Chapter 2

REVIEW OF LITERATURE

The science of aquatic ecology and hydrobiology has gained great significance these years. The freshwater systems – lakes and riverine systems – satisfy our domestic, industrial, transport, and sporting needs and the biotic community of these water bodies, both animals and plants, are intimately integrated associates in this process. Alternations in their relationship depend on changes in the physico-chemical properties of the environment, illustrating the dynamic and delicate balance of these systems. The present fresh water regime is approximately 2.7% of the total global water, of which rivers and lakes constitute only 0.01% (Dhoundial, 1993). Nature is somewhat effectively maintaining a balance in the population of animals through biological control, but the effectiveness of biological control of animal population now-a-days is hampered by anthropogenic interference.

Water quality study forms a very significant area of environmental studies, and the studies on the physico-chemical characters of water bodies have been gained world wide acceptance. The importance of the study of ecology of water resources in our country has been realized from the early years of the previous century. The various physico chemical characteristics, the dynamics of plankton population, the fishery potential and the methods of improvement of the water bodies formed a subject of detailed discussion by various scientists. In the early half of the last century various workers have thoroughly studied the different aspects of water bodies. (Weibe, 1930; Rice,
1938; Redfield, 1934; Yoshimura, 1935; Campbell, 1941 and Chandler, 1944). Weibe (1930) investigated the plankton production in fish ponds. Rice (1938) studied the phytoplankton of river Thames. Redfield (1934) studied the organic derivatives in sea water and their relation to the composition of plankton and stated that high values of phosphorous would be an indicator of potential fertility. Yoshimura (1935) studied the relation between maximum amount of oxygen during summer stagnation period and the transparency of fresh water lakes in Japan. Campbell (1941) studied the vertical distribution of rotifera in Douglas lake, Michigan and reported that the abundance of rotifer can be attributed to factors like dissolved oxygen, carbon dioxide and pH. Chandler (1944) studied the limnology of western Lake Erie and emphasized the effect of temperature on physicochemical factors of water and plankton.

During the second half of the 20th century lot of workers have contributed valuable information about various aspects of lentic and lotic water bodies of different countries. (Welch, 1952; Pennak, 1955; Jitts, 1959; Hutchinson, 1967; Odum, 1971; Hannan and Young, 1974; Spodniewska, 1979; Geldermalsen, 1985; Villar et al., 1996; Elskens et al., 1997; Tafas and Economou-Amilli, 1997; Lind et al., 1997; Virbickas, 1998; Olguín et al., 2000).

Pennak (1955) studied the comparative limnology of eight Colorado mountain lakes and reported higher values of nutrients during monsoon. Jitts (1959) studied the absorption of phosphate by estuarine bottom deposits. Hannan and Young (1974) studied the influence of deep storage reservoirs
on the physico chemical characters of central Texas River and reported that
the light penetration of the river is restricted due to the high density of
phytoplankton. Spodniewska (1979) while studying the eutrophication of
Masurian lakes commented that water turbidity and phytoplankton biomass is
positively correlated. Geldermalsen (1985) while studying the seasonal
nutrient dynamics in the Oosterschelde in South West Netherlands observed
that nitrate showed maximum values in summer. Villar et al.(1996) studied
the macrophytic primary production and nutrient concentrations in the
floodplain marsh of Lower Parana river and opined that floodplain marshes
are nitrate sinks due to denitrification losses and macrophyte uptake. Tafas
and Economou-Amilli (1997) conducted a limnological survey of the warm
monomictic lake Trichonis in Western Greece and reported that
phytoplankton population succession patterns correspond to changes in
environment variables. Lind et al. (1997) studied the clay turbidity and the
relative production of bacterioplankton and phytoplankton in Lake Chapala,
the largest lake in Mexico, and commented that clay turbidity negatively
impacts the bacterioplankton production. Olguín et al. (2000) conducted an
aquatic ecotoxicity assessment in highly polluted urban river(Reconquista in
Argentina) and illustrated the convenience of using algal bioassays in
evaluating the ecotoxicological quality of water receiving effluents of industrial
and domestic origin. Virbickas (1998) studied the regularities of changes in
the production of fish populations and communities in Lithuanian Rivers.
More precise and diversified research is going on in the hydrology, plankton study and fisheries sector in this century also. (Magdeleno et al., 2001; Cabo et al., 2003; Yahia et al., 2004; Castro et al., 2005; Kideys et al., 2005; Zaho Wen et al., 2005) Magdeleno et al. (2001) has studied water pollution is an Argentine river and opined that the pollution of rivers is manifested by low oxygen content, high levels of nutrients, suspended matter, and heavy metals. Cabo et al. (2003) while studying the effect of physico-chemical variable on plankton from delta of the Paraná river in Argentina reported that lowest plankton densities coincides with minimum temperature and also commented that the plankton variables would be affected directly or indirectly by water level and by seasonal climatic condition. Yahia et al. (2004) studied the spatial and temporal structure of planktonic copepods in the bay of Tunis in South western Mediterranean Sea and found that the copepods dominated the mesozooplankton. Castro et al. (2005) studied the rotifer community structure in three shallow lakes in Portugal and recorded peak in terms of abundance and diversity during summer time and it was mainly related to temperature. Kideys et al. (2005) evaluated the phytoplankton abundance, biomass and species composition of Caspian Sea and suggested that the higher value of chlorophyll is due to the decreased grazing of phytoplankton by zooplankton. Zaho Wen et al. (2005) studied the biological and ecological features of saline lakes in northern Tibet (China) and reported that the number of plankton species has a significantly negative correlation with the salinity.
In the early half of the last century a number of workers have studied various aspects of water bodies in India. (Sewell, 1929; Ganapati, 1940; Gonzalves and Joshi, 1946; Bal et al., 1946; Gonzalva, 1947; Chako and Ganapati, 1949; Mukherjee and Bhattacharya, 1949). Sewell (1929) while doing geographic research in Indian waters opined that the fall in salinity in rivers is mainly due to the effect of rainfall. Ganapati (1940) observed an inverse relation between pH and carbon dioxide while studying the ecology of a temple tank. Gonzalves and Joshi (1946) studied the fresh water algae near Bombay and correlated pH with the production of algae. Bal et al. (1946) studied the waters of Bombay harbour during 1944–45 and correlated the chemical and physical characteristics. Gonzalva (1947) studied the algal flora of hot springs of Vajreswari near Bombay. Mukherjee and Bhattacharya (1949) while studying the culture of fish in temporary hard water stressed the effect of rainfall in decreasing the alkalinity of water.

