Modern pollen / spore rain in Surinsar and Mansar lakes, Jammu

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Pollen rain in relation to the extant vegetation in Jammu region is portrayed here through the pollen analysis of surface samples collected from the vicinity of two lakes–Surinsar and Mansar. Total 14 samples–seven each collected from different ecological sites around the above two lakes on pollen analysis have provided the regional pollen rain picture to construct the modern pollen / spore depositional model. Overall pollen assemblage reflected in the present studies show excessively high frequencies of *Pinus roxburghii,* corresponding satisfactorily with the existing pure pine and mixed pine- oak forests seen on the montane slopes around both the lakes. However, oak pollen recovery together with some of its other associated elements such as *Alnus, Dodonaea,* Rosaceae betray the actual composition in the vegetation by remaining extremely low in their frequencies. Furthermore, a number of other taxa viz., *Rhododendron, Cinnamomum, Salix,* etc., presently existing in the area, are totally absent or remain under-represented which can be attributed either to their entomophilous nature or the failure of pollen preservation in the sediments. Non-arboreal elements, chiefly Poaceae, Asteraceae, Cheno/ Ams are recovered in good frequencies, reflecting more or less their true composition in the ground vegetation.

Key-words—Himalaya, Palynology, Recent Pollen Spectra, Surinsar, Mansar, Jammu.

INTRODUCTION

PALYNOSTRATIGRAPHICAL investigations of Quaternary lacustrine sediments are aimed to reconstruct palaeovegetation succession in the region to enable us to decipher the corresponding climatic changes. Modern pollen deposition pattern vis-a-vis the extant vegetation in the region, evaluation of the floristic composition taking into account the pollen frequencies and ecology of variously represented plant taxa is taken as the pre-requisite for meaningful palaeoclimate interpretations. Regional modern pollen rain studies have great relevance while investigating the Himalayas lacustrine sediments owing to the fact that the commonly met with floristic diversity in the local vegetation is generally related to the topography and existing micro-climatic conditions. Such modern pollen rain studies have also been carried out in other regions of Himalaya viz. Kashmir (Vishnu-Mittre & Sharma, 1966; Vishnu- Mittre & Robert, 1971), Himachal Pradesh (Sharma, 1973), Garhwal (Sharma, 1985; Gupta & Sharma, 1991 & Sharma *et al.*, 2000), Kumaon (Gupta, 1977; Chauhan & Sharma, 1991a, b), Kathmandu Valley, Nepal (Vishnu- Mittre & Sharma, 1984), Darjeeling (Sharma & Chauhan, 1994), Sikkim (Sharma, 2001) and Meghalaya (Gupta & Sharma, 1985). Nevertheless, similar studies have not been done so far on the evaluation of modern pollen rain for Jammu region. Consequently, a good number of surface samples were collected along the identified transect at an interval of 100 m each from the vicinity of the two lakes–Surinsar and Mansar, situated about 61 and 54 km respectively from Jammu Tawi (Map).

CLIMATE

Jammu region experiences subtropical climate with maximum average temperature ranging from 28° - 29°C which sometimes touches 35°C in May and June. Minimum recorded average temperature is between 12° - 13°C but sometimes it is as low as 1°C during the extremely cold winter months.

