Chapter One

**Introduction**

Limnology is a new branch of science that emerged in the early 19th century. In the broad sense it is the study of functional relationships and productivity of fresh water biotic communities, as they are affected by the dynamics of physical, chemical, biotic and environmental factors (Wetzel, 1975), as it is essential for all kinds of biotic activities, the study of water is important. The fresh water ecosystems include rivers, streams, lakes, ponds and springs the total water content of these systems is called terrestrial waters. The main source of terrestrial waters is rainfall, although thermal spring beneath the earth’s surface also contributes to the fresh water systems. The amount of fresh water on earth is insignificant as compared to that of the world ocean yet the fresh water systems especially the rivers are important geo-chemically because they are responsible for most of the weathering erosion of land masses. Lakes and ponds are important fresh water habitats throughout many regions of the world, although the amount of water in them constitutes only a minute fraction of the total freshwater resource on earth (Christer and Lars-Anders, 2002). A large
proportion of the fresh water is stored as ice and snow at higher altitudes and around the poles or as groundwater as and less than 0.5% is available for use by organisms, including for human civilization. However, increasing human populations have resulted in accelerating demands on water supplies for drinking, industrial processes, hygiene and agriculture.

Analysis of water availability and human use suggest that human withdrawal of the total available freshwater resource presently amongst to approximately 50%. The expected population increase coupled with economic development and changing life styles over the next 25 year will substantially increase the demand for fresh water resources like lakes and ponds, and without doubt, the availability of freshwater for human consumption will be one of the great issues for human kind in the present century (Johnson et al; 2001). In spite of the great importance to humans of access to freshwater of high quality, freshwater systems have been misused for many years. Small lakes and ponds have been drained or filled into extend arable land, regulated to reduce water level fluctuations, used as dumps for an array of anthropogenic wastes ranging from untreated sewage to synthetic substances, and many natural
populations of commercially important freshwater species have been over exploited (Loganathan & Khannan 1994, Richter et al; 1997, Matthiessen & Sumpter 1998, Burkholder 2001, Leveque 2001)

Fresh water is one of the most important natural resources crucial for the survival of all living beings. It is even more important for human beings as they depend on it for food production, industrial and waste disposal, as well as cultural requirements. Limnology, the science that deals with the freshwater environments, the physico-chemical characteristics, their biota and the ecosystem processes therein, is therefore universal in its significance. Although, changes in land used, biogeochemistry and increasing international commerce have created global environmental stress expressed, for example as climate change, depletion of the atmospheric ozone layer, acidification and invasion of exotic species (Williamson 1995, Mack et al; 2000). All these factors alone and in combination negatively affect the quality and availability of water for aquatic organisms as well for human consumption. Moreover, these disturbances continue to have, serious effects on the natural systems and their biota.
Fresh water habitats occupy a relatively small portion of the earth’s surface as compared to marine and terrestrial habitats. However, their importance to man is far greater than their area for the following reasons.

1. They are the most convenient and cheapest source of water for domestic and industrial needs.

2. The fresh water components are the bottleneck in the hydrological cycle.

3. Fresh water ecosystems provide the most convenient and cheapest waste disposal systems.

Because man is abusing this natural resource, so, it is clear that major efforts to reduce this stress must come quickly. Otherwise, water will become the limiting factor.

Fresh water is a necessary source for man. The fresh water bodies are vital resources for developing countries. In Indian sub-continent, they are mostly man made and bear great economic significance. Indian history is full of events prompting construction of fresh water reservoirs for recreating, irrigation, food control and drinking water supply. Some of these are big and beautifully set in natural surroundings. Increased
construction of impoundments is likely to occur with increasing population and the accompanying urban and industrial growth. In India, new multipurpose water reservoirs are coming up at an accelerated pace although one finds rarely, if ever, an ecological approach towards their protection and maintenance. Very little is known about their chemistry, biology or the rate of siltation.

Pure water is animating fluid while polluted water is a real curse for living beings. The global consciousness towards freshwater system arose in the beginning of the century and the International Biological Programme (IBP), Man, and Biosphere Programme (MAB) were floated to generate information on structure and function of inland aquatic environment, their productivity and the impact of human interference.

