INTRODUCTION
1.1. **Introduction:**

The Valley of Kashmir, so aptly referred as a paradise on earth presents a picturesque mosaic of lakes, mountain tarns, snow and spring fed streams, beautiful morarres, finest meadows and alpine forests. This serene beauty is still maintained largely due to high altitude biogeographical nature of the valley with the mountain chains of Himalayas acting as natural barriers for entry/incursions of several factors that would otherwise bring about a faster ecological deterioration. One of the striking features of the valley and the chain of valley lakes—Dal, Anchar, Manasbal, Wular represent the remnants of huge lake that drained through a gorge at Baramulla as a result of geomorphological changes, river down-cutting, sedimentation and climatic changes over the ages. There are also a number of high altitude or mountain lakes like Kounsarnag, Alapathar, Sheshnag, Vishnarsar, Vishnarsar, Gangabal and many others that provide a great ecological resource. From highly oligotrophic conditions of Kounsarnag they range to the fully eutrophic lake of Anchar, while others are in a process of continuous change towards eutrophication. While these changes result in part from the reactions and coactions of organisms, climatic and other environmental
factors but in recent past many of the changes are brought about under the influence of biotic impact, mostly in the name of development.

With the improvement in the living standards of man and advancement in industrial development together with population explosion the interference by human beings in the fresh water environments, the ecological balance in many of the surface waters has significantly changed. The quality of water in numerous fresh water lakes throughout the world has been greatly effected by the human activity in their catchment areas, Kashmir is no exception. Many of the lakes of the valley of Kashmir especially those located at relatively low elevations in the close vicinity of human settlements are showing positive signs of significant nutrient enrichment and pollution. Since there has not been much of development with regard to industrialization in the valley the main contributors towards the pollution eutrophication and/or of the aquatic habitats of the valley are degradation of the catchment area, surface runoff from the catchment area loaded with domestic sewage and fertilizers applied to agricultural and horticultural fields and different biocides used for agricultural and horticultural crops.
A great number of research studies have been made for accessing the quality of lake water and for understanding the various eutrophication processes and their control throughout the world (e.g. Rodhe 1964, 69; Munawar and Munawar, 1976; Deri, 1971, Karpati and Lantos, 1979, Allanson, 1979). In India as well a number of investigations has been made on the limnology of fresh waters (Zafar 1964, Arora 1966, Lohani and Modak 1983, Singh and Sharma, 1986). The study of quality freshwaters of the valley of Kashmir was also initiated very early (Mukerjee, 1921) and since then a number of reports are available featuring various limnological features of many water bodies (Kaul and Zutshi, 1967, Zutshi & Vass, 1970, Kanth and Kachroo 1973, Qadri & Yousuf 1978, Zutshi & Khan 1978, Zutshi & Vass, 1978, Khan & Zutshi, 1978, Zutshi et al. 1980, Yousuf and Qadri 1981, Mir & Kachroo, 1982; Yousuf et al. 1982, 84, Wanganeo 1984 and Zutshi and Wanganeo, 1984, Balhki & Yousuf, 1990).

On the basis of these studies three well recognised categories of Kashmir lakes are clearly differentiated: (i) the high altitude lakes and tarns (e.g. Tarsar, Alpather, Gangabal etc.) are typical examples of oligotrophic lakes, (ii) some
flat land lakes like Wular, Anchar and Khushalsar lakes are fully eutrophic with parts of these turned into marshes which are extensively used for willow cultivation, (iii) number of low land lakes like Manasbal, Nageen, Dal, although showing significant signs of nutrient enrichment, do not qualify to be included in the eutrophic category. These are referred to as mesotrophic. They are transient lakes where the water quality is continuously changing. Since the biological community respond quickly to the environmental changes such transitional habitats can be utilized to monitor impact of environmental conditions on the aquatic communities. Of the various aquatic groups the planktonic communities respond very quickly to the changes in their environment because of their short life cycles. As such, the species composition and the standing crop of plankton provide an insight into the quality of the lakes in which they live (A.P.H.A. 1985) and act as indicators of lake status.

