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Vegetational history of Nachiketa Tal, Garhwal Himalaya, India*

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ABSTRACT

Vegetational history traced back to 1500 years (based on ^{14}C dating) and the deduced corresponding climate for the temperate region of Uttarkashi in Garhwal Himalaya is discussed in the paper. Pollen analysis of 2 metres deep sedimentary profile dug out from Nachiketa Tal, has revealed the existence of thick broad-leaved forests in the region, evidenced by the dominance of arboreal pollen over non-arboreals, *Quercus* dominated in these forests, associated with *Alnus, Betula, Carpinus, Juglans, Rhododendron, Ulmus, Celtis, Aesculus, Corylus*, etc. The non-arboreal ground vegetation comprised mainly the grasses alongwith few other scattered taxa. Moderate distribution of ferns and preponderance of aquatics, reflect to the prevailing wet habitat conditions inside the forest. Overall vegetational scenario thus depicts warm-temperate and humid climate during the period and probably even earlier which has continued till today without much change except for some minor fluctuations. A gradual decline in oak witnessed around 200 years ago and simultaneous increase in non-arboreal elements as well as culture pollen is indicative of the advent of agricultural practices in the region.

INTRODUCTION

Quaternary palynostratigraphical studies so far carried out over the last few decades have covered a number of regions in the Himalaya from west to east - chiefly Ladakh, Kashmir, Himachal Pradesh, Kumaon, Nepal, Darjeeling and Sikkim. Nevertheless, Garhwal - the Himalayan region lying between Himachal Pradesh westwards and Kumaon ranges on the east, remains uncovered except for the surface sample analysis from some regions carried out recently by Sharma (1985) and Gupta and Sharma (1993). The present pollen analytical investigation of lacustrine sediments from Nachiketa Tal situated in Uttarkashi District, happens to be the first worked out profile for Garhwal, uncovering vegetational history of Late Holocene.

Garhwal Himalaya constitutes the north-west part of Uttar Pradesh and lies between latitudes 28°26' - 31°28' N and longitudes 77°49' - 80°06' E, comprising five districts viz. Uttarkashi, Dehradun, Pauri, Tehri and Chamoli. Compared to Kumaon Himalaya, Garhwal region has more luxuriant and diversified vegetation due to higher precipitation and other physical or topographical factors.

PHYSIOGRAPHY

Nachiketa Tal, situated at an altitude of 2550 m above sea level (Fig. 1) in Uttarkashi District is 4 km from Chaurangi Khal - a small settlement about 27 km east of Uttarkashi township. The lake is elliptical with irregular margin, measuring 150 m in length and 40 m at its broadest.

Both Chaurangi Khal and Nachiketa Tal lie in the region which remains covered with thick ice during the winter.

VEGETATION

The temperate vegetation around Nachiketa Tal is luxuriant and rich in its diversity - characteristic of these Inner Himalayan ranges. The forests at this

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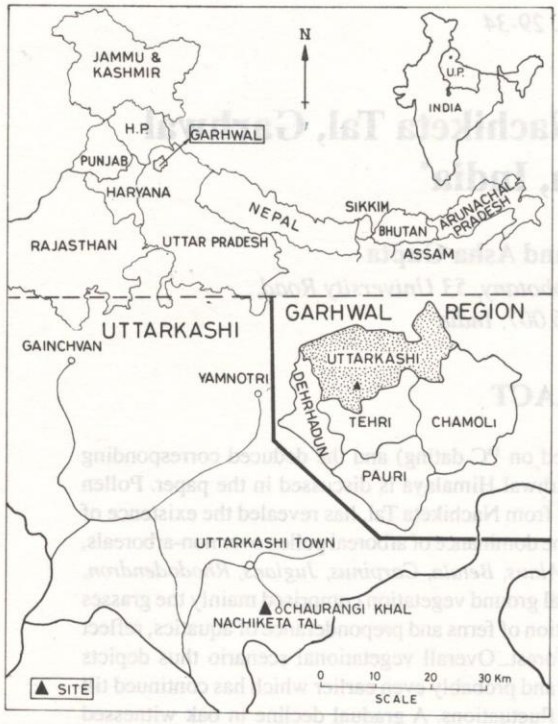