In the past, few decades’ natural polluted waters have been studied in detail all over the world and a considerable data is now available on most kinds of pollutants and their effects on ecosystems as well as organisms. The need of water is increasing day by day, invariably due to the population explosion; unplanned urbanization etc. wastes are being dumped into waters, thus lowering its quality with respect to chemistry as well as organisms, more particularly, the plankton. A glance at
the earlier limnological studies reveals that plankton grows in waters of different trophic levels. Some prefer eutrophic water while certain other prefer oligotrophic or mesotrophic water. Hence, some of the planktons may act as indicators of pollution. Some of the planktons are even capable of tolerating pollution too.

The eutrophication of water, which in simplest sense, means pollution of water or enrichment or nutrients and the resulting degradation of its quality accompanied by luxuriant growth of micro and mactrophytes. It is recognized as a major problem all around the globe. Man has tried and is trying to cope with this problem and has rapidly advanced counteract this malady. In order to study the fresh water ecosystems with respect to their chemistry and biological aspects a new branch of science emerged in the early 19th century, called “Limnology”. Its credit must go to F.A. Forel, who for the first time began the study of fresh waters and described lake as ‘microcosm’ (Welech, 1935). Rapid development of limnology took place only after the invention of microscope and later Hensen (1887) discovered plankton. This branch of science gained momentum in America
and Europe which later spread to other countries including India.

The worldwide problem of increasing pollution of water is an additional factor, as health and well-being are dependent on the quality of water. The environmental pollution has become a threat of future sustainable life on the earth. Pollution is defined as “defiling of the natural environment by a pollutant” and pollutant is a substance that enters the environment or becomes concentrated within it and that may have a detrimental biological effect. However, these definitions speak of natural environment, which has remained independent of man’s influence.

Eutrophication means only an increase in primary production but also an increase in higher trophic levels, changes of the community structure and may also means changes in main paths of energy flow within the aquatic ecosystem (Kagalou 2003). Changes in the aquatic environment accompanying anthropogenic pollution are a cause of growing concern and require monitoring of the surface waters and organisms inhibiting them. The monitoring of the quantity of surface waters by hydrobiological parameters is among environmental
priorities. Because it permits direct estimation of the state of water ecosystem exposed to deleterious anthropogenic factors. The zooplankton community, which closely related to all other components of the biota, is a sensitive indicator of the state of the monitoring of water objects (Vandysh, 2004).

The terms oligotrophic, mesotrophic and euthrophic are used based on the concentration of phosphorus, nitrogen and calcium along with the plankton population. During the last three decades, agricultural practices and unplanned urbanization were responsible for higher nutrient load of the lake water, which caused serious threat to the modern society. Many individuals have contributed to overcome this threat.

Since the problem of water pollution in India is very critical, extensive studies are required to protect the natural and manmade water resources. Thus, water quality assessment can be done either by monitoring the physico-chemical properties of water or by analyzing inhabiting biota. The physico-chemical means are useful in detecting effects of pollution on the water quality but changes in the tropic conditions of water are reflected in the biotic community structure including species

The productivity of reservoir ecosystem is dependent on several characteristics of water. Of these, most important ones are the nutrient available for phytoplankton production, which in turn determines the level of animal production in the reservoirs (Hutchinson, 1957).

Sources of water pollution are countless. Industries are of great concern and industrialization contributing to water pollution has reached the alarming situation. The main pollutants of factory wastes include oil, detergents, suspended particles, poisonous chemicals, including fertilizers and pesticides. Most important source of water pollution and of great concern is the human activities. Even today open defecation in the fields and along the drains is common in India. These sewage drainages ultimately join water resources, make the water pollute and unportable. Thus causing water-born diseases like diarrhea, dysentery, typhoid, fever intestinal helminthes, jaundice, cholera etc., that is endemic to India (Baruah et al; 1998).
The problem of water pollution is now posing a serious problem in India. In many part of India, inland freshwater bodies are the main sources of drinking water for the rural and urban population. Deterioration of these water sources due to contamination with pathogens, parasites, pollutants creates many health problems to the persons consuming this water. The per capita of availability of water in India has come down today in an aggregate terms. However, water availability varies in different parts of the country and during different times of the year. About 460 billion cubic meter of water is used to irrigate the grossed crop area spread in 79.74 million hectares. In comparison, in term of net consumption, domestic water supply accounts for only 25 billion cubic meters, industries 15 billion cubic meter and energy 19 billion cubic meters. But requirements of water for these and other non-irrigation sectors is expected to be almost equal to the utilisable quantity of water available in India by 2025 AD (Ramchandra et al; 2003)

As such, water quality in relation to human health is an important facet of limnology in India and many third world countries. Even though, ecological interrelationships, species diversity and physico-chemical properties of water from ponds
and lakes received considerable attention of limnologists, evaluation of the safety of water has not large scale.

