REVIEW OF LITERATURE
Inspite of the fact that the study of planktonic animals and plants was initiated soon after the discovery of microscope, the exhaustive studies of true limnological character was undertaken only during the last century when Prof. F.A. Forel (1892) published his monumental work on a Swiss lake, Le Leman. Prof. Forel is rightly called father of Limnology as his contributions to this branch are invaluable. Since that time a large number of studies have been conducted in the limnological field and it is quite impossible to review the whole literature within the boundaries of this thesis. As a consequence the review which follows is restricted only to the second half of the present century and possess only the important publications.

Lund (1954) attributed the periodicity of *Melosira italica* to its relatively high sinking rate, its ability to remain alive on and in the deposits in the dark and anaerobic conditions, and thirdly its inability to grow appreciably at high light intensities.

Eutrophic lakes are characterized by blue green algae such as *Anabaena* and *Microcystis* (Rawson, 1956). Allther found *Fragillaria crotonensis* to be abundant only in restricted shore areas of great Slave lake, where waters were usually warmer and with more nutrients than the open lake.
Palmer (1962) worked out the phytoplankton dominated by Euglenophyta is characteristic of hard water lakes without an outlet.

Edmondson (1957), Nauwcrok (1963) and Haney (1973) held that phytoplankton population sustained large herbivorous zooplankton population whereas Govind (1963) and Moitra and Bbattacharya (1965) claimed an inverse relationship between the phytoplankton population.

Das and Subla (1963, 64) gave a detailed account of the topography, physical features, temperature and rainfall of the valley. The authors gave a detailed ecological description of the lakes of Kashmir.

An exhaustive limnological study of a number of ponds in Hyderabad was made by Zafar (1964 a, b; 1968). The author found a close relationship between the diatom population and phosphorus content.

According to Brooks & Dodson (1965) selective predation by plantivorous fish upon zooplankton resulted in a shift of zooplankton communities with dominance of Rotifera.

Sawyer (1966) considered Microcystis as an
indicator of eutrophy. Munro (1966) also concluded that the presence of very large number of *Microcystis* and *Anabaena* indicate a fairly high level of eutrophication. Echlaner (1968, 71) used water transparency as an index of eutrophication in lakes.

According to Hutchinson (1967), the majority of the species of *Euglena* and *Phacus* are found in small or sometimes very minute water bodies, which usually have high organic content. The author believed that blue-green algae dominated in late summer because of a competitive advantage in depleted nutrient concentration and higher water temperatures.

Vasisht (1968), proposed that the absence of thermal stratification in Sukhna lake was due to the presence of winds and vertical currents of water.

*Oscillatoria rubescens* has been considered as one of the most typical species of eutrophic and artificially eutrophic lakes and has become a biological indicator of changing trophic conditions.

Palmer (1969) believes that nutrient levels influence algal composition more than any other factor in the aquatic environment. As a lake environment changed
in response to accelerated eutrophication, a continually changing set of annual niches were made available to the algae, Moss & Karim (1969).

Methods of predicting lake phosphorus from external loading was suggested by Vollenweider (1969, 73).

Williams (1969) reported that *Fragillaria* showed up if sewage entered the lake. Dickman (1969) pointed out that monsoon was an important factor which influenced the development of the phytoplankton. The author pointed out that dilution effect caused by rainfall affected the distribution pattern of the plankton.

Light and temperature have a definite effect on the diatom communities in lakes. Patrick (1969) worked on some effects of temperature on fresh water algae and concluded that the diatom species possessed an optimum range of temperature for growth. The works of Mukarewicz & Likens (1979) and Wetzel (1975) reveal that rotifers are equally limnetic and littoral.

According to Whitford and Schumacher (1969), *Gomphonema acuminatum*, *G. constrictum*, *Navicula decusia* and *Achanthes lanceolata* are normally epipelic or epiphytic growing attached to the bottom or to vegetation in the littoral zone.
Cummins (1969) suggested that negative values of the death rate of *Daphnia hyalina* was due to an increase in the survival of non reproductive individuals or to sampling and counting errors.

Prescott (1969) observed that rise in pH during summer was related to phytoplankton activity. Similar relation was observed in Loch Ard, a typical warm monomictic lake by Maulood and Boney (1981).

While studying the feeding habits, food and ecology of some Kashmir fishes Subla (1970) detailed out the importance of plankton and benthos in fish feeding. The author also showed the effect of selective predation by planktivore fish on plankton community structure in Kashmir valley lakes.

High turbidity values in lake Brie was attributed to presence of suspended material in it, this was worked out by Burns, 1970. The author also pointed out that there was no change in total phosphorus ratio between spring and summer when there were large changes in phytoplankton biomass.

It has been shown by Richerson et al. (1970) that in limnetic waters phytoplankton species may
segregate through a combination of space and time, avoiding intense competitive interactions for nutrients and permitting a maximum number of species of co-existence. Munawar (1970) in a contribution on limnological studies on fresh water ponds of Hyderabad held that exceptionally high values of CO₂ and PO₄-P was a result of liberation of PO₄ from the ferric complex in the absence of oxygen. Yousuf et al. (1982) observed that same was true with Khushal Sar and Malla Bagh pond where the low O₂ values were attributed to the decomposition of organic matter which releases large quantities of CO₂ (70 mg/L and 40 mg/L respectively).


Hall (1970) worked out that ponds receiving high levels of urea, super-phosphate and potassium chloride had abundant green algae while the blue green were rare.