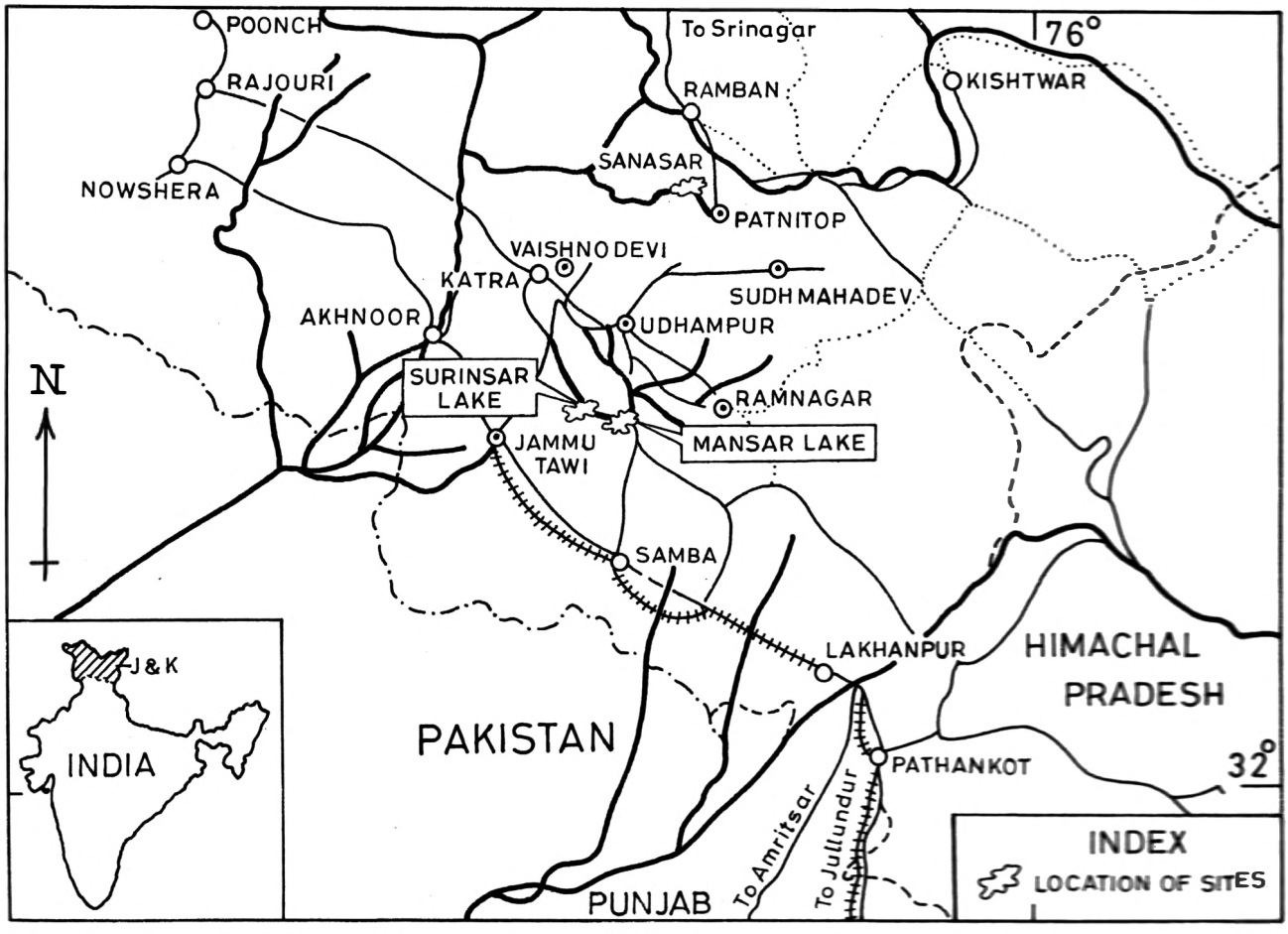
MATERIAL AND METHOD

Fourteen surface samples–seven each from the vicinity of Surinsar and Mansar lake were collected at an interval of 100 m (Figs. 3,4) for the precise appraisal of modern pollen / spore deposition and extant vegetation relationship in Jammu region.

Each sample was boiled in 10% aqueous KOH

Table. Provenance of surface samples collected from Jammu region.

Locality	Sample No.	Nature of sample
Surinsar Lake	1.	Yellowish, clayey sand, having small pieces of rootlets, collected from the vicinity of swampy margin of the lake (facing the school)
	2.	Sandy clay, scrapped from the lake margin.
	3.	Sandy clay, collected from the ground skirting the lake.
	4.	Sandy clay, collected from the swampy margin of the lake.
	5.	Sandy clay having small pieces of rootlets, collected from the swampy margin of the lake.
	6.	Sandy clay, collected from the outer boundary of the lake.
	7.	Sandy clay, collected from the outer boundary of the lake.
Mansar Lake	1.	Sandy clay, collected from the swampy margin of the lake.
	2.	Sandy clay, with small pieces of rootlets, scrapped from the swampy lake margin.
	3.	Sandy clay, collected from the swampy lake margin.
	4.	Sandy clay, with small pieces of rootlets, scrapped from the ground close to *Mangifera indica* growing near the lake.
	5.	Clayey sand, collected from the margin of the lake.
	6.	Yellowish, sticky clay with rootlets.
	7.	Yellowish, sticky clay with rootlets.