In India, the annual rainfall is about 105cm. the country is rich in precipitation and surface water resources. Surface water or river flow is constituted by a direct run off from rain and a delayed run off from subsurface water conserved in the soil and in ground water acquires. The climate characterized by short periods of concentrated and extended hot and dry periods imply seasonality of the input of water resources to ponds.

The major industrialized and thickly populated cities are situated on the fresh water banks. The industries and cities consume large quantity of water and the substantial portion of which is thrown out as wastewater into the water bodies. In India on an average 70% of intake water by the industries is discarded as wastewater, which is contaminated with a host of toxic substance, thus polluting the water bodies (Taqui Khan, 1987). The release of both municipal wastes and industrial effluents into the water bodies has profound influence on the physical, chemical and biological characteristics of the river ecosystem (Kudesia, 1980). The industrial wastes include dissolved minerals, toxic chemical, organic wastes and
sediments. The sewage mainly consists of organic wastes. The organic wastes of municipal wastewaters are biodegradable. The non-biodegradable industrial wastes include heavy metals, salts and other chemicals, which raise the acidity or alkalinity or the aquatic organisms and various other uses. The modern agricultural practices have polluted the water bodies due to excessive application of fertilizers and pesticides (Carpenter, 2005).

Physico-chemical factors are very important in estimating the constituents of water and concentration of pollutant or contaminant. The chemical and biological factors are interrelated and interdependent. The physical factors include water movement, light, temperature, turbidity and suspended solids. The chemical factors include pH, carbonates, bicarbonates, oxygen, carbon-dioxide cations, and anions and dissolved organic materials. The main object of the physico-chemical analysis of water is to determine the status of different chemical constituents, which are present in the natural and disturbed aquatic ecosystem. The quality of water may be affected in various ways due to pollution. The pollution manifests itself either altering the existing elements in the water
or by generating new substances (e.g. Ammonia nitrates) which were not previously present (Janandhan Rao, 1982).

As stated earlier with the civilization and advancement followed by industrialization, the problem of water pollution has been assuming greater dimensions. The sources of pollution in the water bodies are sewage and industrial effluents. Since most aquatic plankton grow in wide variety of polluted water one can hope that the proper knowledge of their pollution biology may provide useful solution for this problem. Thus the importance of biological waste treatment system has caught the attention of workers all over the world and has helped in developing relatively efficient low cost in treating the wastes but also in producing a variety of useful products from their biomass. The planktonic organisms forming a part of the greater biomass, the study of which has greater relevance today, constitute a big link in the life cycle of many organisms and needs intense study of all relevant factors, so that concerted efforts could be made to clear the understanding of the role of biomass in the life cycle.

Limnological variation in pond and reverine ecosystems was done by (Saha and Pandit, 1985). An intimate relationship between the water and ambient temperature was observed. PH
of the pond was alkaline and that of river was acidic. Acidic nature of river was due to higher rate of decomposition to release free carbon dioxide, which is converted into carbonic acid, and this further dissociated into $H^+$ and $HCO_3^-$ ions. More dissolved oxygen was in river than in pond, sodium was high in pond than in the river.

Khan et al; (1986) studied the population ecology of zooplankton in a polluted pond at Aligarh. Alkalinity fluctuated due to photosynthetic activity of green biota. The authors concluded that absence of carbonates, presence of carbon dioxide and low pH indicated respiratory activity of zooplankton and dissolved oxygen were inversely related.

Ecology of three temple tanks of Dharwad was studied by (Hegde, 987). Increased concentration, of soluble organic matter due to human interference led to eutrophication. Nitrates, Phosphates, nitrogenous organic matter were responsible for growth of nuisance algae and spoilage of water quality.