Kant and Kachroo (1971) gave a detailed account of the distribution and seasonal behaviour of phytoplankton from Dal and Nageen lakes.
Berman & Rodhe (1971), studied the distribution and migration of Peridinium in lake Kinneret, they concluded that scarce population during the thermocline was due to nutrient depletion, supra optimal temperature and harmful light intensity.

Lund (1971) studied the seasonal cycle of Melosira in a small lake in the English lake District for 24 years. The author suggested that the normal, seasonal alternation of periods of stratified and unstratified water are of biological advantage to Melosira italica, enabling it to compete with other diatoms which can also produce large populations but cannot live for long on or in the deposits in the dark or in the absence of oxygen.

Phosphorus dynamics of Great lake system was studied by Schelske & Stoermer (1971, 72). Authors found phosphorus to be limiting nutrient. A bloom of Peridinium bernardii was observed by Horne et al. (1971) in clear lake California after floods during the winter months.

According to Round (1971) and Reynolds (1973) Bacillariophyceae species usually dominated the spring populations.

Findenegg (1971) observed the development of
Oscillatoria blooms in some Australian lakes and attributed this to the human interference. The author indicated that blooms of Oscillatoria predicted the rapid pollution in these lakes.

Algal blooms were present throughout the year in the central Florida lakes which were characterised by having hard clear water, the dominant phytoplankton species being Microcystis, Anabeana and Lyngbya (Shannon and Brezonik, 1972).

Powers et al. (1972) while working on lake Shagawa observed that algal growth was stimulated by the secondarily treated waste water and reported that the phosphorus supplied by this waste water of Ely was the cause of the eutrophic status of this lake. Lowe (1972) observed Synedra ulna to prefer eutrophic waters.

Lin (1972) worked out the correlation between silica and diatom population. Jones (1972) examined 16 lakes in English lake district in search of indices that best correlated with high summer standing crops. Total phosphorus stood at the top of the list.

Solobodkin (1972) observed that predators selected only some stages of their prey. This selective
feeding pattern gives the predator a continuous food supply as the prey does not disappear. Such a type of feeding is found in *Coregonus* which selectively prey on motive and large individuals only, while invertebrate predators select immature stages of many different species. The author suggested that predators can be of 2 types, oligostrategic and polystrategic. Former includes those which prey on few tropically unrelated species while later includes those which prey on many tropically interconnected species.

According to Megard (1972) total phosphorus at any one time in the waters of lake Minnetonka, USA, is about equal to an annual increment from outside sources.

The results of the limnological investigations of Tau Daha & Nag Daha ponds in Kathmandu valley (Nepal) were reported by Hickel (1973). Physical conditions (temperature visibility and electrical conductivity) and chemical factors (pH and alkalinity) were determined by the author. The phytoplankton showed significant seasonal variations. During the dry winter the number of plankton species and individuals was low, Diatoms predominated and flagellates were the sub-dominant group. In summer, before the onset of the monsoon developments of different μ-algae and *Ceratium hirundinella* occurred. Although Tau Daha is only 6 m
deep yet μ algae showed a remarkable stratification.

Lean (1973) reported low phosphate values from the surface waters of lakes as most of it is taken up by phytoplankton. Four subtropical mountain lakes in western Nepal were also investigated for their plankton content and hydrographical conditions by the same author. These lakes, according to the author, among the subtropical monomictic type with thermal stratification and with a very low electrical conductivity. The phytoplankton made up of diatom—deshid and dinoflagellate associations comprised a mixture of species from tropical, Indo-Malayan, and temperate regions predominating. The phytoplankton maximum occurred in winter during the circulation period of the lake. Melosira islandica was the dominant species and Staurodesmus phimum and S. leptodermus subdominant.

McCaul and Crossland (1974) have shown in their study on a reservoir that turbidity may be caused by suspended material in the water or by plankton. They also pointed out that turbid water can increase water temperature.

According to Harris and James (1974) blue green algae, particularly Anabeana, Aphanizomenon, and Microcystis are the major toxin-producing group in the fresh water environment. Vollenweider et al. (1974) pointed out that
for studying the effects of eutrophication phytoplankton can play an important role as they are the primary producers.

While working on lake Meretts, Schindler (1974) observed a good crop of *Peridinium* and *Gymnodinium* in spring and summer for three consecutive years. Ferdinando et al. (1974) studied the physico-chemical characteristics of Orta lake during 1964-1970. They found that epilimnion had a normal oxygenation while hypolimnion had scanty. The deeper layers showed high CO$_2$ content which decreased at the end of the winter and surface layers showed normal CO$_2$ content.

Seasonal fluctuations of flora and fauna in an aestival pond in central Alberta, Canada, were studied by Daborn (1974). The studies were conducted through a complete annual cycle during which an exceptional decrease in water volume occurred in response to lower than normal rainfall. Primary production was only detected during summer when a bloom of *Aphanizomenon flos-aquae* was present. During the rest of the study period, phytoplankton populations were low and primary production negligible. Marked changes were noted in the relative abundance of different species between the two successive summers. *Aphanizomenon flos-aquae* was replaced by *Fragilaria* sp.
in 1968, *Keratella cochlearis* by *K. quadrata* and *Diaptomus leptopus* by *D. franciscanus*.

Work done by Burgis (1974) on biomass and production of zooplankton in lake George (Uganda) showed the abundance of cyclopoid copepoda in tropical eutrophic lakes, while Kurasawa (1975) pointed out that in some Japanese lakes (oligotrophic lakes) copepods were dominant and in an eutrophic Japanese lake Rotifer or Cladocera were dominant.

Green (1974) found *Conochilus coenobasis* to be most common and to dominate the zooplankton in a New-Zealand Reservoir and in lake Otatoa it was most common in October (Green 1976) in an Otago pond it was most common in summer, Byars (1960).