Fig. 1: Location map of Nachiketa Tal.

altitude are dominated by *Quercus* -mainly *Q. semecarpifolia, Q. dilatata and Q. incana*, together with *Rhododendron arboreum, Aesculus indica, Salix, Alnus, Betula, Carpinus, Juglans regia, Myrica esculenta, Ulmus*, etc., and a large number of shrubby taxa viz. *Berberis asiatica, B. chitria, Rubus ellipticus, R. niveus, Lonicera, Rosa*, etc. The herbaceous ground vegetation predominantly comprises elements of *Chenopodiaceae, Amaranthaceae, Ranunculaceae, Caryophyllaceae, Polygonaceae, Asteraceae, Brassicaceae* and *Rosaceae*, etc., alongwith various grasses and sedges growing copiously together with the occurrence of scores of interesting but not too common or rather sporadically distributed taxa in specific ecological or habitat conditions.

STRATIGRAPHY AND MATERIAL

Several trial borings were carried out with Hiller's peat auger and the samples were finally collected at an interval of 5 cm each from 2 metres deep profile - maximum depth which could be reached around the lake. The sedimentary column comprised chiefly organic-mud, clay and mud-clay. The demarcable lithological zones are as follows:

Zone III	0-45 cm	organic mud
	45-75 cm	organic mud with clay
Zone II	75-155 cm	gray clay
Zone I	155-200 cm	organic mud

Pollen Analysis

For the analysis, about 500 pollen grains from each sample were counted to reconstruct the pollen diagram (Fig. 2) on the pollen sum based on total terrestrial pollen. The sequence is divided into three assemblage zones, and are described from bottom to the top.

Zone I (200-155 cm)

The bottom zone depicts dominance of arboreals (75-85%) over non-arboreals (17-25%). Among arboreals *Quercus* is the most dominant taxon with frequencies ranging from 44-54% followed by 9-25% *Pinus*. Other arboreal elements such as *Cupressus, Alnus, Carpinus* and *Betula* are represented in low values, whereas *Ulmus, Celtis, Engelhardtia, Rhododendron, Corylus*, etc., are sporadic. The two other conifers i.e. *Abies* and *Picea* are also encountered but scatteredly.

Shrubby pollen are occasional or in low values (up to 2%) representing elements of *Rutaceae, Rubiaceae, Fabaceae, Rosaceae, Oleaceae* and the taxa *Berberis, Ilex* and *Viburnum*.

Among the encountered NAP (non artroscal pollens), *Poaceae* exhibits its dominance with 5.5-17% frequencies and showing also its progressive upward trend. *Cyperaceae* (<1-3%) and Artemisia (<1-5%) maintain their presence throughout the sequence but with low values *Cheno/Ams., Caryophyllaceae, Ranunculaceae, Urticaceae, Brassicaceae, Apiaceae, Tubuliflorae, Polygonaceae, Boraginaceae, Lamiaceae* and *Impatiens* are other herbaceous taxa met with sporadically.

Aquatic vegetation is reflected by overal high percentage in *Botryococcus* (6-29%) and *Pediastrum* (7-21%), the former attaining its maximum values