Adoni and Joshi(1987) working on the physico-chemical regime of three fresh water bodies in Sagar (MP) found that high alkaline values were due to leaching of electrolytes. Carbonates
were high at surface compared to bottom due to higher
trophogenic activity. Bicarbonates were high at bottom. Nitrates
and phosphates concentrations were also high leading to
eutrophication. However, no relation of these factors could be
established with other variations.

The same belt was studied by Yadava et al; (1987) who
observed that there was direct relation between air temperature
and water temperature pH ranged from acidic to neutral and so,
they concluded that profuse vegetation resulted in poor
plankton.

Kulkarni et al; (1988) made studies on physico-chemical
characteristics of the water bodies with reference to stress of
human activities in Maharashtra. High pH indicated greater
photo synthetic activity. Free carbon dioxide concentration was
inversely related to pH. Ammonia and nitrogen concentrations
were high above the oligotrophic limit. This resulted in total
biomass and positive correlation with total nitrogen. More
concentration of H2O indicated high level of organic pollution
along with high concentration of chloride, sulphate, calcium,
magnesium sodium and potassium.
Abiotic factor or a reservoir receiving effluents from a thermal power station was studied by George, (1988). Dissolved Oxygen, free carbon dioxide, phenolphthalein alkalinity, methyl orange alkalinity, total hardness and pH were not much influenced by effluents from thermal power station and recorded almost same ranges as reported by other workers.

In 1989, Sing and Trivedi did studies on the impact of sewage on the quality of Ganga River water. pH dissolved oxygen, nitrogen and phosphorous were directly influenced by water temperature. High alkalinity was due to accumulation of phosphates and silica in sewage. Calcium and Magnesium were high. The high concentration of phosphorous indicated pollution.

Srivastava and Kulshreshtha (1990) studied the seasonal variations in certain physico-chemical parameters in Ganga, Yamuna and tanks in Allahabad region. pH remains constant. The maximum dissolved oxygen was observed in winter. Dissolved oxygen declined in summer and became least in rainy season. No seasonal difference in chloride was observed.
The phosphate load from detergent inputs and its effects in freshwater was done by Mukherjee et al, (1994). Detergents resulted in an increase in pH and total alkalinity. The authors presumed that CO$_2$ is used by detergents and the organisms had to depend on bicarbonates to meet carbon dioxide demand. Michael (1980) presented an article on all the available Indian limnological works in the form of “A Historical Resume of Indian Limnology”, which covered the works done till 1979. A broad categorization of Indian fresh water investigations published till 1979 was presented. They were in the nature of presenting species lists and descriptions of taxa were new to the Indian sub-continent. Giving an idea about beginning of limnological study in India, the paper was a review of the work on zooplankton, general ecology, aquatic macrophytes etc. in central, southern and eastern parts of India.

Saran and Adoni (1982) studied the seasonal variations in pH and dissolved oxygen contents in Sagar Lake, observed high pH at surface that at bottom water which was attributed to high photosynthetic activity at surface level. Dissolved oxygen was also found to be high at surface than at bottom and exhibited
positive correlation with temperature and inverse relation with transparency.

Trivedi et al; (1984), made the evaluation of drinking water quality in Satura District. The wells exhibited high amounts of solids, carbonated chlorides, total hardness, calcium magnesium as compared to the surface sources. Total ion was more in surface sources due to contamination from iron rich soil. The contamination of well water was due to seepage from septic tanks or open defecation.

Jayangoudor (1980), working on different depths in Ajwa reservoir, observed homothermal condition during summer. In other seasons a slight temperature different was noticed. However, pH was always alkaline, remained low in bottom layers. Enough dissolved oxygen as noticed in bottom regions. The surface water was found to be supersaturated on few occasions.

Some of the pioneering Indian works are in this line are, Prasad (1916), Pruthi (1933), Jayangoudor and Ganapathi (1965), Zafar (1959, 1966), Munawar (1970, 1974) Gulati and Wartz-Schultz (1980). A recent trend in the Indian limnology is
about the pollution aspects. Credit of starting limnology study in goes to Gandhi (1959), Jayanagoudar (1964), Bharti and Hosamani (1975), Major contribution has been done in this field by Hegde (1984, 1985a, 1989, 1990)

Seasonal variations in water temperature, which is due to the high specific heat of water (Jyoti et al; 1986). Water temperature reaches its peak in summer (Saha, 1984) and the maximum temperature attained by water in the planes of India is comparatively more than of water located at higher altitudes (Unni, 1985).