Sperling and Blum (1974) in their paper "Early winter diatom communities in Iceland; Nova Hedwigia" pointed that unicellular algae were favoured over by filamentous species during winter due to ice cover and low light intensities. Stewart and Markello (1974) carried out studies on seasonal pattern of nutrient distribution in six western New York lakes. The authors observed high concentrations in winter and low levels in
summer. A similar pattern of nutrient distribution was observed by Heron, 1961; Duthie, 1965; Maulood & Boney, 1980, 1981 in similar bodies of water.

Golterman (1975) while working on lake ecosystems (N.York) recorded that several factors regulate the concentration of dissolved oxygen in water. Oxygen consumption in H₂O is due to respiration, decomposition and the oxidation of dissolved organic compounds. The degree of oxygen depletion is dependent upon the total amount of oxygen present, which varies with depth and the amount of sinking dead material.

Seasonal fluctuations of physico-chemical conditions of 5 temporary ponds (U.K.) were studied by Khalaf & Mac Donald (1975) for a period of 2 years. The hydrochemical features studied were pond volume, air, water and substratum temperature, pH, conductivity and D.O. Vasisht and Sharma (1975) studied the ecology of a typical urban pond in Ambala city. The effect of temperature, pH turbidity, total alk., D.O. PO₄⁻P, NO₃⁻N and Si was observed on the distribution of the plankton, low temperature, low turbidity, PO₄ & NO₃ proved to be beneficial to the development of phytoplankton, while pH acted as controlling factor in case of some rotifers.
Mc Naught (1975) has proposed a hypothesis to explain the succession from Calanoids to Cladocerans during eutrophication. He concluded that calanoids should be dominant in oligotrophic lakes because of their superior fertility capacity and high ingestion rates and efficiencies on low densities of small cell size. In contrast cladocerans (Bosmina) should be successful in eutrophic lakes because of high ingestion efficiencies on both small cell size and their high intrinsic birth rates.

Patalas (1975) while studying 14 North American lakes observed that epilimnion temperature was important factor in determining the plankton abundance and biomass.

According to Forsyth & Mc Coll (1975) the presence of Euglenophyceae indicates the nitrogen rich organic matter in the lake sediments.

Titman (1976) worked out the inter-reaction between Asterionella formosa and a centric diatom Cyclotella meneghiniana in Michigan lakes. In the same year Lehman carried out ecological and nutritional studies on Dinobryon. The author pointed out that Dinobryon can grow in nutrient depleted water when other organisms cannot.
The diatom flora of a district in Jebel Marra, Sudan, was qualitatively analysed by Karim (1976). The author reported that periphyton is related to the type of substratum with which the various diatoms are associated and also found that certain diatoms were restricted to one habitat only; others were common to more than one.

Seasonal variation and distribution of macrophytic zooplanktonic and benethic organisms were studied in relation to pollution of the lake Budine by Barbanti et al. 1976.

Short term fluctuations in the volume of phytoplankton are related to the hydrographical situation, Kell (1976) reported so from the waters of shallow inlets to the south of Darss (South Baltic). Although the correlation between the phytoplankton and the hydrography is always visible at entrance to the shallow inlet, short term hydrographic changes were no longer reflected by the phytoplankton at the stations located further within the shallow inlets.

Tezuka (1976) studied feeding of Daphnia on planktonic bacteria, the author determined the feeding rates by measuring the changes in bacterial concentration (cell number) of the water.

Bohra (1976) studied relationships between

An additional note

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temperature, pH and dissolved oxygen in fresh water reservoirs situated at the base of Jodhpur Fort (India). Of the 3 hydrological factors studied, only temperature and D.O. showed a linear relationship with each other.

An investigation of zooplanktons of lakes of the Bol'schemel'skyaya tundra (USSR) was carried out by Vekhov in 1976. According to the author small lakes were characterized by an almost complete absence of pelagic rotifers, except Conchilus unicornis. Plankton consisted almost exclusively of copepods.

The results of quantitative studies carried out in 1968-71 on diatoms of pelagic areas, coastal zones, benthonic and silt layers in the lakes of the Narochansk group, Belorussia (USSR) were discussed by Mikheeva and Khursevich (1976). The seasons of maximum abundance of diatoms were different in various waters, the species were predominantly freshwater species in all areas studied. Cyclotella comta, Asterionella formosa, Tabellaria fenestrata, Cymbella venbicosa, Fragilaria crotonensis, Melosira granulata and M. ambiguus were the dominant species. M. ambiguus was in different to pH while a significant percentage (29.5 - 38.4 %) of the diatom flora such as M. granulata and C. comta were alkaliophilic.

According to Bulton & Dean (1976) lake Mary, located in San Francisco mountain Volcanic field (USA)
is a long, shallow eutrophic lake. Nutrient levels were relatively high during most of the year especially NO$_3^{-}$-N. Total diatom populations maintained a complex successional sequence and remained at relatively high levels, except during cold mid winter months. *Melosira granulata* was the dominant species in the lake.

Basic limnology of 2 crater lakes of Victoria, Australia, was studied by Timms (1976). The lake waters were slightly alkaline hard and dominated by Na$^+$ and Cl$^-$ ions. Of the three communities investigated (zooplankton, littoral weed bed invertebrates and benthos) none, except zooplankton in lake Surprise, is as diverse as that of a fresh water lake elsewhere in Victoria.

Eutrophication causes rapid advances in the succession of aquatic ecosystems, while the eutrophication is accelerated by increase in phosphorus. The impact of these changes on man was discussed by Lin (1976).

