Chapter - 6

DISCUSSION

6.1 PHYSICO-CHEMICAL VARIABLES

Water resources play a crucial role on earth. Water is essential for human and ecosystem needs and given its non-substitutive nature, use and management of freshwater is vital not only for human welfare but also for environmental conservation; physico-chemical variables of any water body plays an important role in maintaining the fragile ecosystem that maintains various life forms.

6.1.1 Temperature

Atmospheric temperature measured in the lake bund recorded a pattern which was similar for both the years in both the systems. Atmospheric temperature varied from 30 - 37.5 °C with a variation of 7.5 °C for Mugaiyur lake and from 28 - 35.5°C with a variation of 7.5 °C for Tirukoilur lake. Thus atmospheric temperature was on the lower side for Tirukoilur lake when compared to Mugaiyur lake. Nevertheless for both the systems, the atmospheric temperature showed a steadily increasing trend from January to reach the peak in June followed by a decline till December for both the years.

A perusal of literature regarding the period of occurrence of minimal and maximal temperatures in water bodies of south India especially Tamil Nadu reveals that the minimum temperature occurs usually between December and January and the maximum between April and June/July (Malarvizhi, 1989;
Kastooribai, 1991; Jayanthi, 1994; Sivakami et al., 2011; Sankara Rao, 2013; Mugilan, 2014). This is in line with the observations recorded by earlier workers.

A comparison of the surface water temperature of the two systems reveals that it was found to range from 25.5 - 33.5 °C with a variation of 8 °C for the Mugaiyur lake and from 24 - 32 °C with a variation of 8 °C for the Tirukoilur lake. Surface water temperature in both the systems showed the same trend for both the years. It closely followed the pattern of atmospheric temperature showing a steady increase from January to culminate in a peak in followed by a steady decline till November. In general, even though the variation in surface water temperature was the same in both the systems (8 °C). Mugaiyur lake recorded higher levels than Tirukoilur lake.

The bottom water temperatures in both the systems for both the years also showed the same pattern. While the bottom water temperature ranged from 25 - 33.5 °C for Mugaiyur lake, it varied from 23.5 - 31.5 °C in Tirukoilur range. A comparison between the systems reveals that Mugaiyur lake recorded a slightly higher variation (8.5 °C) as well as higher temperature range when compared to Tirukoilur lake. Nevertheless, the bottom water temperatures of both the systems closely followed the pattern of surface water recording the minimal and maximal values at the same periods as that of surface water. However, a close perusal of both the systems reveals that the bottom water temperature was on the lower side when compared to the surface water. A perusal of literature reveals that many workers have found similar observations as reported in the present study.
As to the temperature differences noticed between the two systems, it can be reasonably suggested that the temperature of a water body depends on the time of sample collection, forest cover, weather, climate, season and also the depth of the water body as these characteristics are dynamic and change in individual systems.

Correlating atmospheric, surface and bottom water temperatures indicates a clear positive correlation between them in both the systems. In addition, a comparison between the surface and bottom water temperatures also shows a clear positive correlation (Annexures 1 and 2).

### 6.1.2 Water Level and Transparency

The water level of Mugaiyur lake was found to oscillate from 155 to 585 cm with an overall variation of 430 cm while in Tirukoilur lake it was found to range from 190-480 cm with an overall variation of 290 cm during the period of study. In general, while the minimum level was observed in August, the maximum was recorded in November for Mugaiyur lake while in Tirukoilur lake the minimum was noticed in June, the maximum was observed either in October/November/December. A comparison between the two systems reveals that Mugaiyur lake recorded higher water levels as well as a higher range of variation when compared to the Tirukoilur lake.

Transparency level in Mugaiyur lake was found to vary between 43 - 68 cm with an overall variation of 25 cm while in Tirukoilur lake, it was found to range...
from 25 to 61 cm with an overall variation of 36 cm during the period of study. The minimal level was recorded in July/August, while the maximum in November in Mugaiyur lake while in Tirukoilur lake, the minimum was observed in May and the maximum in October. A comparison between the two systems reveals that Mugaiyur lake recorded higher transparency values but the range was lesser when compared to Tirukoilur lake. A comparison of the transparency values noticed in the present study with other water bodies in Tamil Nadu also appears to be in line with the observations of the present study (Sumithra, 1969: 47-64 cm; Kalavathy, 1980: 53-77 cm; Kastooribai, 1991: 10-68 cm; Jayanthi, 1994: 15-45 cm; Sivakami et al., 2011: 15-30 cm; Shimna, 2012: 15-30 cm).

In the present study, in general, the minimal value was noticed in summer and the maximum during the rainy season in both the systems. The low levels of transparency recorded during summer could be attributed to lower water level due to high rate of evaporation, decaying vegetation and intense planktonic growth while the higher level noticed during rainy season can be directly related to the increased water level and settling of suspended particles. Literature shows that similar observations were also recorded by Jayanthi (1994), Sivakami et al. (2011), Shimna (2012), Sankar Rao (2013) and Mugilan (2014). Further, literature also reveals that there is a direct relationship between dissolved organic matter and transparency. This appeared to be true in the present study also (Annexure 1 to 4).
6.1.3 **Dissolved Oxygen and Free Carbon dioxide**

The surface water dissolved oxygen in Mugaiyur lake ranged from 2.6 to 9.9 mg/l with a variation of 7.3 mg/l. The minimal level was noticed either in May/June while the maximum either in November/December. On the other hand, dissolved oxygen level in Tirukoilur lake was found to vary from 5.7 to 9.9 mg/l with a variation of 4.2 mg/l. While the minimum level was noticed in May, the maximum was observed in October/November. A comparison between the two systems reveals that Tirukoilur lake had higher oxygen levels and a lesser range in oxygen variation when compared to Mugaiyur lake.