The influence of temperature on the dissolved oxygen and distribution of plankton and micro vertebrates in water bodies have been reported by (Quadri and Yousuf, 1980). Similar results were reported by some workers John 1975; Kumar et al; 1977; Krishnamurty 1985; Ilyas 2002; Walunjakar 2004;

Higher pH value indicates a high degree of photosynthetic activities (Sreenivasan, 1963). pH value decreases during summer in polluted water due to higher rate of decomposition and increases in unpolluted water bodies due to higher photosynthetic rate (Sharma et al; 1978). Decrease in pH value is found to be due to increase in the concentration of Carbon
Dioxide, which may increase due to higher rates of decomposition (Saha and Pandit, 1985). The low pH value during monsoon might be due to high turbidity and elevated water temperature, which arrest photosynthetic creativity leading to accumulation of free Carbon Dioxide followed by lower pH during monsoon (Adebsi, 1980). Many researchers have been reported that pH exhibits an inverse relationship with Carbon Dioxide (Munawar 1970; Saran and Adoni 1982; Marinuther and Krishnamurty 1985) and the direct relationship with dissolved oxygen.

The seasonal variations in the concentration of dissolved oxygen of water bodies have shown post monsoon higher values, which are considered to be due to the influx of well-oxygenated rainwater to the ecosystem (Patil et al; 1985). Dissolved oxygen is said to be controlled by temperature (Sreenivasan, 1972) showing an inverse relationship with water temperature (Saran and Adoni, 1982). Hence, maximum values of dissolved oxygen winter are due to low temperature (Saha et al; 1971)

Generally Dissolved Oxygen is directly to photosynthesis, which is generally high when the sky is clear and the days are long (Sreenivasan 1970, 1976) and an inverse relation between
Dissolved Oxygen and rainfall was reported by Manawar (1970). Low Dissolved Oxygen values indicate the biodegradation of organic matter and decay of vegetation (Jameel, 1998). Abundance of Cladocerans population can thrive well in low oxygen concentrations. Drastic reduction in Dissolved Oxygen indicates the influx of pollutants (Bhatnagar Garg, 1998).

Higher values of Dissolved Oxygen coincide with phytoplankton maxima of rainy season and winter season but during summer, their relationship tends to be inverse because of the increased rate of decomposition of organic matter, which utilizes the oxygen reused by the phytoplankton (Vyas and Kumar, 1978). Hence, the rate of decomposition also plays an important role in controlling the levels of Dissolved Oxygen and high levels of organic matter resulting in the depletion of oxygen. Deficiency of oxygen indicates the eutrophic nature of water body (Sreenivasan, 1963 and Sharma et al; 1978).

Dissolved organic Phosphorus in the fresh water medium is believed to exist as orthophosphate (Hutchinson, 1975). Although, it represents only a small fraction of the total phosphorus, it serves as essential nutrients for plant and animal life (Reid, 1961). A key substance in the eutrophication
of a water body is the phosphate content of the water (Shapiro, 1970). Maximum phosphate is being found in the monsoon due to influx of water containing fertilizers from the fields, which bring phosphate from catchments areas (Pandey et al; 1992).

Phosphate showed a direct relationship with plankton as the plankton flourished during the period of high concentration of Phosphate level, which is because of sewage contamination (Welch, 11952). Higher concentration of Phosphates is an indication of eutrophication (Patil and Goudar, 1985).

The lowest concentration of Phosphates during summer, fairly high concentration in winter and the highest during the rains is observed by (Vyas and Kumar, 1968). Thus, there appears a seasonal variation in the inorganic Phosphate content and its concentration appears to be dependent upon rain and drainage and Phosphorous increases during rainy season. (Trivedy et al; 1983). Contrary to this, higher values of Phosphates during summer may be attributed to the decreased water level and release of phosphates due to decomposition of organic matter (Seenyya and Zafar, 1979, and Saha, 1984). Increase of Phosphates during summer in the polluted water bodies is attributed to the increased nutrients in water and
release of Phosphates from sediments and the decrease of Phosphates during rainy season to the dilution, but in unpolluted water bodies the appearance of Phosphates only after rains may be due to surface run off (Goel et al; 1980 b).