A temporal succession of phytoplankton was observed over $1\frac{1}{2}$ years in lake Meredith, USA by Cooper and Charles in 1976. This succession consisted of an apparently organism-produced phosphorus depletion. Following depletion, the P remained at a near constant concentration which was more limited for the alga *Ankistrodesmus falcatus*, than was N for the diatom *Cyclotella meneghiniana*. 
The distribution of the diatom *Melosira binderana*, a species often affiliated with eutrophication, was investigated in lake Ontario (Canada) during 1970-72 in relation to temperature structure, soluble reactive P and silicate during spring when a distinct thermal bar was formed by Munawar & Munawar (1976). *M. binderana* showed a marked near shore to offshore decreasing gradient and maximum densities were observed inside the thermal bar. Excessive growth of this diatom deleted silicate to extremely low levels (25 SiO₂ ug l⁻¹) in the near shore region.

Interdependence of biochemical and species composition of plankton of Mingechaur and Varvara reservoir of USSR was studied by Gadzhieva (1976).

The principal ions in the lake were studied as a function of depth, at various times of the year. Phytoplankton was present in large numbers in lake Laffrey (France): up to 1425 in ind./L near bottom (3 m), at the surface 885 ind./L were present. *Asterionella* sp. and *Fragilaria* sp. were principal representatives of phytoplankton. The former was plentiful near the surface while the latter dominated at 12-20m. *Pediastrum* and *Dinobryon* sp. remained localized below 6m. *Synedra* were plentiful at the surface that disappears at 4m and...
reappeared at 20m. The zooplankton were represented by rotifers and crustaceans. The rotifers were found near the top, Asplanchna was absent at the surface but present between 2 and 12 m; Polyarthra sp. appeared at 10-15m, Notholca was scarce near the surface but reached a maximum at 6m. On the basis of these findings Gachet et al. (1976) concluded that lake has not reached an advanced state of eutrophication.

Studies on phosphate, silicate, NO$_2$/NO$_3$ and NH$_3$ contents of a Norwegian land lecked fjord were carried out by Lannergren (1976).

Hydrological, meteorological and physico-chemical variations were studied in the influent and effluent of lake Nantua (France) by Feuilade & Orand (1976). Tsuda & Ikuko (1976) determined the vertical distribution of dissolved oxygen in lake Biwa, Japan. The results indicated progressive eutrophication in the lake. Kameyan et al. (1976) also worked on the same lake, his work revealed that release of considerable amount of NH$_4$-N and nitrogen accumulated in the bottom mud motivated eutrophication in lake Biwi.

Murphy et al. (1976) suggested that during a bloom of blue-greens other algae can be suppressed completely. This suppression of other algae by blue greens was attributed to loss of iron.
Ecological study of three species of *Ceratium* in the Seto Inland sea area of Japan was conducted by Sasada et al. (1976). *Ceratium* species showed a diurnal vertical migration between surface and 5m layers. Phytoplankton aggregates and scatters periodically in surface waters. A peak in *C. fusca* and *C. furca* population was observed from May-June and September-October while *C. tripos* did not show an increase in autumn.

Physico-chemical and biological parameters of lake Victoria were examined by Akiyama et al. (1977). The common plankton were diatoms *Melosira*, *Nitzschia* and *Surirella*), blue green algae and zooplankton.

While studying seasonal variation of phytoplankton in the shallow Pahlavi Mordab (Iran), Kimball and Kimball (1977) reported that phytoplankton is inhibited by the submerged aquatic macrophyte community either by nutrient competition or by an unknown inhibitory factor.

Biswas (1977) worked on the thermal stability and phytoplankton in Volta lake, Ghana. The author reported that under a predominantly low thermal stability, its increase led to the increase of phytoplankton so that the correlation was +ive. The increase of transparency with the increase of stability was important in this case.
while under a predominantly high thermal stability its
decrease led to the increase of phytoplankton so that
the correlation was -ive. The increase of nutrients in
the upper layers of the lake was important in this case.

According to Rao (1977) ponds rich in \( \text{NO}_3, \text{PO}_4, \)
\( \text{SiO}_2, \text{Ca}, \text{Na}, \text{pH}, \) organic matter and \( \text{O}_2 \) are perhaps better
suited for the growth of diatoms in general. The author
studied the ecology of three fresh water ponds of Hyderabad
(India) and observed that higher oxygen content and low
values of salinity were the basic conditions for
abundance of *Synedra ulna* while *Mastogloia smithii*.
*Nitzchia amphibia* and *Navicula radiosa* were found
abundantly in low conc. of Na and Cl. Certain blue-green
algae which were considered as indicators of the degree
of eutrophication were encountered.

Seasonal algal succession and cultural
eutrophication in a north temperate lake was studied by
Casterlin and Reynolds (1977). The studies revealed
that no uni-algal bloom occurred in the lake, diatoms
dominated in winter and spring, Chlorophyceae in summer
and fall and blue-greens in late summer, fall and winter.
A hypolimnthonic oxygen depletion during summer months
revealed eutrophic conditions which was attributed to
excess nutrient loading resulting from input of domestic
sewage.
Chudybowa (1977) studied composition, quality and seasonal occurrence of algae in the epilimnion layer.

13 spp. of zooplankton were encountered in a study conducted by Beonarz and Symyt in 1977 on some fish ponds near Zator. *Branchionus calyciflorus* and *Polvarthra dolichoptera* were the dominant species.

Minas (1977) examined the relationships between \( O_2 \) and nutrients under conditions of \( O_2 \) depletion and observed that the anomalies are due to the dynamic aspects of the consumption production regeneration system.