The bottom water dissolved oxygen in Mugaiyur lake was found to range between 1.8 and 7.6 mg/l with a variation of 5.8 mg/l during the period of study. While the minimum level was noticed in May, the maximum was recorded either in November or December during the study period. In Tirukoilur lake, the oxygen levels were found to range from 5.3 - 9.5 mg/l with an overall range of 4.2 mg/l with the minimum being recorded in May and the maximum in October for both the years of study. A comparison between the two systems reveals that Tirukoilur lake recorded higher dissolved oxygen levels and lesser variation when compared to Mugaiyur lake. However, the dissolved oxygen levels of bottom water in both the systems followed the same pattern as surface water. Further, in both the systems bottom water recorded lower dissolved oxygen levels when compared to that of surface water. In addition, both the systems in general appeared to show lower levels in summer and higher levels during the rainy season. While the higher amount of dissolved oxygen noticed during the rainy season could be
attributed to the mixing of water in addition to the ability of water to hold more gases at lower temperatures, the low amount noticed in summer could be attributed to enhanced utilization of oxygen by organisms as well as the increased decomposition rates by microbes due to increased temperature. This could also be a reason as to bottom waters recording less oxygen when compared to the surface water. Literature reveals that Hutchinson (1957), Sankar Rao (2013), Shimna (2012) also made similar observations. Further, the difference in the level of oxygen in both the systems can also be attributed to differences in the rate of decomposition as well as the composition of organisms in both the systems.

Free carbon dioxide levels in the surface water of Mugaiyur lake was found to range from 1.3-3.8 mg/l with a variation of 2.5 mg/l, while the minimum was recorded in November, the maximum was recorded in May or June during the period of study. In Tirukoilur lake, free carbondioxide of surface water was found to range from 1.0 to 2.9 mg/l with a variation of 1.9 mg/l, while the minimum level was noticed in October/November, the maximum was noticed in May during the period of study. A comparison between the two systems reveals that Mugaiyur lake recorded higher free CO$_2$ levels as well as higher variation when compared to Tirukoilur lake. Nevertheless, both the systems recorded minimal values during the rainy season and maximum levels during the summer season.

Free CO$_2$ levels in the bottom water of Mugaiyur lake was found to range from 1.8 to 3.9 mg/l with a variation of 2.1 mg/l. The minimal level was noticed in November/December and the maximum in May for both the years. In Tirukoilur lake, bottom water CO$_2$ levels were found to range between 1.3 and 3.2 mg/l with
a variation of 1.9 mg/l, while the minimal level was noticed in October/November, the maximum was noticed in May for both the years. Thus a comparison between the two systems reveals that Mugaiyur lake recorded higher free CO$_2$ levels as well as higher variation when compared to the Tirukoilur lake. Further, both the systems recorded minimum bottom water free CO$_2$ levels during the rainy season and maximum levels during the summer season. In addition, bottom water free CO$_2$ levels were on the higher side when compared to the surface water in both the systems.

As to the varying levels of free carbon-dioxide, it is well known that the concentration of free carbon-dioxide is directly related with the amount and nature of biological activity. Jhingram (1978) suggested that CO$_2$ in natural waters is derived from various sources like respiration, bacterial decomposition in flowing water etc. In addition, photosynthetic activity also includes precipitation of CaCO$_3$ which in turn can bring about a decrease in total CO$_2$ content (Otsuki and Wetzel, 1974).

The higher amount of free CO$_2$ noticed in the bottom waters of both the systems when compared to their surface water can be attributed to higher photosynthetic activity in the surface water due to increased sunlight which would have decreased the level of CO$_2$. In addition, there will be increased rate of decomposition in bottom waters which would have increased the amount of free CO$_2$ in bottom water. The higher amount of free CO$_2$ noticed in Mugaiyur lake may be attributed to increased tropholytic activities releasing CO$_2$ in the bottom when compared to Tirukoilur lake.
The higher levels of free CO$_2$ noticed during the summer season can be attributed to increased organic decomposition due to increased temperature as well as to low precipitation of free CO$_2$ as carbonates. Similar results were also noticed by other workers (Malarvizhi, 1989; Sivakami, 1996; Shimna, 2012).

A perusal of the dissolved oxygen and free CO$_2$ levels in both the surface and bottom waters showed an inverse relationship in both the systems. Thus when DO levels were maximum, free CO$_2$ levels were minimum; correlation between the two clearly indicates an inverse relationship (Annexures 1 to 4). Literature reveals that similar observations were also made by earlier workers (Kastooribai, 1991; Valli, 1997; Sivakami, 1996).

6.1.4 pH

The surface water pH levels in Mugaiyur lake was found to range from 7.3 to 8.1 with a variation of 0.8 units. The minimum level was noticed in October and the maximum in May for both the years. In Tirukoilur lake, surface water pH was found to oscillate between 7.5 and 9.1 with a variation of 1.6 units; while the minimum level was recorded in October, the maximum was noticed in May for both the years. A comparison between the two systems reveals that Tirukoilur lake had a high pH range as well as variation when compared to Mugaiyur lake. Nevertheless, both the systems recorded minimum levels in rainy season and maximum levels in summer season.

Bottom water pH levels in Mugaiyur lake was found to range from 7.3 to 8.4 with a variation of 1.1 units with the minimum being recorded in the month of October and the maximum in March during the period of study. In Tirukoilur lake,
bottom water pH varied from 7.5 to 9.2 with a variation of 1.7 units; while the minimum was noticed in October/November, the maximum was recorded in May during the period of study. A comparison between the two systems reveals that Tirukoilur lake recorded a higher pH level as well as a higher range of variation. Nevertheless, in general, the minimum pH level was noticed during the rainy season and the maximum during the summer season. Further, the bottom water also followed the same trend as the surface water even though the levels were on the higher side when compared to surface water.

In the present study, the maximum pH levels noticed in surface and bottom waters during the summer season can be attributed to enhanced photosynthetic activity which would have resulted in increased CO$_2$ production shifting the equilibrium towards the alkaline side. Similar observations were also made by Ahangar et al. (2012), Sankar Rao (2013) and Mugilan (2014). The low pH levels noticed during the summer season could be due to the result of dilution of water (Verma et al., 2011).

As to the differences in pH noticed between the two systems, Jhingran (1982) opines that the pH concentration of natural water is an important factor, the variation of which is linked with the life processes and species inhabiting the water bodies, in addition to nature of soil.