Limnological studies on the Indian waters made a significant progress during the latter half of 20th century. (Ganapati et al., 1952; Rao, 1955; Das and Srivastava, 1956; George, 1961; Lakshminarayana, 1965; Arora, 1966; George, 1966; Munawar, 1970; Zutshi and Vass, 1971; Jana, 1973; Vashist and Sharma, 1975; Srinivasan, 1976; Zutshi and Vass, 1978; Das, 1978; Singh and Swarup, 1979; Harshey et al., 1982; Patil et al., 1983; Bhatnagar, 1984; Patil et al., 1985; Yadava et al., 1987; Khan, 1987; Usha Kumari et al., 1991; Krishnamoorthy and Bharti, 1994; Venkateswarlu et al., 1994; Patil and Panda, 1997; Kaur et al., 1997; Sharma and Sharma,
Rao (1955) studied the distribution of algae in small ponds and noticed a direct relationship between pH and oxygen, where as an inverse relation was observed between pH and carbon dioxide. Das and Srivastava (1956) studying the plankton population of freshwater ponds and tanks of Luknow found that zooplankton abundance vary inversely with pH. George (1961) studied the rotifer population of shallow ponds in Delhi. Arora (1966) commented that Rotifers indicate the trophic status of water body. George (1966) while studying the comparative plankton ecology of fish ponds in Delhi, commented that variation in pH seems to be a minor seasonal variation. Munawar (1970) conducted limnological studies on fresh water pond of Hyderabad and pointed out that water rich in particulate organic matter and suspended soil particles are rich in nitrates though they are not recipients of sewage. Zutshi and Vass (1971) while studying the quality of high altitude Kashmir lakes found a clear ratio between calcium and magnesium in lakes. Jana (1973) studied the seasonal periodicity of plankton in fresh water pond in West Bengal and opined that temperature has no role in the seasonal periodicity of phytoplankton. Vashisht and Sharma (1975) while studying the ecology of a typical urban pond in Ambala city of Haryana reported that low temperature is responsible for plankton production. Srinivasan (1976) studied the primary production of temple pond ecosystem and found that low chloride content indicates absence of pollution. Zutshi and Vass(1978) conducted limnological studies on Dal lake in Kashmir. Das (1978) studied the ecology of high pollution Lake
of Nainital and reported that a pH range of 6.8 to 8.7 is favourable for aquatic life. Harshey et al. (1982) conducted limnological studies of a tropical fish tank of Jabalpur and reported that the amount of carbon dioxide in water inhibits the conversion of bicarbonate into carbonate. Patil et al. (1985) studied the hydrography of a tropical fresh water fish tank in Jabalpur and observed the absence of a significant relationship between water temperature and atmospheric temperature. According to Bhatnagar (1984) cladocerans and copepods play marked role in vertical migration on daily basis. Ushakumari et al. (1991) while reporting the ecological parameters of Basman Lake recorded the absence of any direct relation between temperature and plankton production. Krishnamoorthy and Barati (1994) conducted an investigation on the dissolved oxygen and oxidizable matter and water temperature of River Kali in Karnataka and found that dissolved oxygen of the river has an inverse relationship between dissolved organic matter and temperature. Venkateswarulu et al. (1994) studied the role of diatoms as indicators of pollution and showed that growth of algal species was influenced by environmental factors and designated them as indicators of pollution. Kaur et al. (1997) studied the interrelation between physico–chemical parameters at Harike wetland in Punjab and pointed out that water temperature showed negative correlation with dissolved oxygen. Sharma and Sharma (1999) studied the freshwater rotifers of Meghalaya. Sharma (2000) studied the rotifers of tropical flood plain Lake of Upper Assam and commented that the rotifers depict a qualitative predominance in floodplain lakes. Khanna et al.
(2000) while investigating the seasonal periodicity of plankton in Ganga River found that total planktonic concentration was the highest in the month of January from where it decreases continuously upto July.

Some of the very recent reports on Indian waterbodies are that of Goswami and Goswami (2001), Malu (2001), Bhave and Borse(2001), Shilpa Shilpa Choudhary and Devendra kumar(2001), Pajevar Madhuri et al.(2002), Reddy et al.(2002), Patil and Singh (2002), Yalavarthi Eswari (2002), Arora and Mehra (2002, 2003), Nandi and Das(2003), Salaskar and Yeragi(2003) and Sharma (2005). Goswami and Goswami (2001) studied the productivity indicators in Mori beel of Assam and reported 9 species of rotifers from one beel. Malu (2001) studied the phytoplankton diversity in Lonar Lake and opined that they are the bioindicators of water quality. Bhave and Borse (2001) while studying the seasonal variation in physico chemical parameters and their influence on planktons in Aner river in Maharashtra demonstrated an inverse relation between salinity and plankton production. Choudhary and Devendra kumar (2001) studied the phytoplankton population of Boorsa lake and reported that chlorophyceae constituted the major group of the lake, and the summer months produced relatively more plankton than the rainy and winter months. Pajevar Madhuri et al. (2002) studied the physico chemical parameters of Lake Ambegosale in Thane and reported that the phosphate level was very high and found an inverse relation between phosphate and the growth of Pistia. While studying the eutrophic status of Hussain Sagar Lake in Hyderabad, Reddy et al. (2002) reported that human activities can heavily
pollute a lake. Patil and Singh (2002) conducted complete limnological investigations of abiotic factors of Ujani wetland of Maharashtra and from the results, they concluded that the wetland is in the moderate stage of eutrophication. Yalavarthi Eswari (2002) while studying the hydrobiology of Red hills reservoir in North Chennai, Tamilnadu reported that phosphate is a limiting factor for the development of plankton. Arora and Mehra (2002, 2003) studied the seasonal variation and species diversity of rotifers in Yamuna river and reported 89 species in 2002 and 110 species in 2003. Nandi and Das (2003) while studying the diversity and population of zooplankton in a man made bheri system in West Bengal noticed a tendency of diminishing overall population density of zooplankton with increase in salinity. Salaskar and Yeragi (2003) studied the seasonal fluctuation of plankton population in Powai Lake in Mumbai and observed a direct relationship between dissolved oxygen and phytoplankton. Sharma (2005) studied the rotifer communities of flood plain lakes of Assam and observed that water temperature, conductivity, dissolved oxygen, and alkalinity record significant relationships with rotifer abundance.

In Kerala, from the previous century itself hydrographic studies and the relation between physicochemical parameters and the biota of aquatic systems have gained great importance. (Mary John, 1958; Rao and George, 1959; Nair and Thampi, 1980; Tressiamma and Nair, 1980; Kuttyamma, 1982; Nair et al., 1984a; 1984b; Nair et al., 1985; Premchand et al., 1987; Subrahmanya, 1987; Nair and Abdul Azis 1987; Ramakrishna et
Mary John (1958) studied the relation between salinity and zooplankton in Kayamkulam Lake while conducting a preliminary survey of Kayankulam Lake. Rao and George (1959) studied the hydrology of Korapuzha estuary. Nair and Thampi (1980) opined that even though light is a prime necessity for photosynthesis; there is a limit at which plants become light saturated. Thressiamma and Nair (1980) studied the phytoplankton of Ashtamudi estuary and have opined that the lowering of salinity and enrichment of nutrients during south west monsoon are mainly responsible for the abundance of phytoplankton. Kuttyamma (1982 studied the effect of salinity on the growth of Penaeid prawns and reported that the growth of post larvae and juveniles was affected by variations in salinity. Nair et al. (1984a) studied the zooplankton ecology of Kadinamkulam back water and opined that rotifers, copepods and copepod nauplii constituted the major part of zooplankton. Nair et al. (1984b) studied the primary productivity of Ashtamudi estuary and opined that the light penetration has not acted as a limiting factor in the productivity mechanism in the estuary. Prem chand et al. (1987) studied the hydrography of Beypore estuary and observed a well defined seasonal variation in temperature. Ramakrishna et al. (1987) studied the physico-chemical aspects of Olippuramkadavu backwater and opined that physicochemical factors like pH, silicates, dissolved oxygen etc. are relatively stable when compared to factors like temperature, chlorides
Subrahmanya (1987) while studying the evolution of Western Ghats stated that the evolution of estuarine tract is closely related with the evolution of Western Ghats. Nair and Abdul Azis (1987) studied the hydrography of Ashtamudi estuary and opined that the oxygen depletion towards close of monsoon was due to eutrophication. Bijoy Nandan et al. (1989) studied the water quality and faunal depletion in the retting zones of backwaters of Kerala and they opined that salinity plays an important role in the distribution of zooplankton. Harikrishnan and Abdul Azis (1989) studied the ecology of Neyyar reservoir and reported higher values of phosphate and nitrate during monsoon. Nair et al. (1995) studied the impact of salinity on the plankton of fresh water riverine system with reference to Beypore estuary and elucidated the impact of salinity on the plankton and also concluded that salinity intrusion has great effect on the ecology of water bodies. Kadeeja Beevi et al. (2004) studied the environmental hazards of retting zones in Kayamkulam backwaters and reported that due to retting of coconut husk, the water quality has deteriorated with the accumulation of toxic organic compounds and a severe depletion of plankton and benthos has occurred.