Akins and Harris (1924), Spurr (1975), Rai and Hill (1981), Pollinger et al (1988) have all noticed that Phosphorous can act as a limiting factor in biogenic activities, but Gonzalves and Joshi (1964) and Viner (1989) did not observe any relation between Phosphates and plankton and plankton growth. According to Zafar and Seenayya (1988), lack of phosphorous in some water does not mean that it is non-productive, nor that it is less eutrophic. Thornton (1989), and Surrendrakumar and Sharma (1991), have used Phosphorous concentration as a tropical index. Pollinger et al; (1988), have convincingly indicated that phosphorous was a nutritional factor which limited phytoplankton growth.

Hardness of water is due to Calcium and Magnesium salts (Saran and Adoni 1984; Adoni and Joshi, 1985) and found to be maximum during summer and winter seasons (Munawar, 1970, Chandrashekar and Jafer 1998). Saha and Pandit (1985) also reported low values of hardness in summer. However, Adoni and
Joshi (1985) have recorded maximum level of hardness during summer. The variations in hardness depend on the water level (Pathak and Shastri 1993) and total water mass (Shardendu and Ambasht, 1988).

The higher values of Phosphates, dominance of bicarbonate with low sulphate and nitrate concentration indicate the hardness to be of non-permanent or bicarbonate type (Shardendu and Ambasht 1988). Bicarbonate hardness is found to be temporary whereas, non-carbonate hardness is permanent. Hardness and calcium are correlated but these do not show correlation with chlorides (Adoni and Joshi, 1985). Contrary to this, calcium and hardness showing positive correlation with chloride was shown in the studies of Hussainy (1967).

Chlorine in Free State, which is used as disinfectant, will be converted into Chloride or combines with organic matter to form toxic compounds (Adoni, 1985). Chlorides increase in summer and decrease during winter (Gonzalves and Joshi, 1964; Singh 1960; Zafar 1964). The chloride shows a well-marked seasonal variations, increase from winter to summer and decrease rapidly during monsoon. The higher values in
summer are due to loss of water by evaporation and the lower once during monsoon may be due to influx of rainwater (Sreenivasan et al; 1973). Chlorides may also increase due to inflow of sewage and drains rich in animal refuse (Saha, 1984) which may account for organic effluents (Verma, 1967). The chloride content is largely dependent on domestic pollution. Hence, water bodies situated in urban areas show chloride content several times more than those situated in rural areas (Unni, 1985). Chloride regulating the salinity of water and exerts consequent osmotic stress on biotic communities.

The polluted waters contain more nitrates than unpolluted waters (Sharma et al; 1978). In the sewage contaminated water bodies however, ammonia is generally found to be in excess over nitrates and nitrites, which is due to low pH and anoxic conditions that facilitate the denitrification and ammonification (Manawar, 1970, Goel et al; 1980; and Goel and Trivedy, 1984). Higher values of NH$_3$N after winter and during summer are due to decaying organic matter provided by algal bloom (Khan et al; 1986). An appreciable quantity of nitrate in the surface waters has been regarded as a warning of sewage contamination (Hutchinson, 1975). However, the absence of Nitrites in the
tropical water bodies has been reported by Sreenivasan et al; (1974) and Jana (1979).

The sediment soils of the reservoirs are affected by dissolved nutrients, organic matter and salt from the catchment area. The total sediment load consists of slat clay particles and organic matter (Gunatilak and Senaratna 1981). The potential energy and an ionic matter are stored in the bottom layer of the reservoir in the form of humus and Total Hardness organic residue which maintains the proper water chemistry of the reservoir (Saha 1984) found difference as it was low in monsoon period and was almost equal in pre and post monsoon periods. This variation may be due to the dilution during monsoon period.

It has been reported that water with alkalinity values between 40-90 PPM are productive (Ohle, 1983) on the basis of Total Alkalinity waters are classified as low (40-50 PPM), moderately (50-100 PPM), and high (100-200 PPM), in productive (Philipose, 1959). Further (Philipose, 1960) suggested that water body with alkalinity value > 100mg /l is nutritionally rich. According to Islam (1999) high alkalinity showed greater
productivity. High Total Alkalinity values are generally indicative of system well buffered against drastic pH shifts (Nolen, 1989).