According to Saxena (2012) a pH between 6 and 8.5 indicates medium production while a pH of > 8.5 indicates high productivity. Based on this classification, Mugaiyur lake can be classified as a ‘medium production’ water body while Tirukoilur lake as a ‘high production’ water body.
6.1.5 Alkalinity

The methyl orange alkalinity (MOA) in the surface water of Mugaiiyur lake was found to be between 180 and 298 mg/l with a variation of 118 mg/l. Tirukoilur lake surface water MOA was found to range between 164 and 286 mg/l with a variation of 122 mg/l. While the minimum MOA was noticed in March (Mugaiiyur lake)/May (Tirukoilur lake), the maximum was recorded in October for both the systems. A comparison between both the systems reveals that Mugaiiyur lake recorded higher MOA levels and lesser variation when compared to Tirukoilur lake.

The bottom water MOA levels in Mugaiiyur lake was found to range between 200 and 298 mg/l with a variation of 98 mg/l while in Tirukoilur lake, the level ranged from 182 - 290 mg/l with a variation of 108 mg/l. The bottom water MOA followed the same pattern as the surface water recording the minimal and maximal levels at the same time as surface water. Nevertheless, bottom water MOA levels were on the higher side when compared to surface water in both the systems. However, between the two systems, Mugaiiyur lake recorded higher bottom water MOA levels and lesser variation when compared to Tirukoilur lake. Nevertheless, both the systems recorded minimal levels during the summer season and maximum levels during the rainy season.

Phenolphthalein alkalinity was absent in the surface and bottom waters of both the systems during the entire period of study. This is due to the presence of CO$_2$ which was recorded throughout the period of study.
Chapter VI

Discussion

Seasonal Periodicity of Bacterial and Algal Diversity in Two Tropical Lakes

Literature reveals that the total alkalinity of water is caused by the cations of Ca, Mg, Na, K, NH$_4$ and Fe which may be present in the form of carbonate, bicarbonate or as hydroxides (Jhingran, 1982; Kastooribai, 1991; Valli, 1997; Indirabai and George, 2002). As to the differences in the alkalinity between the two systems, literature also reveals that natural bodies of water in the tropics usually show a wide range of fluctuations depending on season and location in addition to the nature of bottom deposits as well as the plankton population.

6.1.6 Electrical Conductivity

The electrical conductivity in the surface water of Mugaiyur lake was found to range from 120 - 385 $\mu$mhos/cm with a variation of 265 $\mu$mhos/cm while for Tirukoilur lake it was found to range from 104 - 320 $\mu$mhos/cm with an overall range of 216 $\mu$mhos/cm. Comparing the two systems reveals that Mugaiyur lake recorded higher levels as well as higher variation when compared to Tirukoilur lake. Nevertheless, both the systems uniformly recorded the minimum levels in May and the maximum either in October (Mugaiyur lake) / November (Tirukoilur lake).

The bottom water electrical conductivity of Mugaiyur lake was found to vary from 155 to 410 $\mu$mhos/cm with a variation of 255 $\mu$mhos/cm and for Tirukoilur lake from 98 - 302 $\mu$mhos/cm with a variation of 204 $\mu$mhos/cm. Here also Mugaiyur lake recorded higher levels as well as higher variation when compared to Tirukoilur lake. Even though bottom water electrical conductivity followed the same pattern of surface water by recording the minima and maxima
at the same months, their levels were however higher when compared to the surface water.

In the present study, the fluctuations of electrical conductivity in both the surface and bottom waters in both the systems could be due to the variation in the rate of decomposition, differences in the level of water as well as the movement of nutrients both from within as well as outside the system. Rawson (1966) classified lakes with more than 200 $\mu$hmhos/cm as eutrophic. Based on this criterion, both the systems under study could be classified as eutrophic as the maximum levels recorded in both the systems exceeded 200 $\mu$hmhos/cm.

### 6.1.7 Total Dissolved Solids (TDS)

TDS in the surface water of Mugaiyur lake varied from 358 - 610 mg/l with a variation of 252 mg/l with the minimum being recorded in the month of January and the maximum in October. However, in Tirukoilur lake, the TDS was found to range from 331 - 587 mg/l with a variation of 256 mg/l with the minimum level being recorded in May and the maximum in November. Thus, among the two systems, Mugaiyur lake recorded higher levels even though the variation was almost similar to both the systems.

The bottom water TDS in Mugaiyur lake was found to range from 310 - 710 mg/l with a variation of 400 mg/l; while the minimum was recorded in January, the maximum was noticed in November. In Tirukoilur lake, the bottom water TDS was found to range from 295 - 580 mg/l with a variation of 285 mg/l. While the minimum was noticed in May, the maximum was recorded in
November during the period of study. A comparison between the two systems
reveals that Mugaiyur lake recorded higher TDS levels as well as higher variation
than the Tirukoilur lake. Further, the bottom water TDS levels in both the systems
were higher than the surface water.

As to the differences in the TDS noticed between the two lakes, Jhingran
(1978) reported that the level of TDS depends on location, geological history of
the basin, drainage, rainfall and bottom deposits, while Santharam (1979)
suggested that TDS is related to the age of lakes as well as to autochthonous
inputs.

In the present study, there was a positive correlation between EC and TDS
suggesting that EC is directly proportional to the amount of TDS (Annexures 1-4).

6.1.8 Nutrients

6.1.8.1 Phosphate

The surface water PO$_4$-P level in the Mugaiyur lake ranged from 0.53 to
0.95 mg/l with a variation of 0.42 mg/l. In Tirukoilur lake, the surface water
PO$_4$-P varied from 0.52 to 0.79 mg/l with a variation of 0.27 mg/l. Thus, Muga-
aiyur lake recorded higher surface water PO$_4$-P level when compared to
Tirukoilur lake. Nevertheless, both the systems recorded minimum level during
the summer and maximum levels during the rainy season.