Various workers have studied the physicochemical parameters and its relation to the biota of Vembanad Lake also. (Devassy and Gopinathan, 1970; Wellershaus, 1971; Haridas et al., 1973; Madhupratap et al., 1973; Sreedharan and Sali, 1974; Pillai et al., 1975; Silas and Parameswaran Pillai, 1975; Madhupratap and Haridas, 1975; Madhupratap 1978; Rama Raju et al., 1979; Antony and Kuttyamma, 1983; Abdul Azis, 1985; Joseph, 1987;
Anirudhan et al., 1987; Jacob et al., 1987; Padmakumar, 1987; Jayachandran and Thomas Zachariah, 1993; Unnithan et al., 2001; Padmakumar et al., 2004). Devassy and Gopinathan (1970) studied the hydrobiological features of Kerala backwaters in premonsoon and monsoon months and recorded the salinity range of Vembanad Lake as 6.13 to 31.9. Wellershaus (1971) studied the hydrography of Cochin backwaters and related the salinity with the abundance and distribution of zooplankton. Haridas et al. (1973) studied the temperature, oxygen, salinity and zooplankton biomass of backwaters from Cochin to Alleppey before the construction of Thanneermukkum barrage. Madhupratap et al. (1973) studied the zooplankton of Vembanad lake and has reported the incidence of 12 groups of zooplankton. Sreedharan and Sali (1974) studied the distribution characteristics of nutrients in estuarine complex of Cochin. Pillai et al. (1975) observed that temperature and salinity did not show any significant impact on the productivity of Vembanad Lake. Silas and Pillai (1975) studied the dynamics of zooplankton in Cochin backwater. Madhupratap (1978) studied the ecology of zooplankton of Cochin backwaters and reported that copepod occupied dominant status in Cochin backwaters. Antony and Kuttyamma (1983) studied the influence of salinity on the distribution of polychaetes in Vembanad estuary and commented that among all the physico chemical parameters salinity is found to be the most important ecological factor that influences estuarine organisms. Abdul Azis (1985) reported that waters in Kumarakom region of Vembanad Lake remained acidic and opined that this pH is not considered suitable for the
healthy existence of aquatic organisms. Joseph (1987) studied the environmental pollution with reference to Kuttanad and reported abundant PO$_3$–P with marked seasonal variations. Anirudhan et al. (1987) studied the distribution pattern of salinity and silicon and their interrelationship in Cochin backwater and commented that the construction of Thanneermukkom bund lead to the stagnation of water resulting in the large changes in the hydrography of Cochin backwater. Jacob et al. (1987) studied the hydrochemical aspects of Pamba estuary and reported the mixing of fresh water with saline water. Padmakumar (1987) studied the aquatic pollution with special reference to Kuttanad and opined that Vembanad Lake has become a dumping ground for agricultural field wastes. Jayachandran and Thomas Zachariah (1993) studied the impact of Thanneermukkom salt water barrage on the Vembanad Lake and observed significant differences in the pattern of oxygen, phosphate and salinity. Unnithan et al. (2001) studied the ecology and investigated the fisheries in Vembanad Lake and suggested that there should be only periodic closure of barrage than permanently remained closed for about 4 – 5 months. Padmakumar et al. 2004 studied the potentials of cage culture in Vembanad lake and found it suitable for developing the culture fisheries of Vembanad lake.

The climate is the most important factor affecting the microclimate of a particular habitat. The regional differences in light, temperature, moisture etc. are factors of environmental significance which not only affect the physico
chemical properties of water but also regulate the behavior and activity of flora and fauna. (Adoni, 1985).

Temperature is one of the essential factors which not only act as a limiting factor for the growth and distribution of animals and plants, but also influence the geochemical aspects of aquatic ecosystems. It affects the fundamental stratification and is also responsible for the zonation of water bodies (Lund and Talling, 1957; Odum, 1971).

The effect of temperature and various other physical and chemical factors on ecology of water bodies have been studied by various scientists. (Rice, 1938; Chandler, 1944; Rao, 1955; Klein, 1957; Munawar, 1970; Patil et al., 1985) Chandler (1944) studied the limnology of Lake Erie and emphasized the effects of temperature on aspects like species density, diversity of plankton and physico chemical factors of water. Reports are plenty on the relationship between the atmospheric temperature and water temperature, suggesting that they move more or less hand in hand in smaller water bodies. (Rice, 1938; Welch, 1952; Rao, 1955; Munawar, 1970). Welch (1952) reported that smaller water bodies quickly react to atmospheric temperature and the water temperature will always be lower than atmospheric temperature. But it is not true with large water bodies Patil et al. (1985). Patil et al. (1985) studied the limnology of a tropical fish tank of Jabalpur and reported that in large water bodies the water temperature does not follow closely the changes in atmospheric temperature. A similar study was also made by Patil and Panda (1997) which almost confirmed the earlier results.
Klein (1957) obtained a relation between the water temperatures with dissolved oxygen. He has reported on the rise in water temperature in stream leading to decline of oxygen due to increased microbial activity. Bhatnagar (1984) confirmed the result while studying the limnology of lower lake in Assam. Krishnamoorthy and Bharti (1994) and Kaur et al. (1997) reported on the negative correlation between water temperature and dissolved oxygen. They also found that water temperature has an inverse relationship with dissolved organic matter and dissolved oxygen and organic matter are inter related to each other and change in one influences the other.

Various workers who worked on the relationship of water temperature with other factors were not able to found a significant relation between water temperature and pH and nutrients like nitrate and phosphate. (Zutshi and Vass, 1978; Patil et al., 1987; Yadava et al., 1987; Shastree et al., 1991). Kaur et al. (1997) also came up with the same observation while working on the physico chemical factors of Harike wetland, Punjab. Patil and Singh (2002) studied the abiotic parameters of Ujani wetland ecosystem and reported that high temperature affect the dissolved oxygen content of water by decreasing its solubility.

The studies of Sreenivasan (1964) and Banerjee (1967) emphasized the importance of temperature on primary production. Pillai et al. (1975) and Usha Kumari et al. (1991) reported that water temperature has no direct impact on plankton production. But Vashist and Sharma (1975) found that low temperature is responsible for increased plankton production. Khatri (1984)
while working on the seasonal variation of primary production of Lakhotia lake in Rajasthan confirmed that low temperature favours increased productivity. Khanna *et al.* (1993) studied the phytoplankton ecology of the River Ganga and observed a negative correlation of water temperature with phytoplankton and zooplankton production. Agarwal *et al.* (1995) stated that the values of biological factors increase when temperature increases and that the temperature has got a direct effect on the biology of Sagar Lake.