Map : Sketch Map of Jammu Region

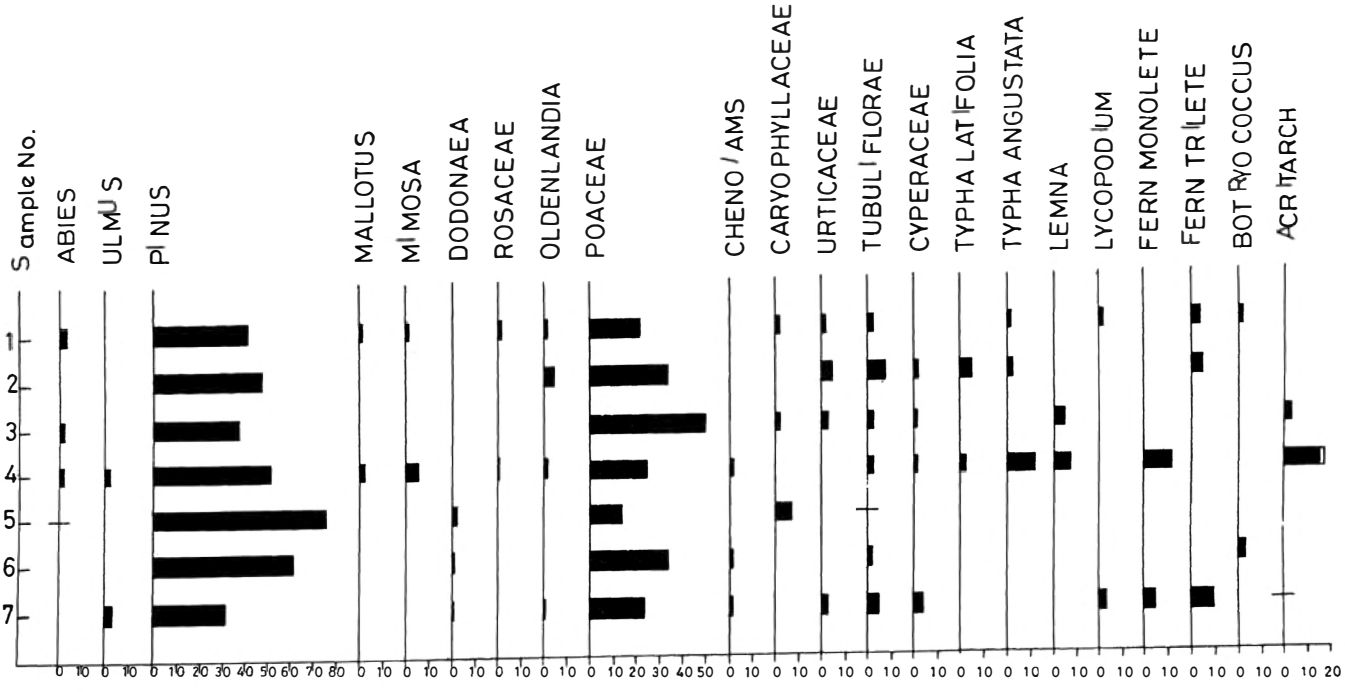


Fig. 1. Recent Pollen Spectra from Surinsar Lake
(Percentages calculated in terms of total terrestrial pollen)

solution to deflocculate the pollen/ spores from the sediments. Thereafter, the samples were treated with 40% HF to dissolve silica followed by the usual technique of acetolysis (Erdtman, 1943) using acetolysis mixture (9:1, acetic anhydride and conc. H_2SO_4). The ultimate pollen material for microscopic observations was fixed in 50% glycerine with few phenol drops to avoid microbial contamination. About 150-250 pollen were counted for each sample.

Constructed pollen spectra are based on the total terrestrial pollen arranged in order viz., trees, shrubs, herbs, ferns and aquatics. Pollen depositional model representing the various major constituents of regional pollen rain is also given in the text (Figs. 2 & 3).

MODERN POLLEN/VEGETATION RELATIONSHIP

Surinsar Lake

It is a fresh-water lake, which lies in the Lower Siwalik range in outer Himalaya at an altitude of 637m (32°46'N, 75°2' E), about 61 km east to the Jammu city. It is surrounded by lofty mountains with steep slopes- providing a panoramic view to the lake. The lake has a small island on its northeastern flank and attracts large number of tourists every year for its scenic beauty.

The mountain slopes surrounding the lake support thick growth of chirpine *(Pinus roxburghii)* forests, almost pure in their arboreal composition together with scanty thickets of *Berberis asiatica, Carissa opaca, Woodfordia fruticosa, Rhus parviflora, Nyctanthes arbor-tritis, Dodonaea viscosa,* etc. The ground cover is mainly comprised of grasses, together with sporadic presence of exotic weed *Ageratum conyzoides* – mainly in shaded situations and some elements of Lamiaceae, Scrophulariaceae, etc. The oak stands are confined mainly to damp and shaded situations on the hill slopes in the proximity of the lake. The oak forest components are chiefly *Quercus incana, Salix, Rosa moschata, Lyonia ovalifolia, Cinnamomum zylenicum,* etc.