The bottom water PO$_4$-P level in the Mugaiyur lake varied from 1.15 to
1.55 mg/l with a variation of 0.40 mg/l and for the Tirukoilur lake from 0.50 to
0.78 mg/l with a variation of 0.28 mg/l. Thus Mugaiyur lake recorded higher
PO$_4$-P levels and variation when compared to Tirukoilur lake. Both the systems
however recorded minimal levels in summer and maximal levels in rainy season. Further, the bottom water PO$_4$-P levels in both the systems were higher than the surface water. In the present study, the maximal values recorded in the surface and bottom water during rainy season is due to the surface waster bringing in large amount of nutrients during the rains while the minimal values recorded during summer season can be due to their utilization by the phytoplankton. Similar observations were noticed by many workers (Ganapati, 1973; Kannan, 1978; Ganesan and Sultan, 2009; Sivakami et al., 2011; Shimna, 2012; Sankar Rao, 2013). Saxena (2012) suggested that phosphorous is the most significant component among the nutrients responsible for eutrophication in a water body with high concentrations indicating the presence of pollution which is largely responsible for eutrophic conditions. In the present study, phosphate showed a significant relationship with turbidity, electrical conductivity, TDS and nitrate while a negative relationship was noticed with water temperature, transparency and pH thus showing their inter-relationship (Annexures 1 to 4).

6.1.8.2 Silicate

The surface water silicate level in Mugaiyur lake varied between 1.50 and 4.90 mg/l with a variation of 3.40 mg/l; while the minimum level was recorded in August, the maximum was noticed in December. In Tirukoilur lake, the surface water silicate level was found to range from 4.5 to 7.1 mg/l with a variation of 2.6 mg/l; while the minimum was recorded in July, the maximum was noticed in November. Thus, Tirukoilur lake recorded higher silicate levels and lesser variation than Mugaiyur lake.
The bottom water silicate level in Mugaiyur lake ranged from 2.9 to 5.3 mg/l with a variation of 2.4 mg/l with the minimum being recorded in August and the maximum in November. On the other hand, bottom water silicate level in Tirukoilur lake varied from 4.2 to 7.4 mg/l with a range of 3.2 mg/l; while the minimum was noticed in July, the maximum was recorded in November. Thus, Tirukoilur lake recorded higher levels and variation when compared to Mugaiyur lake. Further, the bottom water usually recorded higher levels than the surface water in both the systems.

In the present study, the maximum silicate levels noticed in both the surface and bottom waters of both the systems during November is due to the runoff water entering the system due to rains which would have brought large amount of nutrients. Many workers have also recorded the increased effect of rainfall on the silicate content (Kastooribai, 1991; Malarvizhi, 1989; Sreenivasan, 1965). On the other hand, the low levels of nutrients noticed in both the surface and bottom waters of both the systems is due to its utilization by phytoplankters especially the diatoms and also in part to the evaporation of water leading to enhanced concentration of nutrients.

In the present study, a direct correlation was obtained between silica and diatoms as also between temperature and silica. However, a negative relationship was recorded with pH. Weizel (1983), however, opines that silica cycle of most lakes are regulated largely by autochthonous metabolism and losses are balanced by allochthonous inputs.
6.1.8.3 Ammonia, Nitrite and Nitrate Nitrogen

The surface water ammonia levels in Mugaiyur lake was found to range from 0.24 - 0.56 mg/l with a variation of 0.32 mg/l, while in Tirukoilur lake, the levels ranged from 0.11 - 0.31 mg/l with a variation of 0.20 mg/l. Thus, Mugaiyur lake recorded higher levels as well as higher variation of ammonia when compared to Tirukoilur lake. Nevertheless, in both the systems, the minimal levels were uniformly recorded in October and the maximum in May.

The bottom water ammonia levels in Mugaiyur lake was found to range from 0.25 to 0.57 mg/l with a variation of 0.32 mg/l while for Tirukoilur lake from 0.14 to 0.34 mg/l with a variation of 0.20 mg/l. Here also, Mugaiyur lake recorded higher levels and variation in ammonia levels when compared to Tirukoilur lake. However, like the surface water both the systems recorded their minimal and maximal levels in October and May respectively even though Mugaiyur lake recorded minimal levels in November also. However, the bottom water of both the systems uniformly recorded higher levels than the surface water.

The highest levels recorded in the present study during the summer season can be attributed to increased decomposition of organic matter resulting in enhanced release of ammonia. Similar observations were also made earlier by Trussel (1972), Emerson et al. (1975) and Sivakami (1996). The minimal levels noticed during the rainy season may be due to the dilution of water as a result of increased water level.

As to the differences in the level of ammonia noticed between the lakes Goldman and Horne (1983) reported that the actual amount of ammonia present at
any time will depend on the balance between animal excreting rates, plant uptake and bacterial oxidation. Emerson et al. (1975), nevertheless, suggests that the proportions of increase and decrease of ammonia levels in water are dependent on the dissociation dynamics which are governed by pH and temperature. Thus a correlation between temperature, pH and ammonia reveals a positive correlation reflecting their relationship (Annexures 1 to 4).

The surface water nitrate content of Mugaiyur lake was found to vary from 0.8 to 2.0 mg/l with a variation of 1.2 mg/l while in Tirukoilur lake it was found to range between 0.42 and 0.76 with a variation of 0.34 mg/l. Thus, among the two systems, Tirukoilur lake recorded higher levels even though the variation was higher in Mugaiyur lake. Nevertheless, both the systems recorded their minimal levels in May and the maximum in November.

The bottom water nitrate level of Mugaiyur lake oscillated between 0.9 and 2.3 mg/l with a variation of 1.4 mg/l while for Tirukoilur lake, the level was found to vary from 0.50 to 0.78 with a variation of 0.28 mg/l. Thus, Mugaiyur lake recorded higher levels as well as variations when compared to Tirukoilur lake. Further, the bottom water levels were on the higher side of when compared to the surface water in both the systems. However, both the systems recorded minimal and maximal levels at the same period as that of the surface water.

The maximum nitrate levels noticed in November in both the systems could again be attributed to increased runoff water entering the lake bringing in large amount of nutrients while the minimum levels noticed in May is due to their
utilization. Similar observations were also reported by Rajalakshmi (1980), Malarvizhi (1989) and Shimna (2012).

