CHAPTER V
DIATOM AND ENVIRONMENT

5.1 Introduction

Diatoms occur worldwide in all aquatic habitats. Their short span of time makes them respond rapidly to the environmental changes (Stevenson and Pan 1999) and their taxonomic diversity represents a valuable tool in assessment of water quality, as each taxon has precise responses to the environmental factors. Diatoms are valuable indicators of environmental conditions in lakes, rivers and streams, because they respond directly and sensitively to physical, chemical and biological changes. (Squires et al. 1979, Descy and Mouvet 1984, Pan et al. 1996; Kelly, 1998, Steinman et al. 1987a, McCormick and Stevenson, 1989). This great variability is the result of complex interactions among a variety of habitat conditions that differentially affect physiological performance of diatom species and thereby, diatom assemblage composition. At higher spatial and temporal levels, effects of resources and stressors on diatom assemblages can be constrained by climate, geology and land use (Biggs, 1995; Stevenson, 1997).

Diatoms are widely used to monitor lake and river pollution because they are sensitive to water chemistry, especially ionic content, pH, dissolved organic matter and nutrients. Wide geographic distribution and well studied ecology of most diatom species are cited as major advantages of using diatoms as indicator organisms (McCormick and Cairns, 1994). These assumptions imply that diatom-based water-quality assessment tools should have universal applicability across geographic areas and environments. There is evidence, however, that diatom metrics or indices developed in one geographic area are less successful when applied in other areas (Pipp, 2002). This is due not only to the floristic differences among regions, but also to the environmental differences (Kelly et al. 1998) that modify species responses to water-quality characteristics.

The sensitivity of diatoms to so many habitat conditions can make them highly valuable indicators, particularly the effects of specific factors can be distinguished with the use Diatoms occur in relatively diverse assemblages and most species, especially common species, are relatively easily distinguished when compared to other algae and invertebrates that also have diverse assemblages. This chapter discusses the relationship between diatom and lake environment. As diatoms are very sensitive to changes in environment, their presence or absence and abundance holds the key in understanding the nature of environment at specific sites.

Algae are most commonly occurring organisms in polluted and unpolluted water and therefore generally considered useful to determine the quality of water (Joubert, 1980) and as indicator of water pollution (Joy et al. 1990; Kallqvist, 1984; Sharma and Sharma, 1992; Sudhakar et al. 1994; Dwivedi and Pandey, 2002). Due to eutrophication there is an increase in algal growth and other aquatic plants. Hence algae are also good indicators of the level of pollution and are widely used in classification of water bodies as oligo to eutrophication (Palmer, 1969).

Microscopic algae (diatom) are the primary producers of aquatic life. The growth of algae is primarily depends on the status of nutrient such as phosphates and nitrates. High concentrations of nutrients may produce unnecessary algal growth or blooms. Algal blooms have many harmful effects in freshwaters. Algae are the autotrophic organisms, and are primary productivity in aquatic ecosystems (Ganapati, 1972) and occupy the base level in energy transfer within such natural ecosystems (Prasad and Singh, 1980)

Physical, chemical and biological factors controlling the distribution of biotic community composition often act synergistically e.g. the benthos reflect changing environmental conditions (Barton, 1989). Diatom encountered in the water body reflects the average ecological condition and therefore, they may be used as indicator of water quality (Bhatt et al. 1999; Harikrishnan et al. 1999; Saha et al. 2000).

5.2 Diatom and Environment

Diatoms are autotrophic (an organism capable of synthesizing its own food from inorganic substances, using light or chemical energy) and form the basis of food chains in many aquatic ecosystems. Different species occupy benthic and planktonic niches in ponds, lakes, rivers, salt marshes, lagoons, seas and oceanic waters, while some thrive in the soil, in ice, or attached to trees and rocks.

Each species tends to have a preference for a particular water mass, with distinctive ranges of temperature, salinity, acidity, oxygen and mineral concentrations. Diatoms living at times of high nutrient availability often face an acute shortage of dissolved silica, which they overcome by the production of weakly silicified frustules (Conley et al. 1994; Baron & Baldauf 1995).

Diatom distributions are strongly affected by water conditions. For this reason, diaoms are considered as one of the valuable proxies for the lake water quality and are widely applied appiled in quantitative reconstructions of water environmental indicators.