Waters rich in carbonates are more alkaline (Zafar, 1964 and 1966). In addition, those rich in bicarbonates are usually rich in calcium (Zafar, 1964). Studies on Central Indian reservoirs indicate that calcium and carbonates are the most dominant ions and minor reservoirs have higher concentration of bicarbonates as compared to the major reservoirs (Unni, 1985). Though a direct relation exists between calcium and bicarbonates, Zafar (1964) has noticed increase in calcium concentration with decrease in bicarbonate values. Carbonates and bicarbonates show an inverse relationship (Ganpati 1940; Zafer 1964), which is due to conversion of carbonates to bicarbonates during night and free carbon-di-oxide to carbonates during day time (Khan and Siddiqui 1970; Saksena and Adoni 1973). A direct relationship exists between carbonates and pH (Verma 1967, and Khan and Siddiqui 1970).

According to Zafar (1966) and Prasad and Singh (1980), when carbonates are present the water is more alkaline and when it supports large quantities of bicarbonates, carbon dioxide and calcium it is much less alkaline. The water bodies where
carbonates were completely absent throughout study period were less alkaline with high bicarbonates, free Carbon Dioxide and calcium.

Lakes having calcareous basin have shown high concentration of calcium (Kaul et al; 1980). It decreases during summer (Zafar, 1964) and increases in Total Hardness post summer months (Patil and Goudar 1985). pH and calcium show an inverse relationship (Zafar, 1964 and Munawar, 1974). Calcium considered as a basic inorganic element of algae and is regarded as a nutrient for various metabolic processes (Ruttner, 1953). It is needed, as micronutrient calcium is essential for maintenance of the structural and functional integrity of cell membranes in ion absorption (Wetzel, 1975).

The domestic sewage and industrial effluent are the chief sources of sulphates (Chandrasekhar and Jafer, 1998). Monsoon months showed the maximum values indicating that this nutrient brought in from allocanthonous source, low value may be attributed to its utilization by the mactrophytes for their growth (Singh, 2000). High value of sulphate during monsoon might be due to surface run off which brings more suspended solids along with organic and inorganic soluble salts (Sinha,
The low value of sulphate during winter is due to higher phytoplankton population (Sinha, 1989).

Rao et al; (1999) reported the existence of positive correlation of sulphates values with electric conductivity, total dissolved solids, total hardness calcium, magnesium, chloride, nitrate and negative correlation with alkalinity, fluoride, dissolved oxygen. Nandoni et al; (2001) also observed the positive correlation between sulphate and hardness and negative correlation with water temperature, chloride, BOD and COD.

These workers have reported that physico-chemical factors influence the distribution, abundance and type of organisms present in the fresh water bodies. In comparison with these reports and the independent research carried out during the last two years.

Freshwater biodiversity is the overriding conservation priority during the international decades for action “Water for life – 2005 to 2015”. Freshwater makes up only 0.01% of the world’s water and approximately 0.8% of the earth surface, yet this tiny fraction of global water supports at least 1 lakh species out of approximately 1.8 million almost 6% of all described species. Inland waters and freshwater biodiversity constitute a
valuable natural resource. Their conservation and management are critical to the interests of all human, nations and governments. Yet this precious heritage is in crisis.

Freshwater waters are experiencing declines in biodiversity far greater than those in the most affected terrestrial ecosystems, and if trends in human demands for water remain unaltered and species loses continue at current rates, the opportunity to conserve much of the remaining biodiversity in freshwater will vanish before the “Water for Life decades end in 2015”. According to David Dudgeon (2005), global freshwater biodiversity threats less than five heading over exploitation, water pollution, flow modification, destruction of degradation of habitat and invasion by exotic species. Further, they suggested that combined and interacting influences have resulted in population declines and arranged reduction of freshwater biodiversity worldwide.

Biodiversity may be broadly defines as the variety and variability among living organisms and the ecological complexes in which they occur. Biodiversity can be considered at different scales ranging from the gene to ecosystem. The most commonly
used meaning of biodiversity is at the level of species (Organismal biodiversity).

Freshwater systems harbor a unique and diverse set of organisms. About 15% of all animal species that have been described until today live in freshwater systems. More than 70 thousand freshwater species from 570 families and 16 phyla have been describing so far (Strayer 2001).

