CHAPTER - 1

INTRODUCTION
INTRODUCTION

The lakes of Kashmir are socio-economically and bioaesthetically important aquatic ecosystems which harbour a rich and diversified gene pool. In recent years, some of these lakes have shown definite signs of eutrophication due to the increased human activities in their catchment areas. The lake water, a basic component of our natural environment, is being polluted at an alarmingly fast rate due to the discharge of sewage and toxic chemicals into it. Agriculture with its extensive use of fertilisers and pesticides is fast becoming the concomitant factor of further deterioration of water quality. The accelerated erosion of the lake environment during the last two decades has caused a serious economic loss to the entire society and has not only deteriorated the water quality of these lakes but has also affected the biota therein.
The aquatic environment contains within it numerous spatial niches each colonised by a very well defined community of algae - Open waters by the phytoplankton, Sediments by the epipelon, Plant surfaces by the epiphyton, Rock surfaces by the epilithon, etc. These communities have a high degree of independence and slight interplay between them (Round 1985).

Diatoms are among the most ubiquitous of aquatic organisms belonging to golden brown algae accounting for a large portion of the primary biomass production in both freshwater and marine communities (Werner, 1977; Round and Crawford, 1990).

Diatoms are sensitive to changes in their aquatic environments and are reliable indicators of the water quality (Ross and Rushforth, 1980). The reason for this is their reproduction rate, which allows for significant increase in population of a given species under favourable conditions while other species concurrently decrease and/or disappear.

Classifying lakes using algae as indicator organisms is well documented in the literature (Brook, 1965; Jarnefelt, 1952; Nygaard, 1949; Rawson, 1956; Stoermer, 1978). Numerous classification systems have been devised which specifically employ diatoms to assess the water quality e.g., autecological studies have grouped diatoms as Chloride indicators (Kolbe, 1927), Oxygen indicators (Cholnoky, 1968), pH indicators (Hustedt, 1937-1939) and Nitrogen indicators (Cholnoky, 1953, 1958, 1968). Diatoms are an effective ecological tool as they are sensitive to environmental changes through time and their siliceous cell walls are often
preserved in sediments (Bradbury, 1975; Round, 1962)

Numerous investigations have been carried out on diatoms dating back to 1873 when Borscow wrote the first volume containing general remarks on diatoms. The work of de Toni (1891), Heurck (1896), West and West (1912), Naumann (1917), Hustedt (1938), Patrick (1948), Komarosky (1953), Rao (1953), Cholnoky (1953, 62), Singh (1960), Philipose (1960), Zafar (1964), Munawar (1970) and Khan and Ejike (1984) are notable.

**Diatom studies at Global level:**

Crayton and Sommerfeld (1978) encountered a high population of Bacillariophyceae in the Colorado river, U.S.A. and classified them as tychoplankters; organisms which typically are benthic in origin but occur in the plankton accidentally.

Jerry et al. (1978) reported 79 taxa of periphyton in Greasy Creek, Red Rock Creek and Arkansas river, Oklahoma. They found *Gomphonema olivaceum* and some species of *Nitzschia* and *Navicula* as the most commonly occurring dominants.

Moore (1980a) carried out limnological studies on Great Slave lake borders. The epiphyton associated with *Equisetum* consisted of 117 species of algae of which 86 belonged to diatoms.

Moore (1980b) studied the effects of contaminated bottom sediments on the species composition, growth cycles and diversity of epipelic algal communities in the shallow eutrophic Thompson lake. He reported 192
species of benthic algae, of which 181 belonged to diatoms.

Zgurouksa (1980) made comparisons of the taxonomic composition of planktonic diatoms germinating from bottom sediments and plankton. The bottom sediments were found to be peculiar in depository of viable algae occurring both in the form of spores and resting vegetative cells. He found 6 - 14 diatom species in plankton and 19 species in sediments.