Dhamija and Jain (1994) who studied the physico chemical characteristics of a lentic water body reported that variations in temperature and their overall trends can be taken as an indication of pollution. According to Pande (1995) waste waters from industries with high temperature cause marked ill effect on water quality, planktons, macrophytes and fish fauna of the lake.

Reichwaldt *et al.* (2005) studied the effect of temperature in the life history of Daphnia and found that somatic growth higher at higher temperatures but lower in fluctuating temperature. Sharma (2005) studied the rotifer communities of flood plain lakes of Brahmaputra basin and opined that water temperature directly influence the rotifer abundance.

Light reaching the earth, are discrete packages of energy. This energy from the sun is the basic requirement for the existence of life on the earth. The phytoplankton, zooplankton, suspended organic and inorganic particles either reflect or absorb the light rays. In water there is a selective absorption of light at various depths. It functions as a limiting factor, on the distribution
and the varied activities of plants and animals. The extent of penetration of light in water is known as transparency. Various workers emphasized the effect of transparency on the biology of water bodies. Yoshimura (1935) and Rawson (1960) used transparency values as an index of eutrophication and concluded that, the more transparent the water, the more will be the oxygen content at the deeper layers of the water body.

The studies of Sreenivasan (1964), Banergee (1967) and Agarwal (1980) stressed the importance of transparency in the context of increased primary production. Hillbert et al. (1960) studied the phytoplankton of Sargasso Sea and reported that the turbidity and percentage of light transmission influence plankton production. Later many scientists confirmed the results (Menzel and Ryther, 1961; Prasad and Nair, 1963 and Venu and Seshavastharam, 1984). Spodniewska (1979) observed a positive correlation between water turbidity and phytoplankton biomass.

Balakrishnan Nair et al. (1984) studied the primary productivity of the Ashtamudi estuary and opined that the light penetration has not acted as a limiting factor in the productivity mechanism in the estuary. According to Nair and Thampi (1980) even though light is a prime necessity for photosynthesis, there is a limit at which plants become light saturated. But Habib et al. (1997) reported that light was directly related to phytoplankton growth and temperature, constitutes the limiting factor for algal development. Gikuma-Njuru and Hecky (2005) studied the Nutrient concentration in Lake Victoria in
relation to light and commented that high mineral turbidity reduces light availability and limits algal abundance.

Chemical properties of water not only alter the physical properties of the medium but also influence the distribution and metabolic activities of the biota which in turn tend to change the chemical quantity of water in due course of time (Adoni, 1985). The hydrogen ion concentration of water bodies controls the chemical state of many nutrients (Horne and Goldman, 1994). Studies on the effect of pH on aquatic system have been made by various workers. (Weibe, 1930; Welch, 1952; Jana, 1973; Mitra, 1982). Weibe (1930) reported that pH is controlled by photosynthesis of aquatic plants and phytoplankton.

Welch (1952) reported that the range of 6.5 – 7.5 is normal in fresh water bodies. Mitra (1982) showed that in major rivers of India, the pH was moderately on the alkaline side. Swingle (1967) found the pH of pond waters within the range of 6.5 and 9 is quite suitable for fish culture. Klein (1973) studied the causes and effects of river pollution and found that pH between 6.7 and 8.4 are suitable, while values below 5.9 and above 8.4 are detrimental, for aquatic life. Sreenivasan (1964) attributed the decrease in pH in a system to the increase in the removal of CO₂. Abdul Azis (1985) studied the waters of Kumarakom region and reported that the lake remained acidic (4.00-6.5) during the whole year and that this pH is not suitable for the healthy existence of aquatic organisms.
Various workers correlated pH with the productivity of aquatic ecosystem. (George, 1961; Vashist and Sharma, 1975; Bhatnagar, 1984; Ushakumari et al., 1991; Lopes et al., 2005). George (1961) opined that high values of pH promote the growth of phytoplankton and result in blooms. Various other workers also reported increase in plankton production with rise in pH (Davis 1955; Moitra and Bhattacharya, 1965; Jana 1973; Bhatnagar, 1984; Ushakumari et al., 1991). Vashist and Sharma (1975) found pH as a controlling factor only in the case of some rotifers. Datta Munshi and Singh (1991) obtained a positive correlation of pH with phosphate and a negative correlation with dissolved oxygen. Kaur et al. (1997) confirmed this while reporting on the interrelation between physico–chemical factors of Harike wetland, Punjab. Lopes et al. (2005) observed a significant relationship between distribution of phytoplankton species and pH elaborating the importance of pH in aquatic systems.

Salinity is the amount of solid material in grams contained in one kilogram of the water when all the carbonate has been converted into oxide, bromine and iodine replaced by chlorine and all organic matter completely oxidized. McLusky (1974) commented that waters having salinity greater than 0.5% can be referred to as brackish water. The salinity of estuaries remains highest during summer and during drought, when less fresh water flows into the estuary. Nayak and Patra (1982) reported that high salinity value during summer may be due to the rapid evaporation, large surface area and bathing activities. Variable salinity is the characteristic feature of
estuaries due to tides and this may affect up to 10 Km up stream in large estuaries. According to Horne and Goldman (1994) the salinity effect dominates over thermal stratification in an estuary.

According to Dehadrai (1970) and Chandran and Ramamurthy (1984) tropical estuaries undergo strong fluctuation in salinity following monsoon showers. Anirudhan et al. (1987) studied the salinity pattern and silicon content in Cochin backwaters and reported that high monsoonal input of silicon are lost in the estuary which is largely influenced by salinity and a negative correlation exists between salinity and silicon. Vareethiah and Ramadhas (1999) studied the halocline stability in Thungapattanam estuary and found that the tidal mixing and estuarine circulation are crucial factors influencing the hydrographic status of an estuary, which in turn impacts the nutrient distribution and productivity of the system.

Literature on the relationship between salinity and zooplankton have been worked out by various authors.( Kayamkulam Lake by Mary John,1958; Cochin back water by Wellershaus,1971; Silas and Parameswaran Pillai,1975 and Rao et al.,1975; in the Edava-Nadayar back water system by Nair et al.,1983 and in the Gurupur estuary by Bhat and Gupta,1983). Silas and Pillai (1975) while studying the dynamics of zooplankton in Cochin backwaters observed high numerical abundance of zooplanktons during high saline premonsoon period. Madhupratap et al. (1973) reported that in Cochin back waters copepod occupied dominant place and the abundant component vary widely in different waters. Sitaramaiah (1975) studied the temperature,
salinity and plankton of Daman Ganga estuary and the high and low salinities of the estuary was attributed to the maximum influx of sea water into the estuary and the rain fall in upper reaches of the river. Low biomass of plankton is associated with low salinity and high temperature of July, August and September (Sitaramaiah, 1975). Rao (1977) and Qasim and Sen Gupta (1981) reported that salinity plays a pivotal role in the circulation, sediment transport, cycling regeneration and remineralisation of nutrients, plankton distribution and productivity estuaries. Antony and Kuttyamma (1983) studied the influence of salinity on the distribution of polychaetes in the Vembanad estuary and recorded that among all the physico chemical parameters salinity is found to be most important ecological factors that influence estuarine organism. Bijoy Nandan et al. (1989) while studying with the water quality of retting zones opined that salinity plays an important part in the distribution of zooplankton. On studying the impact of salinity on the plankton of fresh water river Nair et al. (1995) also concluded that salinity intrusion has great effect on the ecology of water bodies.