In this chapter, the comparison of diatom with impartant physico chemical parameters such as pH, Temperature (Degrees Celsius (ºC), Electrical Conductivity (EC) in µS/cm, Biochemical Oxygen Demand (BOD) in mg/l, Chemical Oxygen Demand (COD) in mg/l, Dissolved Oxygen (DO) in mg/l, Phosphorus (PO_4) in mg/l, Chloride (Cl) in mg/l, Sulphate (SO_4) in mg/l and Nitrate (NO_3) for assessing the envirnmental condition of the Yercaud lake are discussed. The following pages discuss the role of environmental factors responsible for change in species composition in Yercaud Lake and their correlation with other areas in India and abroad.

5.3 pH

In the present study the minimum values of pH 5 were recorded in middle of the lake i.e. sample no.M-1 during the 2011 monsoon season and diatom species *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula symmetrica, Nitzschia palea, Synedra ulna* were recorded. The highest pH value 9.67 was recorded in the lake at the Outlet i.e. sample no.O-2 during the 2012 winter season and diatom species such as *Achnanthes minutissima, Cymbella aspera, Melosira granulata, Navicula symmetrica, Navicula confervacea, Nitzschia sigma*, *Synedra ulna* and *Pleurosigma elongatum* were recorded. However, the diatom species viz. *Fragillaria intermediate, Melosira granulata, Navicula symmetrica, Synedra ulna* was found all the samples irrespective of pH values.

5.4 Temperature

In the present study, the temperature was varying in the ranges between 17°C and 31°C. The lower water temperature was recorded in the Lake at the Inlet in sample no.I-15 during the year 2012 monsoon season and diatom species *Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula radiosa* and *Navicula symmetrica* were recorded.

The high temperature was recorded in the Lake at middle in sample no.M-.4 during 2011 summer season and the diatom species *Achnanthes minutissima, Cymbella* *tumida, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula symmetrica, Nitzschia palea, Synedra ulna* and *Pleurosigma elongatum* were recorded.

5.5 Dissolved Oxygen

In the present study, lowest oxygen concentration value 4.61mg/l was recorded at Inlet of the lake i.e. sample no I-9 during 2011 summer and diatom species *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula radiosa, Nitzschia sigma, Nitzschia palea* and *Synedra ulna* were observed.

The maximum oxygen concentration value 13.02mg/l was recorded at Inlet of the lake i.e. sample no. I-6 during the summer and diatom species *Achnanthes minutissima, Achnanthes holsatica, Cyclotella meneghiniana, Cymbella aspera, Navicula symmetrica, Navicula cuspidate, Nitzschia palea* and *Synedra ulna* were observed.

However, the diatom *Cyclotella meneghiniana, Nitzschia palea* and *Synedra ulna* were recorded both high and low oxygen concentrations.

5.6 Chloride

In the present study, the chloride concentration was fluctuating. The minimum concentration value 0.2 mg/l was recorded in the Lake Inlet at sample no I-10 during 2011and diatom species *Achnanthes holsatica, Gomphonema parvulum, Cymbella aspera, Cymbella minuta, Fragillaria intermedia, Navicula radiosa, Navicula symmetrica, Nitzschia palea, Nitzschia sigma* and *Synedra ulna* were found.

Chloride concentration value 360 mg/l was recorded in the Middle of the Lake at Sample no.M-3 during 2013 and diatom species *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Melosira varians, Navicula radiosa, Navicula symmetrica, Nitzschia palea* and *Synedra ulna* were observed.

The diatom species *Gomphonema parvulum, Fragillaria intermedia, Navicula radiosa, Navicula symmetrica, Nitzschia palea* and *Synedra ulna* were recorded both at high and low chloride concentrations.

5.7 Biological Oxygen Demond (BOD)

BOD concentrations were fluctuating throughout the study period. In this study, the maximum BOD value 56.91 mg/l was recorded at the Inlet of the lake i.e. sample no.

I-6 during 2011 and diatom species *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa, Nitzschia sigma* and *Synedra ulna* were observed. A high BOD value occurs due to the discharge of domestic sewage and anthropogenic activity in this site.

The minimum concentration of BOD value 0.46 mg/l was recorded in the Inlet of the Lake at sample no. I-1 during 2011 and diatom species *Achnanthes lanceolata, Achnanthes holsatica, Achnanthes minutissima, Cymbella tumida, Fragillaria intermedia, Navicula symmetrica, Nitzschia palea, Nitzschia sigma* and *Synedra ulna* were observed. The diatom species *Fragillaria intermedia, Synedra ulna* were recorded in at high and low BOD concentrations. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed and die.

5.8 Chemical Oxygen Demand (COD)

In the present study, the maximum COD concentration value 50.14 mg/l was recorded in the Inlet of the lake at sample no. I-6 during 2011 in summer season and the diatom species *Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa, Nitzschia sigma* and *Synedra ulna* were recorded.