A study of chemical parameters of 80 small Prairie ponds (Canada) was carried out between 1967-1972 by Driver & Peden (1977). The studies revealed that these waters exhibited 2 basic ionic dominance patterns,

\[
\begin{align*}
\text{HCO}_3^- & \quad \text{SO}_4^{2-} \quad \text{Cl} \\
\text{Ca} \quad \text{K} \quad \text{Mg} \quad \text{Na/HCO}_3^- \quad \text{Cl} \quad \text{SO}_4^{2-}
\end{align*}
\]

Temporary wetlands were characterized by:

\[
\begin{align*}
\text{Ca} \quad \text{K} \quad \text{Mg} \quad \text{Na/HCO}_3^- \quad \text{Cl} \quad \text{SO}_4^{2-}
\end{align*}
\]

Semi-permanent ponds by

\[
\begin{align*}
\text{Mg} \quad \text{Ca} \quad \text{Na} \quad \text{K/SO}_4^{2-} \quad \text{HCO}_3^- \quad \text{Cl}
\end{align*}
\]
while the permanent ponds were characterized by

\[ \text{Ca} \quad \text{Mg} \quad \text{Na} \quad \text{K/} \text{HCO}_3 \quad \text{SO}_4 \quad \text{Cl} \]

The evolution of the trophic State of a part of lake Neuchatel, Switzerland, was investigated by Pubois and Scheltty (1977) for temperature, dissolved \( O_2 \), total \( P \) and nitrates. No decrease in the \( O_2 \) content was observed at any depth in the study period of 12 years.

Quari & Younuf (1977) recorded \textit{Simcocephalus elizabethae}, \textit{Pleuroxus similis} and \textit{Eucyclops speratus} for the first time from Kashmir.

Tilman (1977) in his paper, Resource competition between planktonic algae states that each diatom is limited by a different nutrient.

Zutshi and Khan (1978) while working on the lake typology of Kashmir demonstrated the importance of outflow in reducing the salt accumulation.

According to Kalff and Knoechel (1978) oligotrophic waters typically supported diverse assemblage of limnetic phytoplankton, with perhaps twice as many species as in eutrophic system, even though total biomass and density may be much less.
Physico-chemical and biological indicators of pollution of lake Nainital (India) were investigated by Das & Pandey (1978). Investigations were made on the basis of physico-chemical parameters like colour, odour, pH, D.O., CO and Total alkalinity.

Pollution characteristics of lake Zurich were determined by Walter (1978) from the analysis of 20 physico-chemical parameters of the water samples of 74 inlets in the lake. Green et al. (1978) in their series of ecological studies on Indonesian lakes studied the differences among the 3 lakes in the stability of stratification, composition of plankton, vegetation and fisheries in relation to differences in exposure to wind and in the effects of human settlements on the shores.

The oxygen consumption rates by microbial organisms during decomposition of aquatic plants was studied by Almazan & Boyd (1978). Authors observed the rates of $O_2$ consumption in the following manner:

- *Anabeana*, *Pithophora*, *Chara*, *Najat*,
- *Spirogyra* and *Euglena*, *Typha* and *Eich norinia*.

Zutshi & Vass (1978) studied the chemical features of Dal lake (India) they found the water of Dal lake to
be alkaline and slightly buffered (pH 7.4-9.6). O₂ of
the surface waters ranged from 7.2 to 17.6 mg l⁻¹, Ca and
Mg ratio was 3:1 in winter and 5:1 in summer and the Na
and K content was found to be very low. The studies
revealed that the water of Dal lake to be low silicate,
chloride and SO₄ concentrations which indicated that the
lake was not very rich in nutrients.

Physico-chemical and biological characteristics
of a pond, Chav. Tal were studied by Khan et al. (1978).
They observed a seasonal fluctuation of temperature in
surface waters. D.O. ranged from 0.07 - 11.2 ppm, carbonate
contents from 10.0-50.6 ppm and bicarbonate from 82.0-
650.6 ppm. Turbidity and phytoplankton crop were the
main factors which influenced the transparency of the
water.

Impoundment behaviour was determined for
alkalinity, temp, D.O. and conductivity from station
located along the length of a bottom draining, oligomeso-
trophic, hard-water, deep-storage reservoir located in
central Texas by Hannan, et al. (1979). Bicarbonate
alkalinity and conductivity exhibited both longitudinal
and vertical stratification. Alkalinity and conductivity
increased in the hypolimnion during anoxic conditions and
consequently increased in a down reservoir progression.
During summer stratification bicarbonate decreased in epilimnion and increased in the hypolimnion at all the stations. This decrease was attributed to the phytosynthetic uptake of bicarbonate by phytoplankton.

Fluctuations in physico-chemical factors of surface waters of lake Manasbal, a warm monomictic lake of Kashmir was studied by Qadri & Yousuf (1979). According to authors the lake water is hard with high bicarbonate, negligible carbonate alkalinity and high pH value. The role of temperature and CO$_2$ in the lake was also investigated.

Vass and Zutshi (1979) examined the physical features and morphometry of Dal lake, Kashmir. Bod Dal was found to be the largest and Nagin the deepest. Secchi transparency was highest in Nagin and lowest in Hazratbal basin. Though the heat budgets of the four basins were identical yet their thermal behaviour was found to differ from each other.

According to Janicki et al. (1979) the crustacean plankton community structure was dependent upon temperature and food conditions, predation and competitive interactions between crustacean species.