Kuhn et al. (1981) carried out qualitative characterization of aquatic environments using diatom life form strategies in South mountain lakes, Virginia. They proposed a model which relates the generalised adaptive characteristics of the most abundant diatoms to the environmental conditions.

Agius and Jaccarini (1982) made enrichment experiments to determine which nutrient limits primary productivity in the waters of Marsaxlokk Bay, Malta and observed that both nitrate and phosphate were very scarce. In all the three enrichment experiments, diatoms were dominant in all culture vessels with Chaetoceros sp. and Skeletonema costatum as the dominant species.

Gons (1982) studied structural and functional characteristics of epiphyton and epipelon in relation to their distribution in lake Vechten and observed diatom dominance in epiphyton and epipelon.


Extensive examination of the Utah lake, U.S.A. by Rushforth and
Squires (1985) revealed that the largest contributors of the algae in the lake were diatoms represented by 51 genera.

Admiraal et al. (1990) observed the seasonal development of phytoplankton dominated by diatoms and was followed by particulate silicate. Levasseur et al. (1990) on the basis of the ambient silicate concentration and the silicate requirement of the dominant diatoms suggested that Chaetoceros debilis and Skeletonema costatum were silica deficit.

Bonetto et al. (1991) while carrying out algal bioassays in three rivers found that diatoms were dominant in both the control and the phosphorous enriched flasks. Melosira sp. was first to develop which was later on outnumbered by Synedra sp.

Cohn and Disparti (1994) described the effect of various environmental conditions on the speed of fresh water diatoms and found a wide distribution of cell speed varying from 0 to > 2 μmS⁻¹.

Diatom studies at National level:

Although the Indian waters have been extensively investigated by Singh (1960), Philipose (1960), Zafar (1964, 1967), Munawar (1970), Paramasivan and Sreenivasan (1982) and Satya (1987), yet diatom studies on Indian freshwaters have not received proper attention.

Prasad and Vyas (1987) studied the effect of human interference on the hydrobiological characteristics of the Ahar lake. The microphytic population was dominated by Bacillariophyceae and Myxophyceae. They regarded Navicula radiosa and Gomphonema parvulum as important
pollution indicators.

Tripathi and Panday (1989) found diatom index values less than 0.2 indicating oligotrophy while studying the water quality of Chandari pond (Kanpur). They reported 33 species of diatoms out of which 32 species represented pennaes and one centric diatoms.

Krishna Rao (1990) reported the dominance of Chlorophyceae (48.3%) followed closely by Bacillariophyceae (47.6%) while studying the periphyton in an irrigation tank with permanent turbid waters.

Jindal and Ghezta (1991) observed low qualitative and quantitative yield of plankton in Sukhna lake, Chandigarh with diatom dominated plankton. Species of *Anomoeoneis*, *Fragilaria*, *Gomphonema*, *Gyrosigma* and *Navicula* were most common.

Saha et al. (1991) reported the Bacillariophyceae as the most dominant and diversified group among the phytoplankton community being mainly represented by *Navicula*, *Gomphonema*, *Synedra*, *Stauroneis* and *Diatoma* sp. Singh and Srivastava (1991) investigated the periodicity of phytoplankton in relation to certain hydrological conditions in the stretch of Ganga river between the Buxa and Ballia. Bacillariophyceae was observed to be the dominant group (33.57%) comprising of 16 genera, important among them being *Synedra* sp., *Gomphonema* sp and *Fragilaria* sp.

Swarnalatha and Narsing (1991) in their investigation of water pollution in lake Saroon reported diatoms like *Nitzschia palea*, *N. obtusa* and *Gomphonema parvulum* as the evidence of the pollution in the lake.
Shaji Patel (1992), while investigating the pollution status of a pond at Anand - Gujarat reported five genera from Bacillariophyceae as pollution indicators. The genera were Cyclotella, Melosira, Navicula, Nitzschia and Synedra.