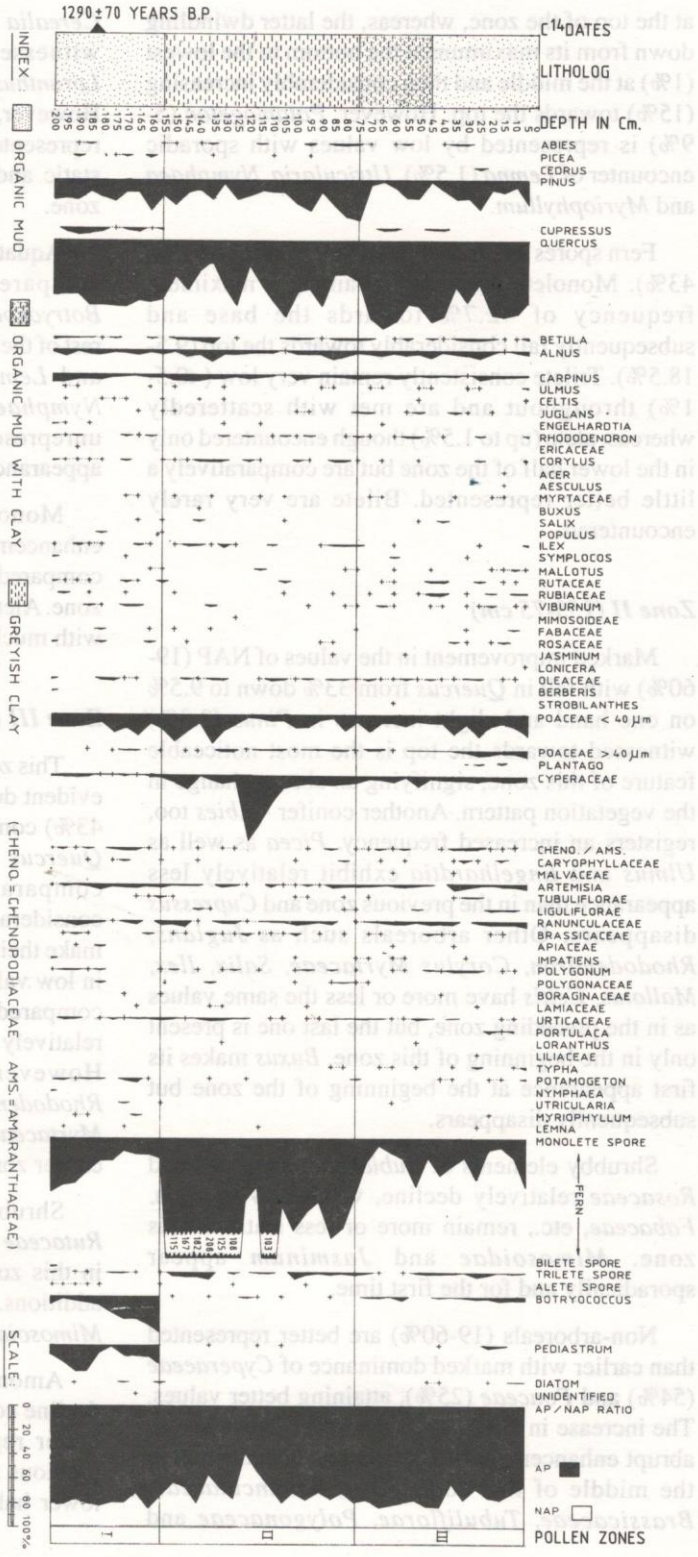

Fig. 2: Pollen diagram of Nachiketa Tal sediment, Garhwal Himalaya (percentage calculated in terms of total terrestrial pollen)

at the top of the zone, whereas, the latter dwindling down from its maximum at the bottom to the lowest (1%) at the middle and then considerably increasing (15%) towards the top. However, *Potamogeton* (5-9%) is represented by low values with sporadic encounter of *Lemna* (1.5%), *Utricularia, Nymphaea* and *Myriophyllum*.

Fern spores are encountered in low numbers (10-43%). Monolete dominate, attaining a maximum frequency of 42.7% towards the base and subsequently fall considerably towards the top (9.5-18.5%). Trilete consistently remain very low (<0.5-1%) throughout and are met with scatteredly whereas, alete (up to 1.5%) though encountered only in the lower half of the zone but are comparatively a little better represented. Bilete are very rarely encountered.

Zone II (155-75 cm)

Marked improvement in the values of NAP (19-60%) with fall in *Quercus* from 33% down to 9.5% on one hand and slight increase in *Pinus* (3.3%) witnessed towards the top is the most noticeable feature of this zone, signifying an abrupt change in the vegetation pattern. Another conifer - *Abies* too, registers an increased frequency. *Picea* as well as *Ulmus* and *Engelhardtia* exhibit relatively less appearance than in the previous zone and *Cupressus* disappears. Other arboreals such as *Juglans, Rhododendron, Corylus Myrtaceae, Salix, Ilex, Mallotus, Celtis* have more or less the same values as in the preceding zone, but the last one is present only in the beginning of this zone. *Buxus* makes its first appearance at the beginning of the zone but subsequently disappears.