The impact of human interference has been largely witnessed in most of the low land lakes of Kashmir, it is therefore imperative to take stock of the present position of their water quality and to
devise suitable measures for their management. Manasbal and Nageen lakes form the two well known tourist resorts in the valley and both these are in a transitional stage between oligotrophic and eutrophic lakes. Nageen lake is a fully urban lake and is subjected to a greater stress on account of more of biotic impact through excessive human activity both within the lake and around the adjacent lake shore. The large number of dwellings within the lake in the form of houseboats, cultivation of vegetables in the floating islands, surfing, the mushroom growth of hotels/restaurants with attendant hazardous effects pose different kinds of problems than those facing Manasbal. The latter is a semi-urban or rural lake with not as much of extensive recreational activities within and a lesser density of population in the immediate neighbourhood, of the lake is being fast developed into a tourist spot of greater interest. Already showing the signs of eutrophication on its own, the added biotic impact may accelerate the process and hasten the inevitable eutrophy. Every year thousands of tourists from different parts of the world visit these lakes because of their scenic beauty. As both of these waters have been reported to show
signs of eutrophication (Vass 1973, Kaul 1977, Wanganeo, 1984) it was decided to study the plankton community of the two lakes for a period of two years so as to have a comparative analysis of their bi limno-logic features. Along with the study of plankton communities, important physico-chemical features of the lakes concerned were also investigated. The investigation was conducted from August 1986 to July 1988 and the data obtained are presented in the present thesis. In the following pages the species composition and abundance of different plankton groups are described in relation to physico-chemical characteristics.

1.2. Study Area

Manasbal:

Manasbal lake is the deepest fresh water lake of the valley with an oblong outline. It is situated at a distance of about 32 kms. North West of Srinagar, at an elevation of 1584 m.a.s.l within the geographical coordinates of 34° 15'N and 74° 40'E. The lake covers an area of 2.8 sq.km. with a maximum depth of 12.5m. It has no permanent inlet and the
water supply maintained mainly by springs within the lake and atmospheric precipitation. An irrigational channel, Lar canal, also joins the lake and supplements the volume during paddy cultivation season. The agricultural runoff and the domestic affluents also enter the lake. The lake has an outlet for flushing excess water from it in the form of a channel that leaves the lake on its western side and joins river Jhelum at a distance of about 1.6 kms from the lake.

The lake catchment comprises a raised table land (Plateau) along its northern bank adjacent to the villages of Manasbal and Jarogabal. On the northwest, there is a drug research farm and in the east is a high range of mountains which extend towards southern region. Almost whole the eastern part of the mountains is bare with no forests and has several queries for extraction of stones. The southern aspect of the chain has patchy forests. At the foot of the mountain range at northeast bank of the lake is the village of Koondabal, where a number of lime kilns are located. A number of tourist huts have came up during the recent past along the lake shore in an attempt to boost tourism and it is proposed to develop the area into a big tourist complex.

The lake supports a rich macrophytic growth composed of both submerged and floating forms, mainly Nelumbo, Myriophyllum, Ceratophyllum, Potamogeton, Trapa, Typha and Nymphaeoides.
Nageen:

Nageen lake is situated at a distance of about 9 kms. to the north of Srinagar. The lake is situated at an elevation of 1584 m.a.s.l, covering an area of 4.5 sq. km. with a maximum depth of 6m. It is connected to Dal lake at Ashaibagh. The water supply is maintained by Dal lake in addition to the springs within the lake and atmospheric precipitation, the agricultural runoff and domestic affluents being the other source of water supply. The lake has an outlet (Amir Khan nallah) on north western end which leads to Khushalsar lake.

Nageen lake is used for aquatic sports and serves as a site for houseboats. The lake has been extensively reclaimed for human settlements and vegetable cultivation by way of creation of floating gardens. The lake receives heavy loads of silt and allochthonous material from catchment besides the heavy amount of untreated wastes from houseboats, hotels and the human habitations in and around the lake. The lake catchment comprises of human settlement and floating gardens.

The lake supports a rich macrophytic growth composed of both floating and submerged forms such as Hydrilla, Typha, Potamogeton, Azolla and Nelumbo.
1.3. Climate:

The lake areas experience the same type of climate as in other parts of the valley. The valley experiences a separate climatic entity because of its peculiarities of the variations of temperature, precipitation and humidity from other regions of India. Kashmir valley is characterized with warm summers and cold winters with sub-freezing temperatures, the Pir-Panchal range acting as a climatic barrier to the south-west monsoon and the lofty Himalayas check the cold blasts from Ladakh region. On the basis of mean temperature and precipitation, the climate of Kashmir has been classified by Bagnoulous & Mehr-Homji (1959) into four seasons viz. Spring (March-May; $\bar{x}$ 8.6 - 17.9°C), Summer (June-August; $\bar{x}$ 21.7-23.9°C), Autumn (September-November; $\bar{x}$ 20.5-7.7°C) and Winter (December-February; $\bar{x}$ 1.05 - 3.5°C).