The minimum COD concentration value 0.69 mg/l was recorded in the Inlet of Lake at Sample No. I-1during 2011 winter and diatom species *Fragillaria intermedia, Tabellaria floculosa, Navicula salinarum, Nitzschia palea, Nitzschia sigma* and *Synedra ulna* were observed.

The diatom species *Fragillaria intermedia, Nitzschia sigma* and *Synedra ulna* were recorded both at higher and lower COD levels.

5.9 Phosphate

In the present study lowest phosphate concentration value 0.01 mg/l was recorded in the Lake Outlet at sample no O-2 during summer 2011 and diatom species *Achnanthes minutissima, Cyclotella meneghiniana, Cymbella minuta, Fragillaria intermedia,* *Melosira granulata, Navicula radiosa, Navicula symmetrica, Nitzschia sigma* and *Synedra ulna* were observed.

The maximum phosphate concentration value 16 mg/l was recorded at the Outlet O-1 during the 2012 in winter. The observed diatom species during this season were *Cocconeis placentula, Cyclotella meneghiniana, Cymbella tumida, Fragillaria biceps, Gomphonema parvulum, Melosira granulata, Navicula radiosa, Navicula confervacea, Nitzschia palea* and *Synedra ulna.* The common species of diatom at higher and lower phosphate concentration recorded are as follows: *Cyclotella meneghiniana, Melosira granulata, Navicula radiosa and Synedra ulna*.

5.10 Nitrate (NO_3)

In this present study, the minimum Nitrate concentration value 0.04 mg/l was recorded at the Inlet of lake sample no.I-8 during 2012 and diatom species *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Navicula radiosa, Nitzschia palea* and *Synedra ulna* were observed.

The maximum Nitrate concentration value 20 mg/l was recorded at inlet of the lake sample no.I- 8 during 2012 in monsoon and diatom species *Achnanthes minutissima, Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa* and *Synedra ulna* were observed.

The diatom species *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Navicula radiosa* and *Synedra ulna* were found both at high and low Nitrate concentrations.

5.11 Discussion

In the present study the minimum values of pH 5 were recorded in the middle of the lake i.e. sample no.M-1 during the 2011 monsoon season and diatom species *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula symmetrica, Nitzschia palea, Synedra ulna* were recorded.

The highest pH value 9.67 was recorded at the lake Outlet i.e. sample no.O-2 during the 2012 winter season and diatom species such as *Achnanthes minutissima, Cymbella aspera, Melosira granulata, Navicula symmetrica, Navicula confervacea, Nitzschia sigma, Synedra ulna* and *Pleurosigma elongatum* were recorded.

However, the diatom species viz. *Fragillaria intermediate, Melosira granulata, Navicula symmetrica* and *Synedra ulna* were found in all the samples irrespective of pH values.

In the present study minimum values of pH-5 was recorded in the Middle of the Lake sample no. Middle (M-1) during the monsoon in 2011 and the diatom species *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula symmetrica, Nitzschia palea, Synedra ulna* were observed.

The highest pH value 9.67 was recorded at the sample location Outlet O-2 during the 2012 and the diatom species *Achnanthes minutissima, Cymbella aspera, Melosira granulata, Navicula symmetrica, Navicula confervacea, Nitzschia sigma* and *Synedra ulna, Pleurosigma elongatum* were found. The diatom species *Fragillaria intermediate, Melosira granulata, Navicula symmetrica, Synedra ulna* were found both at high and lower pH levels. Similar results were observed by Muduli et. al., 2006 from Brahmani river, Orissa where the pH ranges from 7.2 to 8.2 which was considered favorable for the growth of diatom taxa viz. *Achnanthes minutissima, Cymbella aspera, Melosira granulata, Navicula symmetrica, Navicula confervacea, Nitzschia sigma* and *Synedra ulna, Pleurosigma elongatum*.

In the present study, the water temperature was varying in the ranges between 17°C at and 31°C. The lower water temperature was recorded at Lake Inlet sample no. I-15 during 2012 and diatom communities observed were as follows: *Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula radiosa* and *Navicula symmetrica*.

The high temperature value 31°C was recorded at middle of the lake i.e. at sample no. M-4 during 2012 and the diatom taxa observed were as follows: *Achnanthes minutissima, Cymbella tumida, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula symmetrica, Nitzschia palea, Synedra ulna* and *Pleurosigma elongatum*. Similar observation was recorded form Godavari River, India by Sanap et al. 2006. Saha et al., 1975 observed that diatom such as *Melosira* occurs in lower temperature. Similar results were observed in the present study.