Sharma and Sharma (1992a) studied algal diversity in the littoral zone of a polluted shallow lake at Ajmer and recorded a total of 123 species belonging to 60 genera. Among diatoms, Achnanthes hungarica and species of Navicula were regarded as pollution indicators.

Sharma and Sharma (1992b), while studying the diatoms of Anasagas lake of Ajmer, observed 22 species belonging to 15 genera of diatoms. Navicula affine, Nitzschia recta and Placoneis sp. were found to be resistant to sewage pollution.

**Diatoms studied at the State level:**

Although, Kashmir lakes have been subjected to detailed limnological investigations by Kaul (1977), Mir (1977), Mir and Kachroo (1982), Zutshi et al. (1980), Yousuf and Qadri (1981), Sarwar (1985, 1987, 1990, 1991a,b, 1994), Sarwar and Parveen (1996), Sarwar and Zutshi (1987, a,b; 1988; 1989 a, b,c), Sarwar and Mir (1996), yet no exhaustive investigation has been undertaken on diatoms. The stray works on Bacillariophyceae are those of Kant and Kachroo (1977) and Kant (1976) on the seasonal fluctuations of some diatoms associated with macrovegetation in some Kashmir lakes.

Mir (1977) recorded a summer peak of diatoms in Nagin lake while
studying plankton and water soils in relation to lake productivity.

Sarwar (1987) recorded 91 periphytic taxa on *Ceratophyllum demersum*. The contribution of Bacillariophyceae was substantial in terms of number of taxa (50), population density and percentage composition. Sarwar (1989) while studying the impact of developmental activities in and around Dal lake, reported that the increased concentration of nutrients in Dal waters is indicated by the presence of such epiphytic diatoms as *Achnanthes minutissima*, *Amphora ovalis*, *Cymbella ventricosa*, *Cocconeis placentula*, *Nitzschia acicularis*, etc.

Sarwar (1990) reported dominance of periphytic diatoms forms on artificial substrate in rural wetlands of Kashmir, among which *Fragilaria capucina*, *F. construens* and *F. crotonensis* dominated at the end of the first three and the 12th month of incubation period.

Sarwar (1991, a) while studying the trophic status of Dal lake, recorded 178 periphytic taxa from the glass slides and natural substrates of this lake. These taxa belonged to six algal classes with Bacillariophyceae contributing a maximum of 78 taxa. According to him, the enriched status of this water body is further indicated by the dominance of such forms like *Achnanthes*, *minutissima*, *Cocconeis* sp., *Cymbella ventricosa*, *Fragilaria construens* and *Navicula* spp.

Sarwar (1991, b) selected three marshlands of Srinagar for an investigation so as to provide the baseline data on their abiotic environment as also to assess the temporal and spatial variation in periphytic populations.
on various natural substrates. Bacillariophyceae depicted substantial representation both in terms of number of individuals and number of taxa.

Sarwar et al. (1996) drew a distinction between the waters of Dal lake in its floating garden area and those in the open, virtually undisturbed area. Diatom population density values were highest during winter. Several pollution indicator species were identified.

Majid and Sarwar (1996) studied the occurrence, distribution and seasonal variations of diatoms of one of the largest fresh water bodies of the subcontinent, the Wular lake. 53 species of diatoms were recorded amongst which Amphora sp., Cymbella sp., Nitzschia acicularis and Synedra ulna were dominant.

It may be mentioned here that these studies mostly pertain to macrophytes, phytoplankton and periphyton with no attention being paid to compare the community structure and species composition of diatoms in planktonic, epiphytic and epipelic communities.