The nitrite levels in the surface water of Mugaiyur lake was found to vary from 0.09 - 0.28 mg/l with a variation of 0.19 mg/l while for Tirukoilur lake from 0.06 to 0.13 mg/l with a variation of 0.07 mg/l. Thus, Tirukoilur lake recorded higher levels as well as variation when compared to Mugaiyur lake. However, both the systems recorded the minimal levels (November) and maximal levels (May) at the same time.

The nitrite levels of bottom water of Mugaiyur lake was found to range from 0.13 to 0.36 mg/l with a variation of 0.23 mg/l while for Tirukoilur lake from 0.06 to 0.16 mg/l with a variation of 0.10 mg/l. Thus, Mugaiyur lake recorded higher levels as well as variation when compared to Tirukoilur lake. Further, the bottom water of both the systems recorded higher levels than the surface water. The bottom water followed the same pattern as surface water recording minimal and maximal levels at the same time as surface water.

While the minimal levels noticed in both the systems during the rainy season may be due to dilution of nitrite levels as a result of increased water level, the maximum levels noticed during May may be due to the high rate of evaporation leading to decreased water level leading to increased concentration of nitrite. Nitrite is an intermediate product between nitrate and ammonia. In the present study, both the system recorded a positive correlation with nitrate and nitrite and also between nitrite and pH. This agrees with the observation of Russo (1985) who suggested that if the pH of the medium is increased, the concentration
of ammonia will increase which will impede the conversion of nitrite to nitrate resulting in the increase of nitrite levels.

### 6.1.8.4 Sulphate

The surface water sulphate levels in Mugaiyur lake was found to vary from 2.7 to 5.0 mg/l with a variation of 2.3 mg/l with the minimum being recorded in November and the maximum in July for both the years. On the other hand, sulphate level in the surface water of Tirukoilur lake was found to range from 1.9 to 3.2 mg/l with a variation of 1.3 mg/l; while the minimum was observed in November, the maximum was noticed in May. A comparison between the two systems reveals that Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake.

The bottom water sulphate level of Mugaiyur lake ranged from 2.8 to 5.7 mg/l with a variation of 2.8 mg/l while for Tirukoilur lake, sulphate level was found to vary from 2.1 to 3.6 mg/l with a variation of 1.5 mg/l. Thus Mugaiyur lake recorded higher levels and variation when compared to the Tirukoilur lake. Further, the bottom water sulphate levels were higher than the surface water in both the systems. In addition, the bottom water of both the systems appeared to follow the trend as that of the surface water by recording the minimal and maximal levels at the same time as the surface water.

With regard to the fluctuations in the sulphate level in both the systems, Wetzel (1983) observed that agricultural application of sulphate containing fertilizers are of very great importance in recent times. It is also well known that rains can enhance the mixing or circulation of water leading to oxidation of $\text{H}_2\text{S}$ to
sulphates (Hem and Skougstad, 1960; Wetzel, 1983). In the present study, the minimum levels noticed in November in both the systems can be attributed to the utilization of organisms in addition to dilution of sulphates as a result of increased water levels while the maximum recorded in July in Mugaiyur lake may be due to increased runoff water entering the system while the maximum level noticed in May in Tirukoilur lake may be due to decreased water level leading to increased concentration of sulphate.

6.1.8.5 Calcium and Magnesium

The surface water calcium levels in Mugaiyur lake was found to range from 123 to 248 mg/l with a variation of 125 mg/l while the magnesium levels were found to range from 25.5 to 53.2 with a variation of 27.7 mg/l. The minimal Ca and Mg levels were noticed in November and the maximum levels in July (Ca) and in May (Mg) respectively.

In Tirukoilur lake, the surface water Ca level was found to range from 38.6 to 64.2 with a variation of 25.8 mg/l, while the Mg level from 17.6 to 42.4 with a variation of 24.8 mg/l. Here also, the minimal Ca and Mg levels were noticed in November while the maximum in May. Comparing the surface water Ca and Mg levels of both the systems reveals that Mugaiyur lake recorded higher amounts of both Ca and Mg when compared to Tirukoilur lake.

The bottom water Ca and Mg levels in Mugaiyur lake reveals that it varied from 153 to 288 mg/l with a variation of 135 mg/l for Ca and from 34.2 to 56 mg/l with a variation of 21.8 mg/l for Mg. Here also, the minimal Ca and Mg levels was noticed in November while the maximum in July (Ca) / May (Mg). In
Tirukoilur lake, the bottom water Ca level was found to range from 38.8 (November) to 65.6 mg/l (May) with a variation of 26.8 mg/l and the Mg level from 22.8 (November) to 44.2 mg/l (May). Thus the minimal Ca and Mg levels were noticed in November while the maximum in May. Further, the Ca and Mg levels in the bottom waters of both the systems were higher when compared to the surface water.

Comparing the Ca and Mg levels in both the systems reveals that Ca levels were always on the higher side than Mg. Further, both the nutrients recorded minimal levels in November and maximal levels generally in May in both surface and bottom waters even though exceptionally bottom water Ca levels also recorded the maximum in July. While the minimal levels noticed in November could be attributed to increase utilization and also to dilution of nutrients as a result of increased water level due to rains, the maximal levels noticed in May could be due to decreased water levels leading to increase in concentration of nutrients in addition to their utilization. Wetzel (1983) also noted that increased planktonic population would lead to decreased CO$_2$ content which in turn would lead to formation of calcium bicarbonate thus increasing the calcium content. In the present study, there was a positive correlation between Ca and total phytoplanktonic count (Annexures 7 and 8) thus strengthening the above statement.

Ohle (1934) reported that the biota of lakes were poor if Ca < 26 mg/l, good when between 25 and 62.5 mg/l and very good when > 62.5 mg/l. Based on this classification, both the lakes can be considered very well in terms of biota.
6.1.8.6 Chloride

The chloride level in the surface water of Mugaiyur lake was found to range from 97.5 to 266.9 mg/l with a variation of 169.4 mg/l and for Tirukoilur lake from 62.7 to 179.3 mg/l with a variation of 116.6 mg/l. Thus, Mugaiyur lake recorded higher chloride levels as well as variation when compared to Tirukoilur lake. Nevertheless, both the systems recorded minimal levels in November and maximum levels in May.