Shrubby elements of *Rubiaceae, Rutaceae* and *Rosaceae* relatively decline, whereas *Viburnum, Fabaceae*, etc., remain more or less static in this zone. *Mimosoidae* and *Jasminum* appear sporadically and for the first time.

Non-arboreals (19-60%) are better represented than earlier with marked dominance of *Cyperaceae* (54%) and *Poaceae* (25%), attaining better values. The increase in *Poaceae* in the lower half whereas abrupt enhancement of *Cyperaceae* is witnessed in the middle of this zone. Also, *Ranunculaceae, Brassicaceae, Tubuliflorae, Polygonaceae* and *Cerealia* type have overall enhanced values than witnessed in previous zone. *Liguliflorae* and *Loranthus* have first sporadic appearance in the zone. However, *Artemisia* and *Cheno./ Ams.* are poorly represented. *Caryophyllaceae* remain more or less static and *Boranginaceae* is unrepresented in the zone.

Aquatics (0.5-1.5%) exhibit a marked decline compared to the previous zone. Except for *Botryococcus* which is 1% in one of the sample, the rest of the aquatic taxa viz. *Pediastrum, Potamogeton* and *Lemna* do not reach even 1% frequency. *Nymphaea, Utricularia* and *Myriophyllum* are unrepresented. However, *Typha* makes its first appearance in this zone.

Monolete spores exhibit an abrupt marked enhancement and trilete relatively improved, when compared to the values witnessed in the previous zone. Alete are encountered only in two samples and with much declined values.

Zone III (75-0 cm)

This zone is characterized by comparatively more evident dominance of AP (57-86%) over NAP (14-43%) compared to the values witnessed in Zone-I. *Quercus* again registers improvement, reaching comparatively higher values but *Pinus* falls considerably from 21 to 2%. *Acer* and *Aesculus* make their entry for the first time in this zone though in low values. *Juglans* is slightly better represented compared to *Betula, Corylus* and *Ilex* which are relatively reduced than witnessed in earlier zones. However, *Alnus, Carpinus, Ulmus, Celtis, Rhododendron, Engelhardtia, Salix, Mallotus* and *Myrtaceae* remain more or less static compared to earlier zones.

Shrubby elements of *Rubiaceae, Rosaceae, Rutaceae* and *Viburnum* show better representation in this zone; *Lonicera* and *Strobilanthes* are new additions. *Jasminum* maintains almost same values. *Mimosoidae* still remains unrepresented in this zone.

Among NAP, *Cyperaceae* exhibits a marked decline compared to the previous zone. *Poaceae* is better represented again but in contrast to the previous zone, it has a lesser representation in the lower half but higher in the upper. Also *Cerealia*

type, *Cheno./Ams.*, *Caryophyllaceae, Artemisia, Tubuliflorae, Liguliflorae* and *Impatiens* are better represented than in the preceding zone. *Plantago, Malvaceae* and *Portulaca* are metwith for the first time in this zone and *Brassicaceae* as well as *Urticaceae* are poorly represented than in earlier zones. However, *Ranunculaceae, Lamiaceae* and *Loranthus* remain more or less static in their values.

Aquatics are poorly represented but *Botryococcus, Pediastrum* and *Typha* have slightly increased values than witnessed in Zone II. *Utricularia, Myriophyllum* and *Diatom* not encountered in earlier zone are recorded sporadically. *Lemna* maintains more or less same values as in the preceding zone.

Monolete fern spores show a sharp decline compared to Zone II and with considerable local fluctuation. Trilete spores too, have a decreasing trend whereas alete are not represented.