**Aim of the present study:**

The aim of the present investigation was to compare the diatom communities of plankton, epiphyton and epipelon. The present investigation covers three main aspects:

a) Diatom population

b) Assessment of abiotic environment

c) Statistical analysis.
Diatom population

Three main approaches have been adopted:

i. Study of planktonic diatoms

ii. Study of epiphytic diatoms on two macrophytes namely Potamogeton crispus and P. lucens

iii. Study of epipelic diatoms

All the three assemblages of diatoms have been studied for the following aspects:

Species composition

Species distribution

Monthly and seasonal population density values

Common, rare, dominant and co-dominant taxa

Percent contribution of dominant and co-dominant species

Percent similarity between diatom assemblages of various substations of the lake and between those of investigated lakes

Identification of pollution indicator species.

Assessment of abiotic environment

Data on the following parameters has been obtained:

Physical parameters:

Water temperature, Secchi transparency, water level fluctuations, Hydrogen- ion concentration and specific conductance.

Chemical parameters:

Analysis of major cations, anions and trace metals:
Cations: Sodium, Potassium, Calcium, Magnesium, Ammonical-nitrogen and Iron.

Anions: Chloride, Total alkalinity, Nitrate-nitrogen, Silicate, Phosphate phosphorous and total phosphorous.

Trace elements: Copper, Zinc, Manganese, lead and Cobalt.

In addition to these, dissolved oxygen, oxygen saturation and hardness were also determined.

Statistical analysis

Species Diversity Index
Importance value of prevalent species
Similarity indices of diatoms between the investigated lakes
Coefficient of correlation of diatom population density values with some important chemical parameters.
Average monthly and seasonal values
Standard deviations

Description of the lakes

Kashmir is unique in having numerous lakes which can be grouped into two distinct categories; those found at very high altitudes (3500 - 4500 m), mainly of glacial origin. These ecosystem are not disturbed by human activities mainly due to difficult accessibility and inclement weather conditions. The second category of the lakes is scattered in the valley at a comparatively lower altitudes (1580 - 1600 m). Valley lakes, as they are commonly called, support a varied and rich biological life. These lakes are
located close to human settlements and are undergoing fast eutrophication due to sewage contamination (Kaul, 1977).

In the present study, two urban lakes viz; Dal and Anchar were investigated. The two lakes are connected through a channel called "Nallah Amir Khan". Being situated close to Srinagar, both lakes are exposed to typical urban environmental conditions.

Dal lake (34°5' and 34° 10' N lat. and 74° 9' and 74° 9' E long.) is a saucer-shaped multibasined water body situated at an altitude of 1584 amsl, lying at the foot of the Zabarvan mountain (Fig. 1). A great portion of the lake is covered by floating gardens which constitute about 35% of the whole lake. The lake is principally fed by Arrah stream, which arises on the western slopes of Mahadev peak and enters the lake on northern side near the village - Telbal while on its east, it is fed by the Cheshmashahi spring. Several small streams running around the shore also open into the lake. A number of springs present within the lake bed, are also an important source of water to the lake. On the South, there is a sluice gate called Dalgate, through which the excess water of the lake is drained out through a weir and lock system into a circuitous canal "Psunt Kul" which is the loop channel of river Jehlum. The shoreline is mostly interrupted here and there by artificial barricades. The lake is not a continuous sheet of water but is divided into distinct but interconnected parts, viz.; the Hazratbal, the BodDal, the Gagribal and the Nagin basin. These basins differ in their area, volume and maximum depth. The open water area of the lake is 1056 hec. and its volume is 9.83 x 10^6 m^3 (Sarwar, 1985).
Table 1 depicts some of the morphometric features of the lakes. A sizeable portion of the lake extending from the Hazratbal basin to the Gagribal, on the western side is covered by an island which has been utilized for the construction of residential huts by the lake dwellers. The main population is in Nandpora formed by small mohallas viz.; Karapora, Mantimohalla and Hasithal (Trisal, 1977). The lake receives a heavy load of silt, inorganic and organic material from the catchment area. Besides, the heavy amount of wastes from the houseboats, hotels and human settlements located within the lake itself, are threatening the very existence of the lake. The lake is in a state of tremendous stress as the ecological conditions have undergone drastic changes during the last two decades.