Temperature can affect the biological activity of aquatic organisms algal photosynthesis will increase with temperature. Water temperature plays an important role in influencing the periodicity, occurrence and abundance of diatoms (Tripathi and Pandey, 1995, Nazneen, 1980 and Suchi et al., 2004).

Dissolved oxygen is an important factor for aquatic life. The dissolved oxygen showed variation in different sites completely depending on biological activity and input of oxygen demanding wastes. The dissolved oxygen concentration fluctuated at all the stations and it ranged from 4.6 mg/l to 23 mg/l.

Wong et al., 1979 is described to the solubility of dissolved oxygen level is generally related to seasonal water temperature. In present study the diatom species viz, *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Navicula radiosa, Nitzschia sigma, Nitzschia palea* and *Synedra ulna* were found at low oxygen concentrations.

At the same time, the diatom communities viz. *Achnanthes minutissima, Achnanthes holsatica, Cyclotella meneghiniana, Cymbella aspera, Navicula symmetrica, Nitzschia palea* and *Synedra ulna* were found at high oxygen concentrations. The diatoms species *Cyclotella meneghiniana, Nitzschia palea* and *Synedra ulna* were recorded both at high and low oxygen concentrations.

Ganpati 1962 has reported high amount of dissolved oxygen in the winter season due to the intensive photosynthetic activity. The solubility of oxygen will decrease as temperature increases. This means that colder lakes and streams can hold more dissolved oxygen than warmer waters. If water is too warm, it will not hold enough oxygen for aquatic organisms to survive. The higher concentration of oxygen enhance the growth of *Cocconeis placentula* favored moderate oxygen concentration of the river water (Singh,1960, Steinberg and Schiele, 1988 and Fabri and Leclera, 1984). Karathi and Divadkar 2008 reported low concentration of oxygen seen in water due to discharge of sewage. Kumar, 2002 has reported that the chloride in water influences salinity balance, ion exchange and is contributed by dissolution of salt deposits, sewage discharge, effluents from chemical industries and irrigation drainage to natural waters.

In present study, the chloride concentration was fluctuating in all the samples. The diatom species found at minimum chloride concentration are follows: *Achnanthes* *holsatica, Gomphonema parvulum, Cymbella aspera, Cymbella minuta, Fragillaria intermedia, Navicula radiosa, Navicula symmetrica, Nitzschia palea, Nitzschia sigma* and *Synedra ulna*. At the same time, the diatom species found at high chloride concentrations are: *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulata, Melosira varians, Navicula radiosa, Navicula symmetrica, Nitzschia palea* and *Synedra ulna*. However, the diatoms species viz. *Gomphonema parvulum, Fragillaria intermedia, Navicula radiosa, Navicula symmetrica, Nitzschia palea* and *Synedra ulna* were found at high and low chloride concentrations. The most important source of chloride content in the water is the discharge of domestic and industrial sewage George and Koshy, (2008). Chloride serves as an indication of sewage pollution (Gupta et al. 2006).

Presences of decomposing organic substances cause a BOD rise in proportion to volume of organic materials and oxygen in waste water. The measurement of BOD serves as a good index for sewage pollution. The higher values of BOD observed in water indicate high degree of organic pollution. The BOD concentrations were fluctuating throughout the study period. In present study, the diatom communities viz. *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa, Nitzschia sigma* and *Synedra ulna* at high BOD levels. In present study the diatoms taxa viz. *Achnanthes lanceolata, Achnanthes holsatica, Achnanthes minutissima, Cymbella tumida, Fragillaria intermedia, Navicula symmetrica, Nitzschia palea, Nitzschia sigma* and *Synedra ulna* at low BOD concentrations. The diatom taxa *Fragillaria intermedia* and *Synedra ulna* were found both at high and low BOD concentrations. Raised BOD values may be due to the dead organic matter and stagnant water conditions. Similar results were reported by Chaudhary et al. 2004 and Sanap et al. 2006.

Jamil, 2001 has reported high COD values indicate the presence of oxidizable substances in the water. Kapila et al., 2004 has recorded the diatom communities such as *Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa, Nitzschia sigma* and *Synedra ulna* at high COD and BOD values.