Vembanad lake system was a subject of study for the last several decades (Sivankutty Nair and Shynamma, 1975; Jacob et al., 1987; and Jayachandran and Thomas Zacharia, 1993). Sivankutty Nair and Shynamma (1975) studied the salinity tolerance of Villorita and reported that the species is capable of tolerating wide range of fluctuation in salinity. Jacob et al. (1987) reported that Vembanad Lake becomes more or less fresh water during postmonsoon when Thanneermukkom bund remains open and lake water
were flowing towards north. During dry season though the bund was closed
to prevent ingestion of sea water into lake, the lake water were rendered
brackish progressively over larger and larger areas and by summer, the
entire spread of lake become brackish.

Krishnan and Kunnupandi (1987) reported that higher salinity (above
15‰) is needed for the proper development of mangrove crab. Avoy and
Klug (2005) studied the positive and negative impact of riverine input on the
estuarine green alga *Ulva intestinalis* and reported that the growth was
depressed by low salinity and the reduction in this growth can be mitigated by
input of increased nutrients.

Toumi *et al.* (2005) studied the zooplankton distribution in four ponds
of different salinity and found that salinity had a negative impact on the
abundance of copepod and rotifers, which were absent in the pond with
highest salt concentration and the change in zooplankton species
composition along the hyper saline gradient was primarily related to salinity.
Muylaert *et al.* (2005) reported that the phytoplankton biomass and the
estimated annual net production were much higher in fresh water tidal zone
compared to the brackish reaches of the estuary.

Dissolved oxygen is of paramount importance to all living organisms
and is considered to be the lone factor, which to a greater extent can reveal
the nature of the whole aquatic system at a glance, even when information on
other physical, chemical and biological parameters is not available. Odum
(1971) opined that several abiotic and biotic factors determine the dissolved
oxygen content of the system. The occurrence of dissolved oxygen in water is attributed to two phenomena (1) direct diffusion from the air which depends on the solubility of oxygen under the influence of temperature, salinity etc and (2) photosynthetic evolution by aquatic autotrophs which depend on the availability of light (Adoni 1985). In the hypolimnion of mesotrophic or eutrophic lakes, dissolved oxygen is reduced from saturation level by the oxygen demand of decaying phytoplankton. This low oxygen content affects the survival of fish and benthic animals, increases the recycling of nutrients and may produce compounds such as H$_2$S (Horne and Goldman 1994). Venkateswarlu (1986) reported that dissolved oxygen influences the distribution and abundance of algal population. Selvaraj and Kumaraguru (1997) noticed that higher dissolved oxygen concentration favours the growth of the blue green algae- *Microcystis aeruginosa*.

Various authors reported that dissolved oxygen showed inverse relationship with temperature (Shastree *et al.*, 1993; Das and Srivastava, 1956; Olsen and Sommerfeld, 1977 and Islam, 1990). Bhatt and Pathak (1992) reported that the dissolved oxygen concentration may increase upto 15% above saturation level when measured during period of high productivity. Reid (1961) and Pahawa and Mehrotra (1966) observed a negative correlation between dissolved oxygen and phosphate and a positive correlation with chlorides. Patil and Singh (2002) noticed a direct relation between dissolved oxygen and pH. Similar results were obtained earlier by Rao (1955) and Reid (1961). Somashekhar (1981) while working on the
industrial water pollution in and around Mysore city reported that decrease in dissolved oxygen content was associated with increase in nitrates.

Jindal and Kumar (1993) studied the limnology of a fresh water pond reported that dissolved oxygen showed a negative correlation with nitrates. They also found that dissolved oxygen had an inverse correlation with temperature though during some months the inverse correlation could not be established. They attributed this to the abundance of phytoplankton resulting in the liberation of dissolved oxygen by relatively more photosynthetic activity at higher values of temperature. Krishnamoorthy and Bharti (1994) conducted an investigation on the dissolved oxygen, oxidizable organic matter etc. of river Kali and reported that dissolved oxygen of the river has got an inverse relationship with dissolved organic matter. Similar results were obtained earlier by Hynes (1970), Warren (1971), Smet and Evens (1972), Welch (1980), Manikya Reddy (1984), Venketeswarlu (1986) and Seshadri (1989). Hynes (1970) and Welch (1980) found that depletion of oxygen was mainly due to eutrophication of the lake and the degradation of particulate organic matter present in the sewage by the eutrophic bacteria which completely take up all available dissolved oxygen.

Various workers related the dissolved oxygen content with plankton and productivity. (Campbell, 1941; Ganapaty et al., 1952; Biswas, 1972; Balkhi et al., 1984; Usha Kumari et al., 1991; Wasidlewska, 1992). Campbell (1941) observed the vertical distribution of rotifera in Douglas Lake and attributed the abundance of rotifer to dissolved oxygen. Ganapaty et al. (1952) found that
low concentration of dissolved oxygen may favour the abundance of blue
green algae. Alikunhi et al. (1955) correlated low oxygen concentration with
high zooplankton collection and attributed it to the respiratory activities by
increased plankton. Qasim and Siddiqi (1960) studied the pollution of river
Kali and reported that the industrial wastes increase the biological oxygen
demand load which depletes a great deal of dissolved oxygen in river water.

Biswas (1972) and Balkhi et al. (1984) pointed out that temperature and
dissolved oxygen have their influence on the abundance of plankton. Coble
(1982) reported that a better occurrence of fish species in the river, where
dissolved oxygen levels was low (5 mg/l). Nair and Abdul Azis (1987) studied
the hydrobiology of the Ashtamudi estuary and opined that oxygen depletion
in the estuaries towards the close of the monsoon season and in the early
post monsoon was probably due to eutrophication in estuary.

Singhal et al. (1986) studied physico chemical environment and
plankton of managed ponds. They found that the depletion of oxygen content
which occurred in August could be attributed to low photosynthetic activity or
respiratory activity of heterotrophic organisms counter balancing the
photosynthetic production of oxygen. Usha Kumari et al. (1991) studied the
ecological parameters of Basman Lake of Motihari and reported that oxygen
concentration and plankton abundance were closely and directly related.
Chlorophyceae and Cyanophyceae did not show any relation with dissolved
oxygen in Basman Lake. Wasidewska (1992) studied the relationship
between phytoplankton and abiotic elements in Rusalka reservoir and opined
that even though the relation between phytoplankton and dissolved oxygen was not significant, physical indicators of water quality are of greater importance for the prediction of the quantity of phytoplankton biomass. Pushpendra Kumar Khare (1998) studied the ecology of Jagat Sagar pond and reported that total plankton density showed marked and significant correlation with dissolved oxygen.

Magdaleno et al. (2001) studied the water pollution in an urban Argentine river and reported that the level of oxygen indicates the pollution status of the river and dissolved oxygen was positively correlated with nitrate, nitrite and pH. Patil and Marathe (1982) studied the physico chemical factors and plankton of fresh water tanks of Nagpur and observed a wide range of dissolved oxygen content. (2.8–15.1 mg/l).

The productivity of a water body greatly depends on the amount of available dissolved nutrients in water and the productivity within the littoral zone is directly controlled by nutrient cycling in the area. High nutrient content causes eutrophication. When abnormally high amounts of nutrients from sewage, fertilizer, animal wastes and detergents enter the streams and lakes excessive growth or bloom of micro organism and aquatic vegetation occur. Thus the nutrients stimulate algal growth and lead to plankton blooms. Ketchum (1967) observed that 2.53 mg/l of PO₄–P is the maximum limit of its concentration which could be accepted as danger signal of evaluation of eutrophication of estuary. According to Hutchinson(1967), nutrients are the limiting factors for phytoplankton production.
Various workers reported that sewage is the main source of high
nutrient content in aquatic bodies (Hutchinson, 1957; Munawar, 1970; Shane
et al., 1971; Govindan and Sundareshan, 1979; Ravichandran, 1985; Lewis
and Morris, 1986).