The Anchar lake (alt. 1583 amsl), a satellite lake of the Dal lake, is situated at a distance of 14 km to the Northwest of Srinagar (Lat. 34° 24′ N; Long. 74° - 82 E). It is a shallow water body (Fig: 2) of about 6.5 sq. km. with a maximum depth of 3.5 m. It is fed mainly by several branches coming from the Sind Nallah, whose deltoic region lies in the vicinity of this lake. It also receives water from a nearby polluted water body, the Khushalsar. There are numerous springs spread over its basin which also contribute to its total volume. The lake is single basined being connected on the eastern side with the Dal lake through a an inflow channel - the Nallah Amir Khan. The lake enjoys urban as well as rural environment. It has an outlet on its eastern side and it is through this outlet that its water open into the River Jehlum. Unlike Dal lake, Anchar lake is without a regulating process to control the inward and
A number of small irrigation channels from agricultural fields, effluent channels from human settlements around, surface drains from the catchment area and a number of large outlets from the Sher - i- Kashmir Institute of Medical Sciences open directly into the lake. The lake is surrounded by thick stands of dwarf willow bushes which provide material for the wicker work etc. The catchment constitutes a long stretch of elevated land which is partly under paddy cultivation and partly under apple and willow plantation. Significant increase in the number of human settlements has been recorded within the catchment area of the lake and there is a progressive increase in the encroachment within the lake itself. According to Lawrence, the area of the Anchar lake during 1893 - 1894 was 19.54 km² and since then there has been a considerable decrease in the surface area of the lake (6.5 sq.km.) due to unabated encroachments.

**Sampling sites**

Three sites were selected in each lake to record monthly, seasonal and annual fluctuations in physico - chemical characteristics, planktonic epiphytic and epipelic diatom populations. The sites were sampled from October, 1993 to September, 1995.

**Anchar Lake**

**Site A**: It is the portion of the Anchar lake where the river Sind opens into the lake. A network of channels from river Sind enter the lake on its western side forming a delta. Since this perennial water source
brings a lot of nutrients, sediments, animal wastes, etc along with it, thus plays a significant role in changing the ecology of the lake ecosystem. The site is devoid of any macrophytic vegetation.

**Site B**: It is the deepest portion of the lake. It is centrally located, and is colonised by thick strands of *Potamogeton crispus* L., *Potamogeton lucens*, *Myriophyllum spicatum* L. and *Ceratophyllum demersum* L.

**Site C**: It denotes the portion of the lake just in front of the Medical Institute. A large drain from the Medical Institute is directly discharges its contents into the lake. Foul odour and changed colour of the water at the selected site reflects the direct impact of these effluents on the lake. The water surface at the site is covered by dense mats of *Lemna* sp. (*L. minor* and *L. trisulca*), *Salvinia natans* and *Spirodella polyrrhiza*. Along the edges are present dense patches of *Hydrocaris dubia*, *Typha angustata*, *Myriophyllum verticellatum* with intermittent *Polygonium amphibium*.

**Dal Lake**

**Site D**: It includes the open water portion of the lake in between Nehru Park basin and Centaur Hotel. Crystal clear water of the lake at this site is mainly dominated by *Potamogeton lucens*, *Nymphoides peltatum*, *Myriophyllum spicatum* and *Ceratophyllum demersum*.

**Site E**: It constitutes the portion of the lake opposite human settlements in BodDal basin. Several lavatories open directly into the lake at this site. Further, due to increase in human settlements and associated
activities, the lake water at this site receives large quantity of degradable and non-degradable pollutants. The site is dominated by dense mats of *Nymphaea candida* L. and *Nelumbium nuciferum* G. among rooted hydrophytes with floating leaves and *Myriophyllum spicatum* L., *Ceratophyllum demersum* L. among submergants.