Bottom water chloride levels in Mugaiyur lake varied from 101.6 to 274.9 mg/l with a variation of 173.3 mg/l and for Tirukoilur lake from 90.7 to 214.5 mg/l with a variation of 123.8 mg/l. Here also, Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake. Nevertheless, both the systems recorded minimal and maximal levels during the same period as the surface water even though the bottom waters recorded higher levels.

The minimum level noticed in November could be attributed to the dilution of nutrient as a result of rains leading to the increased water level and also due its utilization while the maximal levels noticed in May may be due to decreased water level leading to increased concentration. Gonzalves and Joshi (1946), Prasad et al. (1985) and Sivakami (1996) have also reported increased concentration of Cl during the summer season.

George et al. (1980) suggested that higher level of chlorides is an indication of pollution. Based on this, Mugaiyur lake appears to be more polluted than Tirukoilur lake.
6.1.9 Biological Oxygen Demand and Chemical Oxygen Demand

Biological Oxygen Demand (BOD) level in the surface water of Mugaiyur lake varied from 65.4 to 112.9 with a variation of 47.5 mg/l while in the Tirukoilur lake, BOD in surface water ranged from 12.8 to 33.2 mg/l with a variation of 20.4 mg/l. Thus, Mugaiyur lake recorded higher levels as well as variation than the Tirukoilur lake. Nevertheless, both the systems recorded minimal levels in May and maximal levels in November.

BOD in the bottom water of Mugaiyur lake varied from 69.7 to 113.4 mg/l with a variation of 43.7 mg/l while in Tirukoilur lake it varied from 15.2 to 35 mg/l with a variation of 19.8 mg/l. Between the two systems, Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake. Further, bottom water BOD levels were higher than the surface water even though the bottom water recorded the minimal and maximal levels at the same time as that of the surface water.

Chemical Oxygen Demand (COD) levels in the surface water of Mugaiyur lake was found to range from 88.4 to 257.4 mg/l with a variation of 169 mg/l while the Tirukoilur lake surface water COD varied from 32.6 to 71.8 with a variation of 39.2 mg/l. Thus, Mugaiyur lake recorded higher levels of COD and variation when compared to Tirukoilur lake. However, both the systems recorded minimal levels in May and maximum levels in November.

Bottom water COD levels in Mugaiyur lake was found to range from 91.0 to 272.6 mg/l with a variation of 181.6 mg/l while COD in the bottom waters of Tirukoilur lake varied from 34.4 to 74.6 mg/l with a variation of 40.2 mg/l. Thus
Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake. Even though the bottom water of both the systems recorded higher COD levels than the surface water, the bottom water recorded minimal and maximal values at the same time as that of the surface water.

The higher levels of BOD noticed in both the systems during the rainy season is due to the utilization of the microbes as a result of increased concentration of nutrients in general. The minimal levels noticed in May may be due to increased microbial decomposition leading to decreased oxygen levels in addition to increase respiratory activity of organisms. Similar observations were also made by Shimna (2012), Sankar Rao (2013) and Mugilan (2014).

The differences in COD variation is due to the changes in organic matter, dissolved oxygen content, nutrient environment, salinity and sulphate content. According to many workers (Sarma et al., 1988; Prabhakar et al., 2012; Sivakami et al., 2011) in conjunction with BOD, COD is helpful in indicating toxic condition and presence of biologically resistant organic substances. In the present study, COD showed a positive correlation with nutrient enrichment, high salinity and SO$_4$ (Annexures 1 to 6).

### 6.1.10 Oxidizable Organic Matter and Nitrogenous Organic Matter

The surface water Oxidizable Organic Matter (OOM) of Mugaiyur lake ranged from 16 to 24.6 mg/l with a variation of 8.6 mg/l while for Tirucoilur lake from 7.2 to 9.8 mg/l with a variation of 2.6 mg/l. Thus Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake. Nevertheless, both
the systems recorded their minimal levels in summer (May/June) and the maximum levels in rainy season (November).

The bottom water OOM of Mugaiyur lake ranged from 17.0 to 25.9 mg/l with a variation of 8.9 mg/l while in Tirukoilur lake, it varied from 7.4 to 10.0 mg/l with a variation of 2.6 mg/l. Here also, Mugaiyur lake recorded higher OOM levels as well as variation when compared to Tirukoilur lake. However, both the systems recorded minimal levels during the summer season and maximum levels during the rainy season thus following the same pattern of their surface water.

The surface water Nitrogenous Organic Matter (NOM) in Mugaiyur lake was found to range from 7.6 to 12.3 mg/l with a variation of 4.7 mg/l while in Tirukoilur lake it ranged from 6.8 to 9.6 mg/l with a variation of 2.8 mg/l. Thus Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake even though both the systems recorded minimal levels in summer (May/June) and maximum levels in rainy season (November).

The bottom water NOM level of Mugaiyur lake was found to range from 7.8 to 14.8 mg/l with a variation of 7 mg/l while for Tirukoilur lake it varied from 7.1 to 9.9 with a range of 2.8 mg/l. Thus here also, Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake. Further, the bottom waters of both the systems recorded higher levels when compared to their surface waters. Nevertheless, bottom waters of both the systems recorded their minimal and maximal levels at the same time as their surface waters. Thus, among the two systems, Mugaiyur lake recorded higher levels of OOM and NOM. According to Sreenivasan (1969) high concentration of organic nitrogen can result in
eutrophication while Anon (1969) suggested that water blooms which are persistent for more than an year is due to high organic matter present in a system. This would explain why algal blooms were more persistent in Mugaiyur lake. Correlation between these two factors, as expected, revealed a positive correlation (Annexures 5 to 8).

6.1.11 Suspended Solids

Suspended solids in the surface water of Mugaiyur lake was found to range from 414 to 774 mg/l with a variation of 460 mg/l while in Tirukoilur lake from 70.2 to 123.6 mg/l with a variation of 53.4 mg/l. Thus Mugaiyur lake had a higher amount of suspended solids when compared to Tirukoilur lake. Nevertheless, both the systems recorded their minimal levels in summer (May/June) and maximum in rainy season (November).