DISCUSSION

Vegetational history emerging from two metres deep profile demonstrates that the sequence right from the beginning is in a well developed stage and is probably the continuation of the earlier existing vegetational pattern which remains concealed in the lithocolumn below and not available for the present investigations. The vegetation in Zone I begins with the *Quercus* dominant forests in the region with associated arboreals - *Betula, Alnus, Corylus, Carpinus, Celtis, Juglans, Rhododendron, Myrica,* etc., represented by their low or sporadic pollen frequencies. Presence of conifer is attributable to their transportation from long distances from nearby mountains (Gupta & Sharma 1993) as none of them grow in the vicinity. Shrubs remain poorly represented as witnessed by the low pollen values of *Rosaceae, Rutaceae, Rubiaceae, Oleaceae, Fabaceae, Viburnum* and *Berberis*. Low frequencies of grasses and sedges demonstrate poor ground coverage, supported by poor representation of other herbaceous taxa, such as *Cheno./Ams., Ranunculaceae, Urticaceae, Artemisia*, etc. The overall dominance of arboreals vis-a-vis the poor ground herbage is indicative of the closed nature of forests, supported well by AP/NAP ratio. Occurrence of *Potamogeton, Myriophyllum, Lemna*, Diatom as well as abundance of *Pediastrum* and *Botryococcus*, etc., demonstrate prevailing fresh water conditions in the area. Preponderance of fern spores throughout the sequence again indicate moist and shady habitat in the vicinity of the lake. Thus, it can be inferred from the emerging vegetation pattern that the area enjoyed warm temperate climate with watery or damp habitat conditions - most probably in or around the existing forests.

The next phase in the sequence i.e. Zone II does not portray any radical change in vegetation and is more or less the continuation of pollen Zone I in its broader aspects. However, it is noticed that in this zone, the mixed oak forests exhibit a decline in *Quercus* and slight increase in *Pinus* towards the top. Abies has a better representation in Zone II. Also many shrub elements like *Rubiaceae, Rutaceae* and *Rosaceae* relatively decline in their representation values though *Buxus, Mimosoidae* and *Jasminum* make their first appearance and so do the *Liguliflorae. Loranthus* and sedges too, alongwith other herbs such as Cerealia type, increase. The above change is well corroborated by the emerging aquatic vegetation which declined considerably by poor frequencies of *Botryococcus, Pediastrum, Potamogeton* and *Lemna* and disappearance of *Myriophyllum, Utricularia* and *Nymphaea* from the scene. However, the appearance of *Typha* in this zone and its sudden spurt in the sequence can only be interpreted that there was a change in the watery conditions and this resulted into the decline in aquatics. It can, therefore, be inferred that there was a slight deterioration in the climate during this period which probably turned less humid than before.

In the Zone III i.e. the upper most phase it is seen that the changes towards the establishment of mixed forests is evidenced by the enhancement in *Quercus* values, and considerable decline of *Pinus*, compared to the earlier phase. Addition of *Cedrus* in this phase, better representation of *Juglans, Rubiaceae* and *Rutaceae* compared to Zone II and an increase in broad-leaved taxa demonstrate amelioration in climate and improved vegetation in the area in terms of good forests coupled by the decline in non-arboreals though without evident change in grasses and sedges. Increase in Cerealia type and other culture pollen such as *Artemisia, Cheno./Ams., Asteraceae* as well as appearance of

Plantago and *Portulaca* denote that intensive agricultural activities had been there during the period. Further, enhancement in *Typha* and poor representation of aquatics also reflect to this change.

CONCLUSIONS

The pollen diagram constructed from Nachiketa Tal in Garhwal Himalaya has led to the inference that the present forests have continued to exist in the area at least for the last 1500 years (based on ^{14}C dating) and most probably even beyond. Fluctuations in certain arboreal elements and simultaneous changes in the herbaceous floristic composition-including the aquatics, signify to a possible short term oscillation in climate. For example, around 1500 years B.P., dense-mixed oak forests dominated in the region with abundant several aquatics - depicting the prevailed temperate warm and humid climate. Subsequently, around 1000 years B.P. as depicted through pollen Zone II, a little decline in oak as well as aquatics with simultaneous increase in grasses and sedges point out that the climate deteriorated and became less humid. This dry spell was of brief duration as around 500 years B.P., oak was restored and even improved alongwith other close associates on one hand and decline in pine, sedges and grasses, thus providing the evidence that the climate soon ameliorated and became warm-humid again.

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REFERENCES

Gupta, A. and Sharma, C., 1993, Recent pollen spectra from Nachiketa Tal, Garhwal Himalaya. Geophytology, v. 23 (1), pp. 155-157.

Sharma, C., 1985, Recent pollen spectra from Garhwal Himalaya. Geophytology, v. 15 (1), pp. 87-97.