**Site F**: It is situated on the South west side of the lake just opposite Heemal hotel in between the Nehru park basin and the Dalgate. A large drain from the hotel directly opens into the lake. Further the houseboat area on one side of the lake also has a direct impact on the changing ecology of the lake. Thick stands of *Ceratophyllum demersum* L. and *Myriophyllum spicatum* L. cover this site *Hvdrilla verticellatum* C. is found along the edges at this site.

**Sampling Schedule**

The two lakes have different trophic levels as they receive varying amounts of soluble effluents from the surrounding area. The abundance and species composition of diatoms were assessed in the plankton, epiphyton and epipelon in the two lakes. Diatom dynamics in relation to physico-chemical parameters of the waters of the Dal and the Anchar lakes were studied for a period of two years i.e., from October, 1993 to September, 1995. Epiphyton dynamics in both the lakes was studied on *Potamogeton lucens* L. and *Potamogeton crispus* L. in one year cycle i.e., May, 1993 to April, 1994. Dynamics of epipelic diatoms was determined on seasonal basis in the lakes during Spring, Summer, Autumn and Winter, 1993.
PLATE: 1

ANCHAR LAKE

Site A: Entry of Sind Nallah.

Site B: Central portion of the lake.

Site C: Portion of the lake just in front of Sher-i-Kashmir Institute of Medical Sciences.
Site D: Open water area in front of Centaur Hotel.

Site E: Human settlements.

Site F: Houseboat area just in front of Heemal Hotel.
a : Dense mats of *Potamogeton natans* at site B

b : Mixed patch of *Hydrocaris dubia* and *Myriophyllum verticillatum* towards the edges at site C

c : Dense cover of *Salvinia natans* at site C.
PLATE : 4

d : Dense mats of *Nymphaea alba* at site E

e : Mixed patch of *Trapa natans* and *Myriophyllum spicatum* at the site E

f : Rich growth of *Nelumbo nuciferum* at site E.
**PLATE : 5**

g : Dense patches of *Myriophyllum verticillatum* with intermixed *Salvinia natas* towards the edges at site C

h : Mixed vegetation of *Nymphaeodes peltatum* and *Ceratophyllum demersum* at site F.
Climatology of the study area

The general climatic conditions of the Kashmir valley conform to temperate cum submediterranean type with two dry periods in summer and autumn. Bagnoulus and Meher Homji (1959) classified the climate of Kashmir as submediterranean with four distinct seasons based on mean temperature and precipitation. They presented the following scheme of seasons:

<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
<th>Mean temperature (°C)</th>
<th>Duration (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>March - May</td>
<td>8.4 - 17.9</td>
<td>3</td>
</tr>
<tr>
<td>Summer</td>
<td>June - August</td>
<td>21.7 - 23.9</td>
<td>3</td>
</tr>
<tr>
<td>Autumn</td>
<td>Sept. - Nov.</td>
<td>20.5 - 7.7</td>
<td>3</td>
</tr>
<tr>
<td>Winter</td>
<td>Dec. - Feb.</td>
<td>1.05 - 3.5</td>
<td>3</td>
</tr>
</tbody>
</table>

Subsequently, Meher Homji (1971) presented a different scheme of seasons which are based on mean temperature:

<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
<th>Mean temperature (°C)</th>
<th>Duration (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>Nov. - Feb.</td>
<td>1.0 - 7.5</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>March - April</td>
<td>8.0 - 14.5</td>
<td>2</td>
</tr>
<tr>
<td>Autumn</td>
<td>October</td>
<td>8.0 - 14.5</td>
<td>1</td>
</tr>
<tr>
<td>Summer</td>
<td>May - Sept.</td>
<td>17.5 - 24.0</td>
<td>5</td>
</tr>
</tbody>
</table>