Suspended solids in the bottom water of Mugaiyur lake was found to range from 424 to 884 mg/l with a variation of 460 mg/l while in Tirukoilur lake from 71.4 to 129.4 mg/l with a variation of 56 mg/l. Here also, Mugaiyur lake recorded higher levels and variation when compared to Tirukoilur lake even though both the systems recorded their minimal and maximal values at the same time. Further, the bottom waters of both the systems recorded higher levels when compared to their surface waters.

In the present study, the maximum amount of suspended solids noticed during the rainy season can be due to the entry of surface water bringing along with it copious amounts of silt, colloids and other substances thus increasing the amount of suspended solids in the system. The low level of suspended solids
noticed during the summer season is probably due to the settling down of particles leading to less turbulence of water.

6.2 FLUCTUATIONS OF MICROBIOLOGICAL VARIABLES

6.2.1 Bacterial Abundance and Diversity

6.2.1.1 Total Bacterial Density (TBD)

The TBD in the surface water of Mugaiyur lake ranged from 6.2 to $14.4 \times 10^7$ cfu/l and for the Tirukoilur lake from 5.4 to $8.6 \times 10^6$ cfu/l. For the bottom water, Mugaiyur lake recorded levels ranging from 6.4 to $14.8 \times 10^7$ cfu/l and for the Tirukoilur lake from 6.0 to $8.8 \times 10^7$ cfu/l. The bottom water TBD of both systems followed the same pattern as that of surface water recording minimum levels in January and maximum in November. However, a comparison of TBD levels reveals that bottom water recorded higher levels than surface water in both the systems. Similar observations were also noticed by Shimna (2012), Sankar Rao (2013) and Mugilan (2014). The maximum TBD noticed during November in present study is due to the rains resulting in the mixing of waters along with run-off water entering the systems bringing nutrients for enabling the growth of the organisms while the minimal values noticed in January may be due to the lower water temperature which is unsuitable for the growth of bacteria. Similar observations were also recorded by Shimna (2012), Sankarrao (2013) and Mugilan (2014). A perusal of the concentrations of OOM, NH$_3$-N, NO$_3$-N and PO$_4$ levels in the waters of both the systems reveals a higher concentration during the rainy season which could also be a reason for the highest TBC shown during this season. In the present study, correlation between TBC and oxidizable organic
matter, suspended solids and ammonia showed a positive relationship indicating their effect on bacteria (Annexures 5 & 6).

The differences in bacterial count noticed during the different seasons of the year can also be attributed to the differences in temperature and suspended solid levels as suggested by many workers (Seki, 1972; Fukami et al., 1983; Sivakami et al., 2011, 2012) in addition to oxidizable organic matter and nutrients (Sivakami et al., 2012; Sankarrao, 2013).

A comparison of the nutrient levels in different seasons also reveal that the TBC was high when the nutrient levels were also high. Correlation between TBC and nutrients like phosphates, nitrates and sulphates also revealed positive correlation in both the systems (Annexures 1 to 10). However, Jones (1971), suggested that temperature, pH and oxygen are the main limiting factors controlling the vertical bacterial population.

A comparison of TBC among the two systems reveals that Mugaiyur lake recorded higher levels than Tirukoilur lake. This is probably due to higher amount of suspended solids, oxidizable organic matter as well as nutrients in this system.

6.2.1.2 Total Coliform Count (TCC)

TCC in the surface water of Mugaiyur lake was found to range from 165 to 1635 per 100 ml and from 315 to 521 per 100 ml in the Tirukoilur lake. The bottom water TCC levels in Mugaiyur lake ranged from 205 to 1685 per 100 ml and from 330 to 585 per 100 ml in Tirukoilur lake. Both the surface and bottom waters in both the systems followed the same pattern by recording minimal levels in January and the maximum in November.
In the present study, the maximum TCC that was recorded in November in both systems can again be due to entry of water into the system due to rains resulting in surface run-off entering the systems resulting in suspended solids, OOM and nutrients. Correlating TCC with suspended solids, OOM and nutrients like NO$_3$, NH$_3$, SO$_4$ and PO$_4$ reveals a positive correlation in both the systems (Annexures 4-6). The higher TCC levels noticed in the bottom waters when compared to surface waters can again be attributed to increased amount of SS, OOM and nutrients in the bottom water when compared to the surface water.

Among the two systems, Mugaiyur lake recorded a higher level when compared to that of the Tirukoilur lake which may be due to higher amount of suspended solids, temperature, OOM and nutrients like PO$_4$, NO$_3$ and NH$_3$. Literature reveals that similar findings were also suggested by Kumar and Shaka (2009), Petter et al. (2012), Shimna (2012), Sankar Rao (2013) and Mugilan (2014).

6.2.1.3 Faecal *Streptococci* (FS)

Faecal *Streptococci* in the surface water of Mugaiyur lake was found to range from 82 to 482 per 100 ml and from 102 to 252 per 100 ml in the Tirukoilur lake. The bottom water Faecal *Streptococci* count in Mugaiyur lake was found to range from 92 to 562 per 100 ml and from 132 to 257 per 100 ml in Tirukoilur lake. The bottom water Faecal *Streptococci* count followed the same pattern of surface waters in both the systems recording minimum level in January and maximum in November.
Vasconcelos and Swartz (1976) reported that viability of faecal and coliform bacteria is inversely proportional to temperature, since high temperature enhances the growth of such bacteria in water. In the present study also both the systems recorded the maximum counts during rainy season (November) when temperature was low. Statistical correlation of Faecal Streptococci, total coliform count and total bacterial count with temperature showed a negative correlation (Annexures 1 to 10) thus showing their interrelationship.

6.2.1.4 Bacterial Species Diversity

In Mugaiyur lake a total of 22 species were noticed which belonged to 16 genera while in the Tirukoilur lake, a total of 28 species belonging to 18 genera were recorded with both the systems recording 11 perennial species each. Among the perennial species, seven species (E. coli, S. aureus, B. subtilis, A. aerogenes, F. johnsoniae, P. aeruginosa and A. hydrophila) were common to both the systems while one species was unique (Enterobacter cloacae) to Mugaiyur lake while for Tirukoilur lake five were unique (Alcaligenes denitrificans, Bacillus megaterium, Shigella flexneri, Streptococcus bovis and S. equines). Further, in both the systems E. coli and P. aeruginosa were the dominant species in terms of count even though in Mugaiyur lake F. johnsoniae also dominated while in Tirukoilur lake, A. hydrophila also dominated. With regard to the least dominant species. Mugaiyur lake recorded S. sonneri and V. alginolyticus while in Tirukoilur lake it was E. rhapsontici and E. nurabilis.