Lam and Silvester (1979) investigated inhibition
of Chlorella (Diatom) growth by Microcystis. Authors indicated that the nature of inhibition was due to production of inhibitory extracellular products of Microcystis. On the other hand inhibitory effect of Anabena on Chlorella was due to nutrient competition, as Anabena was more effectively competing for available P04.

Dakshini and Gupta (1980) made comments on Microcystis as an indicator of organically rich waters.

The studies conducted by Kuenzler et al. (1980) revealed that algae were extremely efficient at taking up filterable reactive phosphorus. McDiffett (1980) carried out limnological studies on several lakes on the lake Wale Ridge. The author observed that all the lakes were clear and nutrient poor, with very soft water; lake Annie was found to be more acidic than other lakes, and this was attributed to relatively large amount of decomposing plant material. The higher pH in lake Francis was thought to be due to higher photosynthetic rates during periods of large blooms of Microcystis. The early summer maximum of pH correlates well with the increasing productivity observed during that time. Low transparency values also were indicative of the early summer bloom. The NO3-N peaks in winter in all lakes reflected nitrification of some NH4-N produced during fall and winter
decomposition of macrophytes although no corresponding decrease in NH$_4$-N was seen during the same period.

The influence of eutrophication on the standing crop and composition of planktons was studied by Gary (1980). Swar and Fernando (1980) investigated the ecology of limnetic zooplankton in lake Bagmas and lake Rupa (Nepal). Four peaks of zooplankton abundance were noted with copepods dominating in both the lakes. *Bosmina longirostris* was abundant in lake Rupa.

Burns and Mitchell (1980) while working on the seasonal succession and vertical distribution of zooplankton in lake Hayes and Lake Johnson, observed that zooplankton was found at all the depths during holomixis but was restricted to surface waters only during stratification. A bimodal vertical distribution was found with a peak in the metalimnion and other in the epilimnion. *Ceriodaphnia* and *Bosmina meridionalis* were dominant in Hayes lake.

Okuda (1981) conducted various surveys on physical limnology of lake Biwa. The author also discussed the environmental problems of the lakes.
Yousuf & Qadiri (1981 a,b) have described the effect of various physico-chemical characteristics of water on the distribution and abundance of rotifers and Cladoceran plankton in lake Manasbal. According to the authors the temperature and the hydrogen-ion concentration of the water are the main factors which govern the plankton distribution.

The effect of phosphate and pH in regulating nitrate and ammonia uptake by phytoplankton was investigated in two Oklahoma lakes by Toetz, 1981. A correlation analysis was suggested by author that NO$_3^-$ is not used by phytoplankton when NH$_3^+$ concentration exceed about 210 µg NH$_3^+$ - N(1).

Makarewiez & Baybutt (1981) analysed the long term (1927-78) changes in the phytoplankton community to determine the changes in the phytoplankton community related to the eutrophication of lake Michigan, USA.

Species composition and seasonal dynamics of plankton in the littoral zones were studied in three piedmont North Carolina lakes for one year by Lemly and Dimmick (1982 a,b). Authors suggested the relative abundance of specific taxa of phytoplankton to be strongly influenced by the abundance of herbivorous zooplankton.
Mir & Kachroo (1982) examined the role played by Bacillariophyceae in lake ecology during 1974-1976 in Dal and Nagin lakes, Kashmir. They reported that diatoms to form 20-60% of the total biomass, Chlorophyceae 6-27% and Cyanophyceae 7-23%. In decreasing order of preponderance were Dinophyceae, Euglenophyceae and Chrysophyceae.

Asplanchna priodonta, Conochilus unicornis, Gastropus stylifera and Ascom, Orpha spp. became much dominant while Keratella cochlearis (filter feeder) decreased after an experimental reduction of the fish population, Stenson (1982).

Five Welsh lakes situated in agricultural catchments were nutrient rich; their water samples contained high concentration of N, P and Si compounds, particularly in late summer and autumn. The succession of phytoplankton was dominated by taxa of large celled algae, mainly diatoms and Buoyont blue green algae. While in mountain lakes marked population increases of small green algae were observed when concentration of PO₄-P and NO₃-N in the water samples were minimal (Pruddle and Happeywood, 1983).

The dynamics of periphytic and planktonic algae of a Cypress stand (USA) was studied by Atchue et al.
(1983). A clear temporal pattern in phytoplankton dominance was observed.

Binsle (1983), while studying long term changes in planktonic associations of Crustaceans in lake Constance, observed that changes in Crustacean populations, caused by immigration of new species in the course of eutrophication of the lake, resulted in the establishment of new relationships between the members of the association. In the period of its maximum abundance, *Cyclops vicinus* was a significant predator of other copepods.

Nagrdy (1983) reported 2 new rotifer species (*Lecane aliger* & *Proales pugio*) from Bahama Islands, Florida and California. The author also discussed some rare rotifers (*Epiphanes clavulata, E. branciromus spinous, Lecane crepida* and *Proalides tentaculatus tentaculatus*) which preferred subtropical conditions.

Horizontal patchiness in zooplankton populations was investigated in 2 kettle lakes in Southern Ontario by Malone & Mc Queen (1983). In Tory lake *Skistodiatomus* and Copepod nauplii were found over dispersed and in lake St. George *Polyarthra* spp. *Keratella cochlearis, Asplanchna* spp., *Daphnia galeata mendotae, Bosmina longirostris, Eubosmina coregoni* and Copepod nauplii were all patchy in terms of both vertical and horizontal
distributions. The author suggested 4 basic types of patches, which are -

(i) large scale (1 km diameter),

(ii) small scale (caused by wind induced water movement),

(iii) longmuir (circulation aggregations) and

(iv) Swarms (potentially caused by biotic factors).