According to Koul (1979) the climate of Kashmir is highly variable and does not confirm to any definite type. He suggested the following scheme:
<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
<th>Mean temperature (°C)</th>
<th>Duration (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cool season or Winter</td>
<td>Nov. - March.</td>
<td>0 - 10</td>
<td>5</td>
</tr>
<tr>
<td>2. Hot season or Summer</td>
<td>June - Sept.</td>
<td>20 - 30</td>
<td>4</td>
</tr>
<tr>
<td>3. Transition season</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Warm (Spring)</td>
<td>April - May</td>
<td>10 - 20</td>
<td>2</td>
</tr>
<tr>
<td>ii. 2nd warm</td>
<td>October</td>
<td>10 - 20</td>
<td>1</td>
</tr>
</tbody>
</table>

In present investigation, the seasonal pattern used is after Bagnoulus and Meher Homji (1959) where each season is of three months duration.

Table 2. summarizes the mean monthly values of relative humidity, rainfall and maximum air temperature.

The temperature ranged from an average daily maximum of 30.5 °C and minimum 14.1 °C in June, 95 to a average daily maximum of 7.6 °C and minimum of -0.5 °C in January, 94. Highest mean rainfall (173.4 mm) was received in July, 95 and lowest (0.7 mm) in November, 94. The percentage relative humidity during the investigation period ranged between 46% to 95%.
Table 1: Morphometric features of the Anchar and the Dal lakes.

<table>
<thead>
<tr>
<th>Basin characteristics</th>
<th>Unit</th>
<th>Anchar</th>
<th>Dal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum length</td>
<td>Km</td>
<td>2.55</td>
<td>9.50</td>
</tr>
<tr>
<td>Maximum depth</td>
<td>m</td>
<td>2.90</td>
<td>3.10</td>
</tr>
<tr>
<td>Mean depth</td>
<td>m</td>
<td>1.03</td>
<td>1.96</td>
</tr>
<tr>
<td>Surface area</td>
<td>Km²</td>
<td>11.0</td>
<td>5.2</td>
</tr>
</tbody>
</table>
Table 2: Meteorological data for the Srinagar district during 1993--1995

<table>
<thead>
<tr>
<th>MONTH</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Average Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCT., 93</td>
<td>23.3</td>
<td>73</td>
<td>1.3</td>
</tr>
<tr>
<td>NOV.</td>
<td>15.4</td>
<td>92</td>
<td>41.1</td>
</tr>
<tr>
<td>DEC.</td>
<td>11.2</td>
<td>93</td>
<td>0.0</td>
</tr>
<tr>
<td>JAN., 94</td>
<td>7.6</td>
<td>95</td>
<td>68.1</td>
</tr>
<tr>
<td>FEB.</td>
<td>8.1</td>
<td>90</td>
<td>87.8</td>
</tr>
<tr>
<td>MAR.</td>
<td>16.0</td>
<td>84</td>
<td>70.4</td>
</tr>
<tr>
<td>APR.</td>
<td>18.5</td>
<td>72</td>
<td>96.1</td>
</tr>
<tr>
<td>MAY</td>
<td>24.1</td>
<td>73</td>
<td>89.4</td>
</tr>
<tr>
<td>JUN.</td>
<td>29.2</td>
<td>70</td>
<td>46.1</td>
</tr>
<tr>
<td>JUL.</td>
<td>29.9</td>
<td>81</td>
<td>44.2</td>
</tr>
<tr>
<td>AUG.</td>
<td>29.7</td>
<td>83</td>
<td>76.3</td>
</tr>
<tr>
<td>SEPT.</td>
<td>26.8</td>
<td>77</td>
<td>20.5</td>
</tr>
<tr>
<td>OCT.</td>
<td>20.9</td>
<td>86</td>
<td>41.6</td>
</tr>
<tr>
<td>NOV.</td>
<td>17.1</td>
<td>91</td>
<td>0.7</td>
</tr>
<tr>
<td>DEC.</td>
<td>7.5</td>
<td>95</td>
<td>154.2</td>
</tr>
<tr>
<td>JAN., 95</td>
<td>3.2</td>
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