Hutchinson (1957) found that high quantity of phosphate and nitrate
may be due to sewage pollution and several others confirmed this view.
(Shane et al., 1971; Govindan and Sundareshan, 1979 and
Ravichandran, 1985). Jhingran (1971) observed that the phosphate content
of more than 0.2 ppm may be considered as the productive nature of water.
Lewis and Morris (1986) studied the toxicity of nitrite to fish and opined that
sewage effluents also contain high amount of nitrite which may be too toxic to
fish.

Redfield (1934) and Amstrong and Harvey (1950) have stated that
high values for phosphorous would be an indication of potential fertility.
According to studies conducted by Mortimer (1941, 1942), Jitts, (1959), Miller,
(1952) and Ritterberg et al. (1955) sediments in estuaries trap 80-90% of
phosphorous and release the same to overlying water. Murthy and Veerayya
(1972) studied the sediments of Vembanad Lake and reported wide limits
(37-1677 µg/l) of phosphate in the sediment. Joseph (1987) studied the
environmental pollution of Kuttanad and reported abundant PO$_3^{-}$-P (max
18µg/l) with marked seasonal variations.

Goel et al. (1980) recorded least phosphate during rainy season and
highest in summer. But Verhoff et al. (1982) is of the view that phosphates
increase with increase in rain flow. Harikrishnan and Abdul Azis (1989) who studied the ecology of Neyyar reservoir reported higher values of phosphate during monsoon, confirming the result of Hutchinson (1941) Pennak (1955) and Govind (1963). Vargheese et al. (1992) also confirmed the same findings.

Suvarna and Somasekhar (1997) studied the ecology of River Vrishabhavathi and reported that nitrates and phosphates are the major components responsible for eutrophication. Abbasi et al. (1996) studied the limnology of Kuttiadi lake, and showed that the lake is tending towards eutrophication. Niroj and Sinha (1998) studied the pollution in the ponds of Orrissa and opined that phosphate as such is not harmful to organisms but it stimulates algal growth causing eutrophication in stagnant water bodies. Sharma and Hussain (1999) while studying the temporal variations in the abiotic factors of a tropical floodplain attributed the lower phosphate content in water to its uptake by the luxuriant growth of aquatic macrophytes. Officer and Ryther (1980) studied the importance of silicon in marine eutrophication and showed progressing eutrophication of waters gradually decreases the content of silicon in relation to phosphorous and nitrogen. From the studies on the silicon cycles in estuaries, Liss (1976) and Aston (1978) observed that removal of silicon in estuaries by flocculation and precipitation depends largely on salinity gradients.

Reynold (1984) studied the ecology of fresh water plankton, and found that the soluble reactive silicon is the only form of silicon available for diatoms
and other phytoplankton. Saad and Abbas (1985) noticed an increase in silicate concentration after rainfall and arrival of flood waters and lower silicate in high saline waters. Anirudhan et al. (1987) also reported loss of silicon in the estuary which comes from high monsoonal input, since a negative correlation exists between salinity and silicon. Habib et al. (1997) studied the seasonal changes in the phytoplankton community structure in relation to physico chemical factors in a fresh water lake, Loch Lomond, Scotland and found that silicate appeared to be more important than nitrate and phosphate as an environmental determinant that influence phytoplankton assemblage.

Munawar (1970) studied the limnology of fresh water ponds of Hyderabad and reported that those waters, rich in particulate organic matter and suspended soil particles are rich in nitrates, though they are not recipients of sewage. Geldermalsen (1985) observed that nitrate showed maximum values in summer and nitrite is produced only in winter. Billen et al. (1985) studied the nitrogen budget of the Scheldt hydrographical basin and he showed that denitrification play an important role in the fluctuations of nitrate in water. Lipschultz et al. (1986) pointed out that nitrification is a rapid irreversible sink for ammonia leading to the formation of nitrite and nitrate.

Rao and George (1959) in Korappuzha estuary and Sreedharan and Sali (1974) in Cochin back waters observed a postmonsoon peak of nitrate and attributed it to the cumulative impact of rainfall. Nair and Abdul Azis (1987) recorded similar results for Ashtamudy estuary. Boltermans and
Admiral (1989) reported low nitrate content and attributed it to the low percentage of oxygen which inhibits biological oxidation of ammonia.

Raina et al. (1984) reported that higher nitrate content in excess of 0.3 ppm known stimulates algal blooms. Reddy and Prasad (1988) studied the seasonal nutrient status of Banjara Lake and didn’t get any clear pattern of diel variations for nitrate, phosphorous and silica. Aravind kumar (1995) studied the periodicity and abundance of plankton in Tropical wetland of Bihar and found that the total plankton density showed a marked and significant correlation with phosphate and nitrate content. In a study on the hydrobiology of Singanallur lake at Coimbatore by Shanthi et al. (2002) a significant variation in various nutrients like sulphate, phosphate and nitrate was recorded.

The role of nutrients on the plankton production has been a subject of intense research by various workers (Goldman, 1960; Lund, 1965; Venkateswarlu and Round, 1984). According to Moesenburg and Vanni (1991) zooplankton affects phytoplankton communities by recycling nutrients. Ecology of algae in Abbot’s pool, Somerset, UK was studied by Venkateswarlu and Round (1994) and reported a positive correlation with nitrate and Bacillariophyceae. Elskens et al. (1997) studied the contribution of nitrate to the uptake of nitrogen by phytoplankton in an ocean margin environment. They reported that the transport of nitrate into the euphotic zone appears to be a major factor regulating the standing stock and production of phytoplankton. During summer the ammonium in water bodies is
preferentially utilized and it can reduce the nitrate uptake rates of phytoplankton by 50%. In a study in Lake Ambegosale, Thane by Pejaver Madhuri (2002) found very high phosphate level and an inverse relationship between phosphate and the growth of Pistia.

The plankton community is a heterogeneous group of tiny plants (Phytoplankton) and animals (Zooplankton) adapted to suspension in sea and fresh waters. This group is an important component without which the system cannot exist. Essentially these groups play a role in at least 2 trophic levels of the food chain–producers and primary or secondary consumers. Phytoplanktons act as the producers and zooplankton act as primary or secondary consumers.

Planktons have an important role in the natural purification of polluted waters. Some micro organisms are responsible for the precipitation of sewage by flocculation. Ciliates ingest the pathogenic bacteria and make the effluent safe. So the prevalence of ciliates is profitable in the process of natural purification. Owing to the role of purification the Cladocerans have been called the living bacterium and detritus filter.

Chacko and Krishnamoorthy (1954) studied the plankton of three fresh water fish ponds in Madras city and could not establish any relation between temperature and occurrence, abundance or dominance of plankton. But Vyas and Kumar (1968) observed the phytoplankton peak when temperature and pH was high. Qasim et al. (1972) stated that the temperature of water is of little direct importance to production in tropical seas. Sitaramaiah (1975) after
studying the temperature, salinity and plankton of Daman Ganga estuary reported low biomass of plankton and associated it with high temperature. Vashist and Sharma (1975) while studying the ecology of an urban pond in Ambala city in Haryana reported that temperature is responsible for plankton production. Bhatt et al. (1984) studied the limnфаuna of river Kosi and found that temperature when compared to other factors has got significant effect on the abundance of biotic population. Similar results were obtained earlier by Holden and Green (1960) and Badola and Singh (1981).

