damp condition along lake margin also favours the propagation of fungi such as *Glomus*, *Tetraploa*, *Nigrospora* and fungal spores of uncertain affinities, which is evident from their frequent presence in almost all the samples. However, fungal diversity is more at southern flank probably owing to more-damp condition in contrast to other flanks. They decline sharply in number and frequencies on the western flank because of pronounced dry condition. The recovery of stray pollen of *Pinus* in the sediment suggests their transportation mainly by watercourse as well as winds from the temperate and subtropical belts of the Himalaya, where it grows abundantly.

CONCLUSIONS

Comparative assessment of AP and NAP ratio from open vegetation at Chaudhari-Ka-Tal reveals only average 17% arboreal (trees and shrubs) pollen out of the total pollen influx.

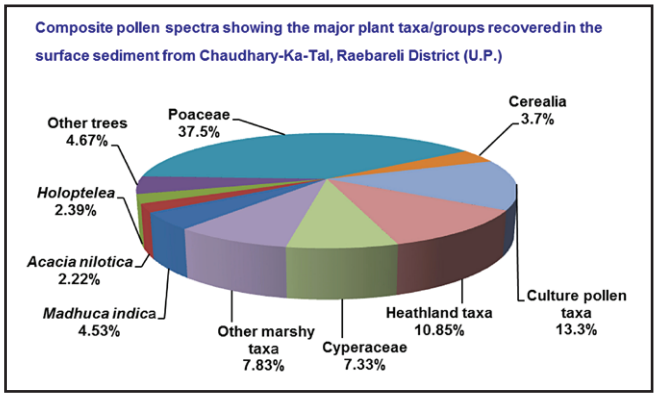

Fig. 3. Composite pollen spectra from Chaudhary-Ka-Tal, Raebareli District.

Among the trees *Madhuca indica* average 4.53%, *Holoptelea* average 2.39% and *Acacia* average 2.2% being the major ingredients. The rest of the trees are represented by average 4.69% pollen only (Fig. 3). The extremely poor depiction of other trees in the pollen rain could be attributed to their low pollen productivity as well as their sparse presence in the area. The shrubs such as *Mimosa*, *Aspidopterys*, Fabaceae, etc. with average 3.7% pollen are meagerly present. Further, the arboreal pollen diversity is relatively better on the eastern and western flanks as the areas adjoining to these parts of the lake support good groves of trees and shrubs. Among the non-arboreals grasses (Poaceae) are recorded with average 37% of pollen, whereas Cerealia, culture pollen taxa and heathland taxa collectively form average 17% proportion of the total pollen rain. On the whole the terrestrial herbs constitute the largest fraction of average 64% pollen. On the other hand, marshy sedges and others are encountered with average 15.15% pollen. The non-arboreals with largest fraction of average 80% pollen, encompassing terrestrial and marshy herbs, by and large validates the presence of open vegetation in the region. Hence, it is suggested that this comparative database on pollen rain vis-à-vis vegetation is to be taken as a modern analogue for the judicious assessment of vegetation dynamics of the past, while interpreting the pollen sequences from the Central Ganga Plain and other regions with equivalent extant floristic set-up. The pollen rain data-grid also elucidates the existing climatic condition in the region as dealt elsewhere in the text.

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