Pollen Rain

Surface samples numbering 1–7, as per the details given above (Fig. 1), collected from Surinsar lake site were analysed to understand the pollen depositional pattern in the area. The sample wise

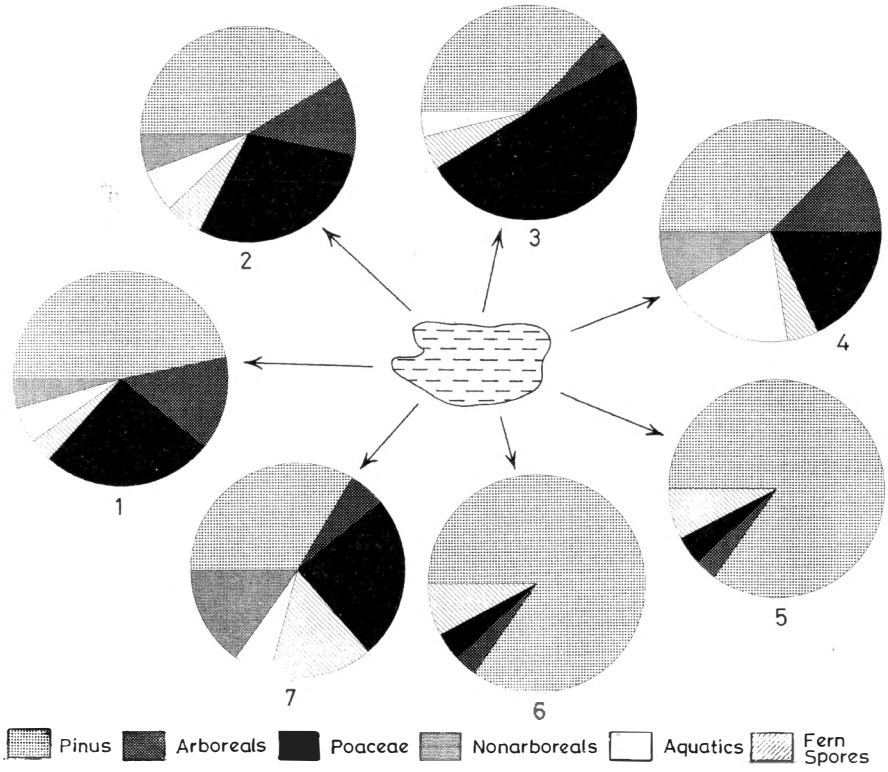


Fig. 2 Recent Pollen Depositional Model of Surinsar Lake

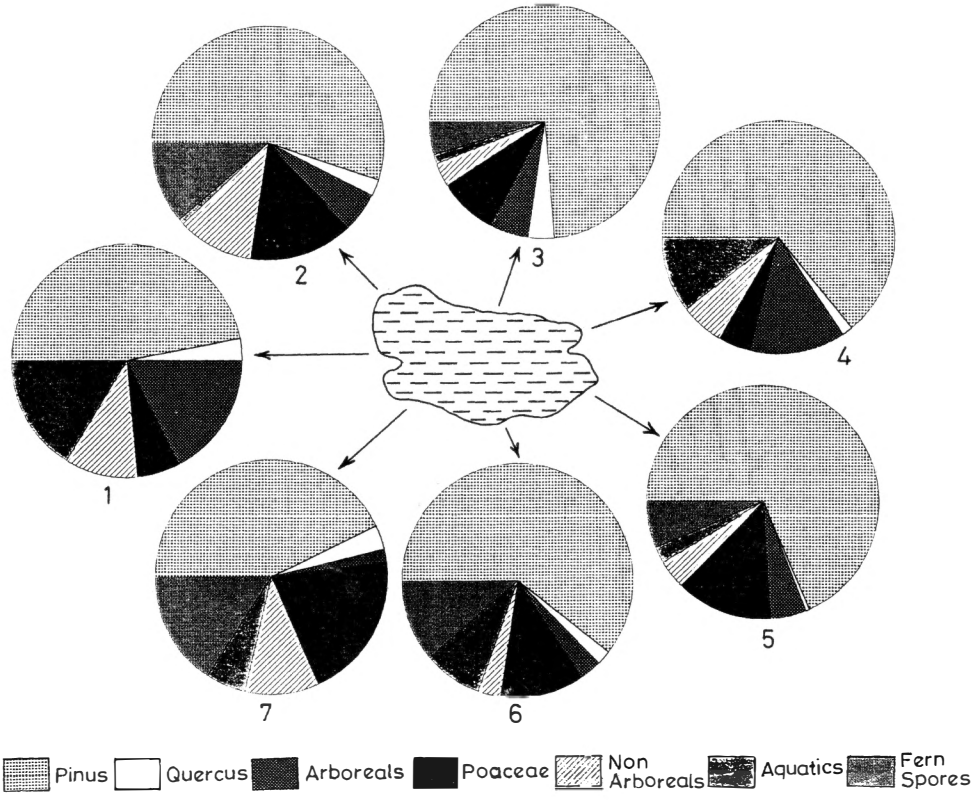


Fig. 3. Recent Pollen Depositional Model of Mansar Lake

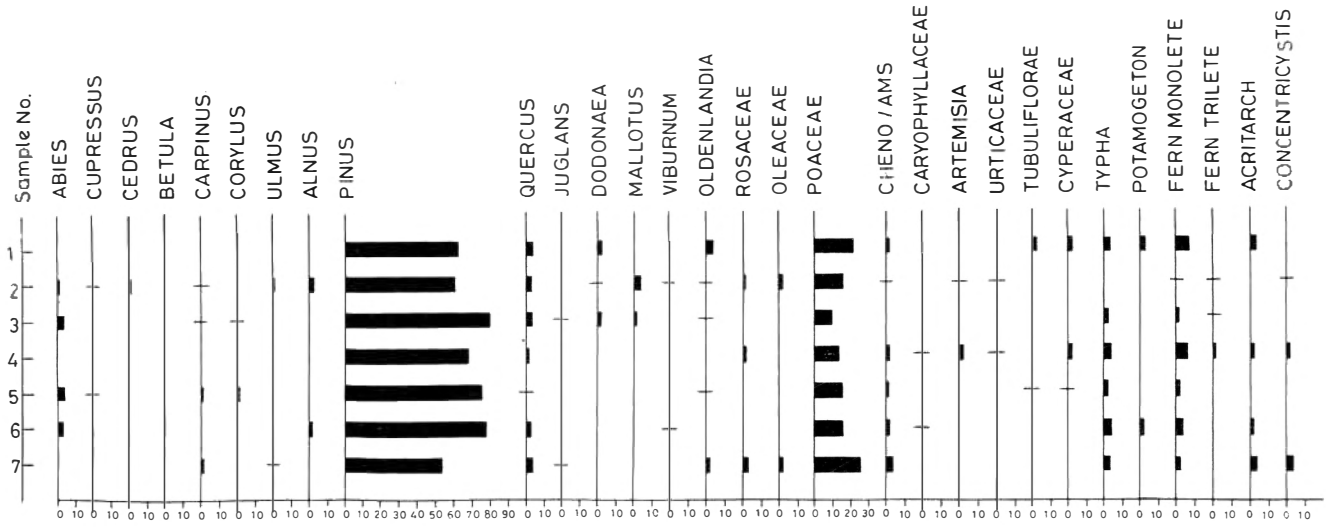


Fig. 4 Recent pollen Spectra from Mansar Lake
(Percentages calculated in terms of total terrestrial pollen)

emerged pollen spectra are described below (Figs. 1&2).

Spectrum 1– Pollen assemblage revealed high value of *Pinus* pollen (41.7%) as compared to other encountered arboreals such as *Abies* (2.1%), *Mallotus* (1%) and *Mimosa* (2.1%). Ground vegetation is reflected by the overall dominance of Poaceae (22.9%) growing along with few other non-arboreals such as *Oldenlandia* and Tubuliflorae- both recorded in low values and so is *Typha* pollen (2-5%).

Spectrum 2– Pollen assemblage in sample-2 portrays slightly higher frequency of *Pinus* (46.9%) as compared to spectrum 1, whereas other associated arboreal elements are not encountered in this sample. Likewise, Poaceae (33.3%), too is represented by a little higher value along with *Oldenlandia* (5.2%), though Tubuliflorae (8.3%) and Urticaceae (5.2%) recovered in moderate values. Among the ferns, only trilete spores (2.1%) are met with in low values.

Spectrum 3– This pollen spectrum, unlike the above two reflects reversed condition i.e. dominance of nonarboreal over arboreals where Poaceae attains its highest frequency (51%). *Pinus* (40%) has almost the same frequency as was in the spectrum 1, together with associated *Abies* and *Mallotus* recorded in low frequencies. Among associated other non-arboreals, *Oldenlandia* (2.6%), Tubuliflorae (1.3%), Urticaceae (2.6%) and Caryophyllaceae (1.3%), are represented in very low frequencies. *Lemna* (2.1%)– the sole representative of aquatic vegetation is encountered for the first time in this spectrum and so are the acritarchs.