Agarwal et al. (1995) reported that the values of biological factors increase when temperature increases and that the temperature has direct effect on the biology of Sagar Lake. Patil (2002) observed that temperature plays an important role in the seasonal periodicity of planktons. Hutchinson (1944) and McCombie (1953) also observed similar results earlier but contrasting results were obtained earlier by Jana (1973) and Chari (1985). Nasar (1977) reported that the temperature alone cannot be a limiting factor for the growth of zooplankton though it plays an important role either directly or indirectly.

Many workers established a strong relation between salinity and plankton production. (Sitaramaiah, 1967; Qasim et al., 1972; Rao et al., 1975; Rao, 1977; Thresiamma and Nair, 1980; Qasim and Sen Gupta, 1981; Bijoy Nandan et al., 1989 and Bhave and Borse 2001). Sitaramaiah (1967) reported rich amounts of plankton at higher salinity ranges at Mississippi sound. Qasim et al. (1972) found that salinity has a marked influence on the
photosynthesis and growth of plankton in tropical seas. The distribution of zooplankton in Cochin backwaters was studied by Rao et al. (1975) and reported that salinity acts as the major factor controlling the distribution of organisms in backwaters. Rao (1977) and Qasim and Sen Gupta (1981) reported that salinity plays a pivotal role in the plankton distribution and productivity of estuaries. Thresiamma and Nair (1980) also have reported that the lowering of salinity and enrichment of nutrients during south west monsoon directly influence the abundance of phytoplankton in Ashtamudi estuary in Kerala. Bhave and Borse (2001) demonstrated an inverse relationship between salinity and plankton population.


Sath et al. (2000) studied the temporal trends of phytoplanktonic diversity in the river Ganga at Haridwar and reported that the plankton concentration was the highest in the month of Dec–Jan and the lowest in June–July. Godhantaraman (2001) reported the abundance of plankton exhibited a clear seasonal variation i.e. highest in summer and lowest in monsoon. Nandi and Das (2003) noticed a tendency of diminishing overall
population density of zooplankton with increase in salinity in man made brine systems.

Other hydrographic parameters also influence the production of plankton and Davis (1955) established a relation between pH and Rotifer population. Prescott (1969), Singh and Singha (1995) also related pH with plankton production.

Various workers have related plankton with hydrographic parameters (Hillbert et al., 1960; Menzel and Ryther, 1961; Prasad and Nair, 1963; Verma et al., 1977; Wellershhaus, 1971; Prasad and Saxena, 1980; Lair, 1980; Venu and Seshavatharam, 1984; Shastree et al., 1993; Aravind kumar, 1995; Madan Mohan Rao et al., 1996; Habib et al., 1997; Khanna et al., 2000; Choudhary and Singh, 2001; Nanda kumar et al., 2001; Sukumaran, 2001; Halvorsen et al., 2004; Sedamkar and Angadi, 2003). Mc Avoy and Klug (2005) studied the positive and negative effects of riverine input on estuarine green algae and reported a depressed growth in low salinity. He opined that the negative impact of reduced salinity can be outweighed by the positive impacts of high nutrient concentration in aquatic systems. Castro et al. (2005) studied the rotifer community structure in three shallow lakes of Portugal and commented that a peak in abundance and diversity of rotifer was during summertime. Reichwaldt et al. (2005) studied the effects of fluctuating temperature in diel vertical migration of Daphnia and reported that somatic growth was higher at higher temperatures but was lower in the fluctuating temperature. Zhaowen et al. (2005) reported that the total number of plankton species has a
significantly negative correlation with salinity and decreased with increasing altitude while studying the biological and ecological features of saline lakes in northern Tibet, China.

Hillbert et al. (1960) opined that turbidity and percentage light transmission were found to influence plankton production significantly. Similar results were obtained later by Menzel and Ryther (1961), Prasad and Nair (1963) and Venu and Seshavatharam (1984). Habib et al. (1997) also reported that light was directly related to phytoplankton growth. Halvorsen et al. (2004) studied the zooplankton in Lake Antsjoen and could not found any clear correlation between development of plankton and the environmental conditions.

Descy (1976) reported algae to be the most important group among aquatic plants for the assessment of water quality. Other workers like Venkateswarlu and Seshadri (1981), Seshadri (1981) and Venkateswarulu et al. (1994) have also showed that algae can be used as a useful tool in pollution studies. Plankton community around Sanganer has been studied by Chaturvedi et al. (1999) and revealed that certain algal forms like Chlorella and Closterium grew well in polluted waters as well as sewage and designated them as indicators of organic pollution. Malu (2001) studied the phytoplankton diversity in Lonar lake and found that some of them are the bioindicators of water quality. Patrick (1973) opined that algae are pollution indicators and can be used for assessing water quality of rivers. Same results
were observed by Kumaran and Rao (1975); Borse et al. (2003) and Webber et al. (2005).

Aquatic systems all over the world are subjected to plankton studies. Some of the important works are those of Khan and Ejike (1984); Chidobem and Ejike (1985) and Wani (1998). Khan and Ejike (1984) studied the limnology and plankton periodicity of a reservoir in Nigeria and reported the dominance of Bacillariophyceae. Chidobem and Ejike (1985) reported the dominance of Cyanophyceae and Bacillariophyceae. Wani (1998) studied the seasonal dynamics of phytoplankton in a Himalayan lake and reported the maximum abundant phytoplankton group as diatom. Patil (2002) reported that in Ujani wetland, Chlorophyceae was the dominant group and Euglenophyceae was very poorly represented. Das (1978) studied high pollution lake Nainital and opined that the occurrence of Chlorogonium, Stigcocalonium, Scendesmus, Nitzchia, Oscillataria, Anacystics (phytoplankton), Brachionus, Keratella, Polyarthra and Platyias (zooplankton) indicate presence of high organic pollution at the site. Bilgrami (1988) reported that blue green algae, Euglenophyceae some zooplanktons etc. serve as good indicators of stressed aquatic environment, various algal forms will be in higher density at organically polluted sites. Khan and Siddique (1970); Vijayaraghavan (1971); and Sharma and Sahai (1995) revealed that maximum phytoplankton production occurs during day hours and in terms of number, it showed a wide range of fluctuations.
Green (1972) and Venketeswarlu and Round (1994) pointed out that *Brachionus* is the important genus in tropical area. The latter reported that high incidence of *Brachionus* may be due to low oxygen content. But various workers reported Rotifera as abundant species (Radwan, 1976; Arora, 1961, 1966; Pejler, 1974; Zutshi et al., 1980; Subla et al., 1984; Hardy, 1980; Hardy et al., 1984; Nair et al., 1984; Paggi and Joce de Paggi, 1990; Bozelli, 1994; Patil, 2002; Yalavarthi Eswari, 2002; and Sharma, 2005). Patil (2002) attributed the dominance of Rotifera to the feeding of fishes on large crustaceans and to the absence of predator fish fauna.