In ponds, most animal species belong to crustaceans, rotifers, insects, or oligocheats. Planktonic and periphytic algae as well as different life forms of microphytes are also specious in ponds and lakes. A number of factors, both abiotic and biotic that operates at different scales affect freshwater biodiversity. Environmental disturbances may result in reduced biodiversity due to either direct lethal effect on organisms or due to more complex interactions between different factors (Lodge et al; 1987).

Zooplanktons are small animals that float freely in the water column of lakes and oceans and whose distribution is primarily determined by water currents and mixing.
The zooplankton community of most lakes ranges in size from a few tens of microns (Protozoa) to >2mm (Macro-zooplankton). In terms of biomass and productivity, the dominant groups of zooplankton in most lakes are crustacean and Rotifers and these protocols emphasize these groups. Zooplankton plays a pivotal role in aquatic food webs because they are important food for fish and invertebrate predators and they graze heavily on algae, bacteria, protozoa and other invertebrates. Zooplankton communities are typically diverse (>20 species) and occur in almost all lakes and ponds. Zooplanktons are rarely important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses.

Zooplankton communities are highly sensitive to environmental variation. As a result, changes in their abundance, species diversity or community composition can provide important indications of environmental changes or disturbance. Zooplankton communities often respond quickly to environmental change because most species have short generation times, (usually days to weeks in length). Zooplankton communities respond to a wide variety of disturbances including nutrient loading (McCauley and Kalff 1981; Pace 1986; Dodson
1992), acidification (Brett, 1989; Keller and Yan 1991; Marmoreka and Kormann 1993), contaminants (Yan et al; 1996), Fish densities (Carpenter and Kitchell 1993), and sediment inputs (Cuker 1997).

In India, more work has been done on the ecological and seasonal distribution of plankton than any other tropical and subtropical countries. The first ecological study in India was made by Prasad (1916), who worked on the seasonal conditions governing the pond life in Punjab Pruthi (1933) and Sewell (1934) had studied the bionomics of fresh water in relation to change in Physico-chemical conditions of tank of the Indian Museum of Kolkata.

Trivedy et al; (1983) studied on limnology of five lakes in Kolhapur with reference to human activity. According to them the densities and species composition of phytoplankton with an over, dominance of bloom forming cynophytes and pollution tolerant algae indicated the eutrophication of the habitats.

Earliest contributions to zooplankton studies in India came from scientists working in the laboratories either of the zoological survey of India (Prasad, 1916, Sewell, 1924) or with
the state or central Fisheries Departments (Chopra 1930). However, Ganapati (1940 and 1960) working as water analyst in the Madras city corporation contributed significantly to ecological studies of hydro-biological impacts. However, the bulk of zooplankton studies in relation to hydrobiology have come only during the last fifty years. Universities have contributed significantly during recent years Vasist (1975), Das (1982), Tandon and Singh (1988), Nayar (1968, 1970) Vasist and Sharma (1975) and Mishra et al; (1978, 80, 81) Gopal (1990).

An overview of the global fisheries trend brings out the growing importance of aquaculture in recent years. The freshwater fish aquaculture of our country includes 2.25 million hectares of ponds and tanks, 1.30 million hectares of derelict water, 2.09 million hectares of lakes and reservoirs, 0.12 million km of canals and 2.30 million hectares of paddy fields (Anita, 2003). Considering the availability of water area exclusively in the form of ponds and tanks. It is observed that only 45 percent of the areas have been brought under aquaculture. This shows that potential of horizontal expansion of this sector in the coming years (Ayyappan, 2000) maintenance of healthy aquatic environment and production of sufficient fish food organisms are
primary factors for successful pond aquaculture operation. Production and growth of fish food organisms directly depends on the available nutrient elements in the water and related physico-chemical parameters. Although a number of workers have studied the limnology (Unni, 1993) no systematic work has so far been reported on bio-ecology of the reservoirs in Kundalika Dam regarding the potentialities of fish aquaculture. Hence, the present investigation was undertaken to study the fish fauna and prospectus in aquaculture of reservoir in relation to the limnological parameters.

The quality of available freshwater is the problem of greater and immediate concern. The present hydrobiological studies are the first attempt to investigate the status of Kundalika Dam of this region.

The comprehensive work provides database for future development. The results of this work are expected to generate data forming basis for remedial measures in effective management of aquatic resources. Since agriculture and its related sources are main source of income of this area, the assessment of surface water resources is very much important to decide the appropriate cropping pattern in particular locality.