Spectrum 4– *Pinus* reaches 51.1% in this spectrum. Other associated elements viz., *Mallotus,* Rosaceae, *Mimosa,* and *Oldenlandia* also demonstrate little higher values ranging from 1 to 6%. Few temperate taxa viz., *Ulmus* and *Abies* (4% each), are encountered in good frequencies. Poaceae (25%) continues to dominate in the ground vegetation along with other non-arboreals- Cheno/Ams, Tubuliflorae, Cyperaceae, etc., though with low values. The two important aquatic elements *Typha* (4-14%) and *Lemna* (10%) showing enhanced frequencies demonstrate local watery situations, supported by the encountered acritarchs in the pollen assemblage.

Spectrum 5– In this pollen spectrum, *Pinus* exhibits its highest value (76.3%), whereas *Abies* is encountered sporadically and *Dodonaea* by 2.5%. Non-arboreal encountered taxa are few and are met with in low values–including Poaceae (12.7%). Caryophyllaceae (6.8%) is well represented but aquatic elements remain unrepresented.

Spectrum 6– High value of *Pinus* (62.2%) though with slight decline is witnessed in this spectrum as compared to the preceding one. *Dodonaea* (2%)

happens to be the only represented broad - leaved arboreal taxon. Poaceae shows marked increase in its frequency reaching up to 33.3% compared to spectrum 5, whereas other non-arboreal elements viz., Cheno/Ams and Tubuliflorae (1% each) are recorded scantily. *Botryococcus* (4%) is recovered in appreciable number.

Spectrum 7– Lowest frequency of *Pinus* (31.3%) is registered in this sample as compared to the spectra from other six samples. Likewise, *Mimosa* (2.6%), *Oldenlandia* and *Dodonaea* (1% each) too decline with marked low values and are encountered scantily. However, the temperate element *Ulmus* as in sample 4 attains its maximum value (4%). Poaceae (22.2%) has a reduced frequency whereas, Tubuliflorae (10.4%), Urticaceae (2.1%), Cheno/Ams (2.1%) and Cyperaceae (4.2%) are characterized by their better representation in contrast to the preceding six spectra. Fern spores (monolete 2.1% and trilete 10.2%) too have good representation.

Mansar Lake

Like Surinsar lake, Mansar too, is a fresh water lake situated in the Lower Siwalik belt at slightly higher elevation (665m) and is about 54 km from the Jammu city (32°42'N, 75°9'E). Mansar is one of the oldest lakes in this outer Himalayan subtropical belt.

As seen around Surinsar, this lake site also has chirpine (*Pinus roxburghii*) forests all around it on the adjacent mountain slopes. However, the oak forests seen in the vicinity of Mansar Lake are comparatively more luxuriant, occupying mainly the damp and shady slopes and the depressions having moist conditions. *Quercus incana* is the principal constituent of these forests frequently seen with other associates viz., *Rhododendron, Alnus nitida, Salix* sp., *Mallotus philippensis, Lyonia ovalifolia, Cinnamomum tamata,* etc. In addition, *Dodonaea viscosa, Principia utilis, Pyrus mallus* and *Myrica esculatus* are other arboreal components of these forests. Shrubby vegetation is comparatively rich around this lake, comprising mainly *Rosa moschata, Rosa lesiocarpus, Rhus ellipticus, Viburnum cotonifolium, Zanthoxylum alatum, Crataegus crenulata, Myrsine africana,* etc. Also the ground vegetation is comparatively richer - chief constituents being grasses and sedges along with scattered patch-forming many temperate elements such as *Saxifraga, Berginia, Viola, Ranunculus, Anemone, Cotoneaster, Majus japonica, Micromeria biflora,* etc. Many aquatic elements thrive well towards the lake margin or in shallow water - chiefly *Typha, Lemna* and *Potamogeton.* Arboreals viz., *Grewia oppositifolia, Celtis australis, Bauhinia variegata, Boehmeria platephylla, Ficus palmata, Ficus glomoreta,* etc. are frequently seen in the open ground chiefly at the outskirts of villages around the cultivated field.

Pollen Rain

Like Surinsar, 7 pollen surface samples (Table) from Mansar Lake are described below (Fig. 3&4). sample wise.

Spectrum 1– This pollen assemblage has over all dominance of *Pinus* showing 63.0% value. Associated *Quercus* is represented by 4.1% and *Dodonaea* within 2.7%. In the ground vegetation Poaceae (23.3%) dominate, whereas, other non-arboreal taxa viz. Tubuliflorae and *Oldenlandia* are encountered in low values (2.7% each). Monolete fern spores are recorded to the frequency of 6.8%. *Botryococcus* and Acritarch are met with in low values (4.1% each).