But Vargheese and Naik (1992) studied the biological characteristics of a polluted tropical pond and reported that copepoda were the dominant group. Akpan and Akpan (1994) reported that cladocera as the more dominant group and rotifera the minimum. Relation between the phytoplankton and zooplankton was also established by various authors (Qasim, 1970; Singh, 1990; Bucka et al., 1993; Baruah et al., 1997; Khan et al., 1998). Vareethiah and Haneefa (1998) opined that phytoplankton biomass is known to control the fishery potential of estuaries very much. But Qasim (1970) stated that the annual turn over of primary production is not grazed by zooplankton and hence sinks to bottom as detritus.

Fishes are the masters of aquatic environment and dominate the trophic pyramid in most lakes, streams, rivers and estuaries. Jhingran (1977) reported that all major estuarine systems are rich in fishery potential. The high quality and abundance of fish in and near estuaries is a result of the food
and protection the estuaries provide for the young. The great mobility of fish enables them to make large spatial movements in response to changes in the distribution of resources such as food, spawning habitat or to escape dangers such as predators, lack of oxygen, or the unsuitable temperatures. Physicochemical factors and richness of plankton determine the distribution and abundance of fishes.

Various workers had contributed to the study on the impact of various aspects of estuaries on fishery resources. (Panicker, 1969; Haridas et al., 1973; Sivankuttynair, 1975; Badola and Singh, 1981; Kuttyamma, 1982; Abdul Azis and Nair, 1987). Brown (1975) reported that a large number of physical and chemical qualities are known to affect the distribution of fishes in fresh water. Verma and Daleela (1975) studied the pollution of Kalinadi by industrial wastes near Mansurpur and reported that the suspended solids inflicted mechanical injuries to the gills leading ultimately to asphyxiation. In a report of FAO, Alabaster and Lloyd (1980) have shown that the high concentration of suspended solids led to increase in turbidity which affect the visibility and reduce the activity of the fishes. Jior and Suxena (1993) related this suspended solids as a factor which reduce the availability of fish food due to blanketing.

Badola and Singh (1981) studied the fish and fisheries of river Alakananda and reported that the pollution of river by flash floods, land slides, soil erosion, over fishing, dynamiting etc may be responsible for the depletion of fish fauna. Similar studies were conducted by various other
workers (distillery waste toxicity by Shaffi, 1981; industrial pollution by Roy and Laha, 1981; heavy metal toxicity by Mukhopadhyay et al., 1994; pesticide pollution by Verma et al., (1979, 1981); Veena Saxena et al., 1997). Shaffi (1981) reported that waste will cause metabolic dysfunctioning. Kumaraguru (1995) reported that pollution may cause morphological changes, teratogenic effects, skin ulcerations and lesions as well as various other diseases in fish and shell fish, and it may interfere with sensory mechanism also.

Sivankutty Nair (1975) studied the rate of growth of backwater clam and reported that the period of rapid growth coincides with the period of high salinity. Kuttyamma (1982) studied the effect of salinity on the growth of some penaid prawns and reported that the growth of both post larvae and juvenile of *Penaeus indicus*, *Metapenaeus dobsoni* and *Metapenaeus monoceros* was affected by variations in salinity to certain extent. Sehgal et al., (1981) have reported that the higher concentration of free carbon dioxide affected the occurrence of fish adversely, in case the dissolved oxygen is low. David (1963) studied the biology of *Pangassius pangassius* and reported that certain fishes breed in freshwater and its young one drifts into tidal stretch of river, and he opined that dams located on the lower and middle reaches of river usually obstruct these fishes and adversely affect its population. Abdul Azis and Nair (1987) studied the status of aquaculture development in Kerala and they opined that massive inland fisheries development programme becomes extremely crucial for exploiting the brackish water fish culture potential of Kerala.
Various workers have studied the diversity of fishes in India. Among them the contribution of Day (1865, 1878) is the most important and significant one. Later Pillay (1929), John (1936), Hora and Nair (1941) and Hora and Law (1941) studied about the fresh water fishes of Kerala. Pillay (1929) have given a detailed list of fishes taken in Travancore from 1901 to 1915. A total of 369 species of 74 families have been reported by him. Mukherji (1931) have conducted a detailed study on the fish fauna of Bhavani River. John (1936) studied the fresh water fish and fisheries of Travancore and has given a list of 73 fresh water fishes along with its local name. Chacko (1948) reported 35 fishes in Periyar Lake and commented that the lake is suitable for development of fisheries. Silas (1951, 1952) has given the details of fishes from the high range of Travancore. The contribution of Rajan (1955) on the fresh water fishes of Bhavani river system is also worth mentioning. He reported 40 species of fishes from Bhavani River.

Ajith kumar and Vijayan (1987) studied the fish fauna of Keoladeo National park, Bharatpur (Rajasthan) and 40 species have been recorded.

Barman (1994) studied the fish fauna of Tripura and recorded 129 which fall in 32 families. Ajith kumar et al. (1995) studied the composition, abundance and distribution of fish in Banganga Gambhir river system and reported 46 species of fishes in the system. Surendranath (1998) have recorded *Clarias batrachus* for first time from Lake Surinsak in Jammu and Kashmir. Arunachalam et al. (2002) studied the fish fauna of streams and rivers of Maharashtra and reported a total of 39 species.
Inasu (1993) studied the sexual dimorphism of fresh water puffer fish and reported that after the record of Hora and Nair (1941) from Pamba River this fish has not been reported till 1993. Raghunathan (1993) studied the fish fauna of Wayanad and 34 species of fishes have been recorded. Shaji et al. (1995) studied the fresh water fish diversity in Aralam wild life sanctuary and recorded a total of 33 species. Easa and Shaji (1995) have given an addition of *Puntius melanampyx* to the fish fauna of silent valley.

Various other workers have also attempted to study the fish fauna of different habitats are reported the number of species (35 species by Zacharias et al. (1996) in Periyar tiger reserve; 83 species by Ajith kumar et al. (1999) in Chalakkudy river system; 40 and 20 species by Biju et al. (1999) in Parambikulam wild life sanctuary and Manjeswaram river respectively; 53 species by Cheriyan et al. (2001) in Trivandrum). Menon and Jacob (1996) has reported a new cyprinoid fish from Thanikkudy (Thekkady). Another cyprinoid fish named *Garra surendranathanii* has been reported from southern Western Ghats by Shaji et al. (1996). Biju et al. (1998) has given an addition of *Glyptothorax lonah* to the ichthyofauna of Kerala. A principal hill stream fish *Barilius bendelisis* has been reported for the first time in Chalakkudy River by Raju Thomas et al. (1998). Raju Thomas et al. (1999) added *Mystus bleekeri* as a new specimen to the fish fauna of Kerala. Raju Thomas et al. (2002) has given a detailed list of fresh water fishes of Kerala with notes on the distribution of endemic and endangered species.
The reports of distribution and abundance of fishes of Vembanad Lake are confined to the studies of Pillay (1960), George (1965), Shetty (1965), Kurup and Samuel (1980a,1980b,1983,1985,1987) Gopi and Radhakrishnan (2001) has reported the presence of *Osteobrama bakeri* and *Labeo dussumieri* from Pamba Manimala region.

Even though various scientists have studied the various aspects of northern region of Kuttanad (Vembanad Lake alone) separately, a complete work on Kuttanad is rare. The major work on this regard was Kuttanad water balance study project conducted by Indo Dutch Mission in 1989. Reghunadh (2002) studied the ichthyofauna and ecohydrology of Kuttanad. As this unique wetland is not confined to the lake alone, this work has been planned to investigate the entire stretch of Kuttanad, covering almost all the agronomic zones of Kuttanad.