Saad and Antonie (1983) studied the effects of pollution on the phytoplankton in the Ashar canal, Arab. Chlorophyta, Conjugatophyta, Mycophyta and Bacillariophyta flourished during periods of high temperature. The disposal of domestic sewage and agricultural wastes in the canal led to adverse seasonal variations. The distribution of Bacillaria paradoxa was restricted by the raised salinity.

Studies conducted by Yousuf et al. (1983) on seventeen water bodies of four different categories of Kashmir revealed that the water temperature in the lentic habitats follows closely that of the atmosphere but in case of lotic waters the underground source and continuous flow of water results in an appreciable difference between air and water temperature. Twentysix species of Crustacea (20 Cladocerans and 6 Copepods) reported formed
associations in 14 water bodies while 3 water bodies revealed complete absence of crustacea. Highest population density was observed in ponds while the lowest in springs.

An attempt was made by Sladicek (1983) to describe rotifers as indicators of water quality. He reported *Branchionus* from alkaline waters. *B. angularis*, *B. rubens*, *B. calyciflorus*, *Filinia longiseta*, *Botaria rotatoria* and *R. neptunia* were reported from highly eutrophicated and polluted waters.

Yousuf et al. (1984) studied the occurrence and abundance of Cladocera during summer and winter seasons in Anchar lake, Kashmir. 31 taxa were recorded of which 13 were eurythermal, 14 warm-stenothermal and only four cold stenothermal. Authors also reported an inverse relationship between the free CO₂ and D.O. in waters.

An analysis of temporal and spatial heterogeneity of the Cladoceran *Bosmina longirostris* and the herbivorous Olanoid Copepod *Diaptomus tyrrelli* in lake Tahoe by Byron et al. (1984) revealed important difference between the 2 types of zooplankton. Although the productivity of both species is limited to varying degree by the abundance of certain algal species and the availability of particulate nitrogen, they differ strongly in the mechanisms responsible for mortality.
Ecological studies on the phytoplankton of Korsfjorden, Western Norway were carried out by Erga and Heimdal (1984). An investigation of vertical distribution of Arctic zooplankton in summer by Longhurst et al. (1984) revealed that diel migration was absent or negligible in late summer, and that seasonal and ontogenetic migrations dominate the pattern of zooplankton vertical distribution.

Subla et al. (1984) studied the distribution of 151 species of zooplankton from 14 aquatic habitats of Jammu and Kashmir. Maximum species were collected from either meso or eutrophic waters and it was observed that rotifera was the most dominant group followed by Cladocera. The authors also observed oligo-mesotrophic situation with low nutrient levels, depicting paucity of plankters.

Subla et al. (1985) worked on the seasonal variation and abundance of zooplankton in Hokarsar and found that the Crustacean population was low in the water body. Yousuf and Qadri (1985) studied the seasonal fluctuation of zooplankton in Manasbal lake and observed that more than half of the total population was represented by Copepods. During stratification zooplankton was reported to have a well marked preference for thermocline zone.
Bist (1986) pointed out that the variations in the physico-chemical and meteorological parameters were responsible for the fluctuations in the quality of plankton and other biota. The author reported a positive relationship of pH, total alkalinity and DO with plankton and an inverse relationship of planktonic population with water temperature.

Shanker and Sangu (1986) carried out a diurnal study in the river Ganga at Hardwar to assess the effect of diurnal changes in abiotic factors on distribution of plankton. They observed a negative relationship of plankton population with temperature and positive relationship with turbidity. In the same year Haque et al. carried out hydrobiological studies of a perennial polluted pond, which receives wastes from a vanaspati oil factory. Phytoplankton of the pond were dominated by blue green algae while zooplankton population showed a dominance of Rotifers.

Effects of physico-chemical factors on the seasonal abundance of Cladocera was studied by Battish and Kumari (1986). Yousuf et al. (1986) carried out investigations on some limnological aspects of a wetland (Mirgund) of Kashmir.

Ondok et al. (1986) reported that the aquatic
plants affected the stratification of temperature in the water column mainly by their selective scattering and absorption of the radiation and by local reduction of turbulence.

Saksena and Sharma (1986) described the morphological form variation in a coricate rotifer, Keratella tropica Apstein. They recognised three morphological forms, viz. reducta, asymmetrica and heterospina.

Mtada (1986) made some limnological observations on a tropical reservoir of west Africa. According to him, although surface warming and wind action promote thermal stratification, a reversal of these factors does not necessarily produce vertical mixing as the levels of water withdrawal determine its heat budget. The author concluded that for manmade lakes or reservoirs, their physical limnology ultimately depended on local topography, vegetation and water management which work in concert with each other.


Bazaz and Koul (1987) studied the distribution
and inter-relationship of Phosphorus and nitrogen in water and sediment in Dal lake and revealed that sediment acted as a major sink for both the nutrients and also played a significant role in the internal phosphorus and nitrogen loading during spring and summer.

According to Zutshi (1987) Kashmir Himalayan lakes presented a wide range of variations in their morphometry, physical features, water quality, sediment chemistry and the nature and distribution of biological communities. The high mountain lakes were found to be oligotrophic and the lakes at lower altitudes were eutrophic.

Singh and Mahajan (1987) observed temperature and dissolved oxygen to be the major controlling factors in the distribution of phytoplankton. The Cyanophycean and Chlorophycean members were largely affected by the nutrients. A direct relationship between silicates and diatoms was observed by the authors.