Spectrum 2– In this pollen assemblage, dominance of *Pinus* (60.7%), is more or less the same as seen in spectrum 1. Two other conifers viz., *Cedrus* and *Cupressus* are recovered in low frequencies (2.5% each). Many broad-leaved arboreals namely *Quercus, Alnus, Carpinus, Ulmus, Mallotus,* Rosaceae and Oleaceae, etc., though represented in this sample but exhibit low pollen frequencies or appear sporadically. Amongst the nonarboreals, Poaceae (15.5%) as true to all the investigated 14 samples maintains its dominance in the ground flora associated with *Artemisia,* Urticaceae, Cheno/Ams (1% each), Cyperaceae (2.1%) etc. Fern spores, both monolete and trilete are encountered sporadically.

Spectrum 3– Among all the surface samples analysed, this pollen assemblage exhibits the highest frequency of encountered *Pinus* (86%) and so is true with other conifers. *Abies* shows good frequency (4.5%). However, all the broad-leaved taxa viz.

Quercus, Betula, Carpinus, Corylus, Juglans, Dodonaea and *Mallotus*- are encountered either low in their values or sporadically.

Poaceae (12%) despite being the dominant element of the ground vegetation, depicts markedly low value along with sporadic *Oldenlandia,* etc. thus, reflecting meagre ground coverage. *Typha* (1.4%) is scantily present, whereas monolete as well as trilete fern spores are sporadic.

Spectrum 4– *Pinus* (67.4%) continues to have dominant position in this pollen spectrum and other arboreals viz., *Quercus* and Rosaceae (under 1% each) are lowly represented. Reflected ground vegetation is more or less the same as depicted in the preceding spectrum with Poaceae (14%) and *Artemisia*, Tubuliflorae and Cyperaceae maintaining almost the same frequencies. *Typha* (4%) and monolete (6.2%) fern spores have relatively higher values. Acritarch are encountered in low values.

Spectrum 5– In this spectrum, *Pinus* (76%) reaches nearer to the highest recorded values in analysed samples (cf. nos. 5 in Surinsar and 3 above). *Quercus, Betula, Carpinus, Corylus, Juglans, Dodonaea* and *Mallotus* are met with sporadically. *Abies* (3.7%), the temperate element is represented by good frequency. Poaceae (15.4%) though represented poorly, remains dominant among the ground vegetation components. Other non-arboreals are meagrely represented. *Typha* too is scanty.

Spectrum 6– In this spectrum too, *Pinus* (77%) is closer to the highest met with frequency in sample 3. Whereas other arboreals remain low, compared to their earlier recorded values i.e. *Quercus* (2.6%), *Alnus* (1.3%) and Oleaceae (1.3%). The ground vegetation is dominated by Poaceae (15.4%) and has almost the same value as witnessed above. Ferns-monolete are recorded by their low value (3.8%).

Spectrum 7– In this spectrum, *Pinus* (54.5%), is depicted by comparatively reduced value compared to all the constructed preceding six spectra. *Quercus, Carpinus,* Rosaceae and *Dodonaea* are encountered within the range of 2.2-4.3%. Poaceae (26.1%) dominates the ground vegetation, exhibiting considerable enhancement in its value. Cheno/Ams and *Oldenlandia* (2.2-4.3% each) are lowly present. *Typha* (3.7%) has fairly good representation, whereas acritarchs (4.3%) show their maximum value compared to all the preceding samples. Fern spores (monolete) are 2.2%. In general, the plotted modern pollen depositional model (Fig. 4) for Mansar Lake based on recorded major floristic elements demonstrates overall dominance of *Pinus,* ranging from 54.5-86%. *Quercus* constantly remains lowly encountered taxon fluctuating between 1 and 4%, whereas other associated arboreals range from 4 to 12%. Poaceae (12-26.1%), the most dominant element among the ground cover components, remains constantly subordinate to the *Pinus* frequency except in the case of spectrum 3 in Surinsar lake. Aquatic elements exhibit much fluctuating values ranging 1-14% of the total pollen rain. Fern spores (5-30%) are encountered consistently in appreciable numbers in all the analysed samples.

DISCUSSION AND CONCLUSION

Attempt has been made to understand the dispersal and sedimentation of pollen and spores through the analysed surface samples collected from the surroundings of Surinsar and Mansar - two fresh water lakes situated in the sub-Himalayan subtropical vegetation belt of Jammu region. Correlating the emerging pollen/spore frequencies with the extant vegetation in the area provides a valuable base to reconstruct the past vegetation scenario through generated proxy data from the analysed lake profile samples and to deduce the corresponding palaeoclimate. Earlier pollen rain studies in relation to the extant vegetation carried out through the pollen analysed surface samples deal mainly with north-west Himalayan region i.e. Kashmir sector covering different floristic belts.