In present study, the diatom taxa such as *Fragillaria intermedia, Tabellaria floculosa, Navicula salinarum, Nitzschia palea, Nitzschia sigma* and *Synedra ulna* were observed at low COD concentrations. At the same time the diatom species *Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate, Navicula radiosa, Nitzschia sigma* and *Synedra ulna* were recorded at high COD concentrations. The species such as *Fragillaria intermedia, Nitzschia sigma* and *Synedra ulna* were recorded both at high and low COD levels. Khan et al. 2005 has reported in the low values of oxygen and high values of BOD and COD reflected high pollution levels due to discharge of sewage wastes.

Generally Phosphate and Nitrate are together referred as nutrients. They are most important for the growth and maintenance of aquatic life in ecosystem. In present study, the diatom communities *Achnanthes minutissima, Cyclotella meneghiniana, Cymbella minuta, Fragillaria intermedia, Melosira granulata, Navicula radiosa, Navicula symmetrica, Nitzschia sigma* and *Synedra ulna* were observed at low phosphorus concentrations. At the same time the diatom communities *Cocconeis placentula, Cyclotella meneghiniana, Cymbella tumida, Gomphonema parvulum, Melosira granulata, Navicula radiosa, Nitzschia palea* and *Synedra ulna* were observed at high phosphate concentrations. However, the species such as *Cyclotella meneghiniana, Melosira granulata, Navicula radiosa and Synedra ulna* were recorded at high and low phosphorus concentrations.

Phosphate plays an important role in algal population and acts as a primary limiting factor. Phosphate and nitrate in natural water may be derived through allochthonous input, through rain water, leaching of soil and weathering of rocks (George and Koshy, 2008). Phosphate is one of the most important factors that control the algal production. Phosphate was found in high concentration, where a many sewage are dumping their domestic wastes. Sewage is considered as the principle source of phosphate and other nutrients. Edmondson, (1972) gave the most detailed data on the study of effect of sewage effluents, on the aquatic habitat. He found that sewage effluents are good source of phosphorus. (Himanshu and Kapila, 1999) observed that over 80 % of phosphorus entered from sewage in Tapi. Majority of phosphorus may be trapped by sediments (Jitts, 1959). Decrease in phosphate content may be due to absorption by plankton community also (Ragothman and Ramaiah, 1986). Very low amount of oxygen, high value of BOD, COD and phosphate were found in Tapi (Kapila et al. 2004). Phosphate is considered as one of the important nutrients which are limiting the growth of Diatom (Welch et al. 1978). In the present study, Diatom exhibited a direct relationship with Phosphate. The significant direct relationship between phosphate and Bacillariophyceae shows higher phosphate concentration which favored their growth (Kumar and Azis, 1999). Zafer, 1964 suggested that discharge of domestic sewage and industrial waste containing nitrogen and phosphorus compounds would ultimately result in increase in nutrient levels.

In present study, the diatom communities *Cocconeis placentula, Cyclotella meneghiniana, Fragillaria intermedia, Gomphonema parvulum, Navicula radiosa, Nitzschia palea* and *Synedra ulna* were observed at low nitrate concentrations. At the same time the diatom communities *Achnanthes minutissima, Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Melosira granulate* and *Navicula radiosa* were observed at high nitrate concentrations. However, the diatom taxa *Cocconeis placentula, Fragillaria intermedia, Gomphonema parvulum, Navicula radiosa* and *Synedra ulna* were found at both high and low nitrate concentrations.

Domestic sewage was important sources of nitrates in the aquatic ecosystem by Saxena, 1987. The minimum nitrate value observed in sites was probably due to the growth of diatom which might have consumed it as reported by Gonzalves and Joshi, 1946 and Singh, 1965. Munawar, 1970 have stressed that the nitrate is the main nutrient controlling periodicity of diatoms. Singh and Swarup, 1979 observed that nitrate and Phosphate are significantly equal for their growth. Ganapati, 1960 observed that tropical unpolluted water showed deficiency of nitrate either due to utilization of nitrate by dense population or due to higher denitrifying activity at elevated temperature. Nitrite is the intermediate stage in nitrification from ammonia and nitrate and denitrification from nitrate to ammonia is highly unstable and generally in traces or even absent in natural waters. Nitrite will be in measurable quantities in waste water domestic sewage and other organic wastes. Diatom productivity depends on the changes in environmental factors such as temperature, meterological, hydrobiological, nutritional and biological characteristics. Pendse et al. 2000 studied phosphate concentration in the water which favors luxurious growth of diatoms population. Similar results of Diatom population were observed by (Sudeep and Hosmani, 2007). (Fogg, 1982) has suggested that nutrient concentration and availability of light are the major parameters which govern diatom primary production.