Sarwar & Zutshi (1987) investigated periphyton communities from natural and artificial substrates of three Kashmir Himalayan lakes (Dal, Anchar, Waskur) for species composition seasonal changes and population
dynamics. A total of 214 taxa representing six classes were recorded with Chlorophyceae contributing maximum number (99) of taxa, whereas diatoms were the main contributors in terms of percentage population composition.

Sarwar *et al.* (1988) related higher values of conductivity, total alkalinity, calcium, magnesium, chloride, ammonical-nitrogen, nitrate-nitrogen and total phosphorus of Malakrag spring (Kashmir) to high biotic interference.

Yousuf (1988) reported on the Copepod plankton of lake Manasbal (Kashmir) and recorded nine species of Copepods, of which *Mesocyclops leuckarti*, *Cyclops vicinus* and *Cyclops sp.* were the dominant forms. The group contributed more than 50% to the total zooplankton in the lake. A detailed review on the literature available on the zooplankton research in North India was conducted by the author in 1989. He concluded that there are still large gaps in the knowledge about the dynamics of the zooplankton of Indian waters as little work has been done on the species composition, population abundance, feeding and breeding biology, seasonal succession and diel variations of the zooplankton.
Yousuf and Parveen (1990) detailed out the dynamics of phytoplankton in Dal lake (Kashmir). Authors reported 84 taxa of phytoplankton. Chlorophyceae dominated the phytoplankton population of the lake qualitatively as well as quantitatively. The phytoplankton population in the water body exhibited spring - early summer peak of Chlorophyceae and diatoms, summer peak of Cyanophyceae and late summer-early autumn peak of euglenoids, autumnal high of Chlorophyceae and winter peak of diatoms.

Malkhi and Yousuf (1990) discussed the distributional pattern of Copepoda in the freshwaters of Kashmir valley.

Studies on pollution, in three rivers of Madhya Pradesh, due to domestic or industrial effluents were carried out by Sharma et al. (1989). Various physico-chemical characteristics were studied for a period of one year and the values were compared with the standard permissible limits. All the chemical characteristics except B.O.D. and C.O.D were found to be within permissible limits.

Kant and Vohra, 1989 gave a detailed account on sediment composition and eutrophication impact of sewage and physical processes and management of the lake. They also gave some control measures for the conservation of the lake ecosystem.
Das et al. (1990) studied the impact of paper and pulp factory effluents, (which are rich in bleaching powder and other organic matter) on the fish and their environment in Hooghly Estuary. In the same year Nandy et al. reported the phytoplankton populations of the Hooghly Estuary. Their observations indicated that the diatoms, which tolerate higher temperatures, were mainly *Synedra ulna*, *Coscinodiscus granii* and *Chaetoceros* sp. while these thriving well at lower temperatures were certain species of *Coscinodiscus*, *Melosira granulata*, *Chaetoceros* sp. and *Biddulphia* sp.

Jha (1990) studied abundance and fluctuation of periphyton in Gobindasagar and allied water, with particular reference to diatoms. The author reported temperature to be the most important factor bringing considerable changes in the size and quality of the community. *Melosira*, *Cyclotella* and *Stephanodiscus* preferred to grow below $20^\circ C$ while *Cymbella turgida*, *Gammatophora serpentina*, *Pinnularia virdis* and *Navicula cuspidata* were found thriving well even at a temperature above $25^\circ C$.

The seasonal fluctuation in the zooplankton community of Azibo reservoir (Portugal), was studied for a period of one year by Vasconcelos (1990). The
zooplankton community was numerically dominated by rotifers. The highest rotifer density was reached in the beginning of spring and it decreased after the Cladocerans peaked in May. Copepods exhibited 2 maxima, one in April and another one in September.

The specific composition and diversity of the zooplankton in 18 impoundments in Zimbabwe were analysed by Green (1990). 30 species of Rotifera and 20 of Crustacea were identified from the samples taken in July and August 1983. Some records represent considerable extensions of known ranges, *Daphnia laevis* was the most widely spread and frequently dominant Crustacean, while among the rotifers *Keratella cochlearis* was most frequently dominant.

Role of Chlorophyceae algae as possible indicators of organic pollution was discussed by Tripathi and Gupta (1991).

An investigation of one hundred waterbodies of Kashmir carried out by Balkhi and Yousuf (1991) revealed a total of 70 species of Rotifera belonging to 19 families. Higher number of species of Rotifera (25 and above) were recorded from water bodies with rich vegetation, generally towards littoral regions. Compara-
tively, water bodies with very little or no vegetation at all produced minimum number of species.

Chakraverty and Kumar (1991) investigated different fresh water fish ponds of Bhagalpur in different seasons of the year 1987 and obtained a considerable number of genera and species of Rotifers.

Jindal & Ghezta (1991) studied the seasonal distribution and abundance of plankton and benthic fauna in relation to hydrobiological factors of the lake Sukhna, Chandigarh. Plankton yield was very low, exhibiting a bimodal pattern of fluctuation with one maxima in summer and other in winter.

Basic limnology of Ghana canal (Bharatpur) before and after dredging was studied by Saha et al. (1991). No remarkable change was noticed in the pH, D.O., Ca and Mg ion concentration during the pre and post dredged period. However, carbon dioxide, bicarbonate and chloride ion showed considerable variation. Zooplankton population increased after dredging while Cyanophycean density decreased.

Blue green algae were reported to be most
dominant and constituted about 70% of the bulk of phytoplankton in Saroor and Barijara lakes of Hyderabad. Average concentrations of $\text{NO}_3^-$, $\text{PO}_4^-$, and $\text{OM}$ differed in the two lakes, which probably accounted for the difference in the species composition of flora and density of population (Swarnalatha and Rao).