Jammu region lying in the sub-Himalayan hilly tract with Kashmir Himalayan ranges on its north remained to be properly covered to have the pollen/spore depositional spectrum. While evolving the present modern pollen rain spectra for Surinsar and Mansar lake sites, emphasis has been given to collect the surface samples from suitable ecological situations keeping in view different forest formations around the two lakes- chirpine dominated and chirpine- oak forests. The analysis of samples, 7 each from the two worked

out lake sites, depicts outright dominance of *Pinus roxburghii* pollen among the arboreals and Poaceae in the ground cover vegetation. The frequency of retrieved *Pinus* pollen from Surinsar surface samples which range from 31 to 76% could be attributed to the existing pure pine forests around the lake on the hill slopes as well as on account of its being the high pollen producer. Total absence of *Quercus* pollen in all the spectra in Surinsar, in contrast to Mansar site, can only be explained by its very scanty distribution as the forest component and also its being a low pollen producer. However, the sporadic encounter of pollen of broad-leaved allies viz., *Alnus, Ulmus,* members of Rosaceae, etc. is registered in some Surinsar spectra.

The overall comparison of pollen spectra from the two lakes- Surinsar and Mansar brings out constantly higher frequencies of *Pinus* (max. 86%) in case of the later and association of *Quercus* which happens to be the most prominent ingredient of these mixed pine- oak forests existing on the surrounding hill slopes exhibiting its maximum frequency of 4.1%. Proximity of pine dominated forest besides the high pollen productivity factor of *Pinus* are the important factors attributed to its over-representation in Mansar spectra. *Quercus* remains meagrely represented or absent in the samples gathered from pure pine stand. However, it is recorded though sporadically in the pollen spectra from shady gentle hill slopes where it is sometimes the only other prominent arboreal component of the pine- oak forest. Other broad-leaved associates of oak also exhibit extremely low frequencies misleading their factual density in these forests. This discrepancy or under representation of these taxa is most probably the manifestation to their low pollen production coupled with poor pollen preservation under the existing conditions.

Mallotus, Dodonaea and *Oldenlandia* though mark their presence in good frequencies, reflecting the regional vegetation seen mostly on the outer hill slopes around Surinsar, have somewhat sporadic distribution. Under representation of these taxa in the pollen spectra from Surinsar site could be due to their low pollen production or owing to entomophilly. Poor preservation of their pollen in the present sedimentary environ can not be denied. Except for *Pinus,* none of the remaining arboreal components exhibit any coherence with their *de facto* presence or distribution in the region.

On the other hand grasses, together with some other herbaceous taxa such as Asteraceae, Urticaceae and Cyperaceae come up as the prominent constituents among the non-arboreals and their representation in the pollen spectra from Surinsar corresponds fairly satisfactorily with their distributional frequency in the ground flora. High frequency of *Typha* and *Lemna* in spectrum-4 and recovery of fern spores from the pollen spectra-3 and 7 signify their good growth around the provenance of the samples reflecting the watery conditions around the sites.

Some temperate plant taxa viz., *Abies, Cupressus, Cedrus, Betula, Carpinus, Corylus* and *Ulmus* are also met with quite frequently despite their absence in these forests around the two lake sites. The encounter of these taxa at the two sites reveal their transportation from the higher reaches.

Around the other lake site i.e. Mansar, shrubby vegetation is meagrely represented in the pollen spectra excepting for few taxa viz., *Oldenlandia, Dodonaea,* etc. Grasses true to their preponderance in the region remain the most dominant constituent of the ground vegetation, attaining maximum values even in the pollen spectra from inside chirpine forest at Surinsar site. The pronounced recovery of grass pollen is attributed to their better ground coverage under the prevailing ecological conditions as well as being high pollen producer and capability of pollen to stand degradation or desiccation. In pollen spectra from Mansar lake, grasses were better represented which can be attributed to their constant representation from many chirpine-oak forests and so are Tubuliflorae and other herbaceous taxa viz., Cheno/Ams, Caryophyllaceae and Urticaceae, etc. *Typha* and *Potamogeton* are the two important aquatics encountered frequently. Fern spores, both monolete and trilete, which are of local origin maintained their high values.

In conclusion, it can broadly be stated on the basis of studied surface samples, that the constructed spectra correspond satisfactorily with the existing veg-

etation. However, many important arboreal elements which happen to be the conspicuous components of the forest community at the two lake sites or are the components of open vegetation remain either under-represented or absent in the constructed spectra.

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