With regard to their most favourable period of occurrence in maximal numbers, total bacterial count as a whole in both the systems recorded higher
levels during the period between October and December even though each species appeared to occur in highest counts in different months of the year. Thus both the systems showed both uniqueness and similarity between them. Between the two systems, Tirukoilur lake recorded higher diversity in terms of both species as well as genera. This variation may be due to the differences in nutrient levels as reported by other workers (Lim and Flint, 1989; Bogosian et al., 1996; Shimna, 2012; Sankar Rao, 2013; Mugilan, 2014).

In the present study, the presence of *Vibrio*, *Aeromonas*, *E. coli*, *Enterobacter*, *Staphylococcus* species *etc.* indicates the presence of significant levels of microbial pollution. The presence of *E. coli* in both the systems possibly indicates faecal contamination. According to Kataria and Ambhore (2012) the presence of *E. coli* indicates potentially dangerous contamination requiring immediate attention. Hence this requires immediate attention if such systems are used for the betterment of man.

6.3 Algae Population in Two Lakes

6.3.1 Quantitative and Qualitative Analysis

Algae that occurred in Mugaiyur lake totaled 50 while for Tirukoilur lake 63. Nevertheless, in both the systems algae that were recorded belonged to four groups, Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae.

A comparison of Cyanophyceae composition reveals that Mugaiyur lake recorded 11 species of which five were perennial while Tirukoilur lake recorded 14 species of which 7 were perennial.
Even though Cyanophyceae as the groups were recorded throughout the period of study, a closer look shows that they preferred the periods between March and May within which they recorded the highest level in May in both the systems.

Literature reveals that Ghosh et al. (1974) reported their maximum occurrence during the monsoon period while Singh (1981) recorded their preference for the summer season. Thus there appears to be differences in the seasons of dominance. However the present study supports the view of Singh (1981). Literature also reveals that Ganapati et al. (1953) reported maximal amount of Cyanophyceae occurred when temperature, pH, PPA and MOA were high. In the present study also there was a significant correlation with temperature, pH, PPA and MOA as they were on the higher side when cyanophyceal count were high. Further, Ganapati et al. (1953) also suggested that increased silicates and phosphates also resulted in high cyanophycean counts. This appeared to be true in the present study also as highest counts were recorded when the levels of the above nutrients were also high. In addition, literature also indicates that many workers have also found a direct correlation between Cyanophyceae and nutrients like calcium, ammonia, nitrate and oxidizable organic matter (Rao, 1977; Hegde and Bharathi, 1985, Sivakami, 1996). This also appears to be true in the present study (Annexures 7 & 8).

A comparison between the two systems reveals that Tirukoilur lake recorded higher species diversity when compared to Mugaiyur lake. These differences may due to local climatic conditions as well as due to differences in
nutrient concentration. In general, their total count reveals that there was a gradually increasing trend from January to reach the peak in May followed by a decline till December in both the systems.

A perusal of the species composition reveals that genus *Microcystis* dominated in both the ponds. As to the presence of Cyanophyceae, Pennak (1955) suggested that *Microcystis* could be considered as an indicator of pollution while Sreenivasan (1972) reported that *M. aerugniosa* as an indicator of eutrophication. Ganapati *et al.* (1953) cautioned that cyanophycean blooms should not be allowed to form a dense scum on the surface as they can cause fish mortality.

With regard to Chlorophyceae, Mugaiyur lake recorded 19 species belonging to 15 genera while Tirukoilur lake recorded 24 species belonging to 19 genera, while Mugaiyur lake recorded 6 perennial species, Tirukoilur lake recorded 8 perennial species.

A comparison of the most preferred period of occurrence reveals that they preferred the period between February and April (Mugaiyur lake) / February to May (Tirukoilur lake) within which they preferred March to record their highest counts. A perusal of total count reveals that in both the systems an increasing trend was noticed from January to record their peak in March followed by a decline till December. A perusal of literature reveals that Sivakami *et al.* (2012) recorded their preference between October and February while Sirajunisa (2014) reported their preference between January and February. Hence the observation made in the present study are in line with those of earlier workers of south India.
In the present study, the highest counts recorded during March could be due to increased amount of nutrients recorded in the lake during this period. A comparison between both the systems revealed that Tirukoilur lake lake recorded higher diversity when compared to Mugaiyur lake. The differences in species composition and total count noticed in both the systems could again be attributed to the local climatic conditions, the nature of the bottom conditions as well as differences in physio-chemical and nutrient levels. According to Singh (1960) increased dissolved oxygen is required for their growth. Correlating dissolved oxygen with Chlorophyceae also showed a positive one. Pearsall (1932) suggested that green algal production increased with increasing organic matter, while Zafar (1964) noticed that high pH values favour their growth. In the present study, Chlorophyceae appeared to show a positive correlation with both these factors suggesting their interrelationship (Annexures 11-14).

A comparison of the Bacillariophyceae population reveals that Mugaiyur lake recorded a total of 12 species while Tirukoilur lake recorded 14 species, of which four species were perennial to both the systems.

Bacillariophyceae as a group preferred the period between June and July for Mugaiyur lake and January and February for Tirukoilur lake. A perusal of literature reveals that Bacillariophyceae appeared to prefer different months in different water bodies. While Kastooribai (1991), Jayanthi (1994) and Sivakami (1996) reported their preference during the months from February to May, Sukumaran (1989) and Singh (1990) reported their preference between January
and September while Hegde and Bharathi (1985) and Ganai et al. (2010) reported their preference during the winter season.

According to Wetzel (1983), one of the most important factors that control Bacillariophyceae is the negative relationship between diatoms and silicate content, which was also demonstrated in this study. Pearsall (1932) suggested that diatoms flourished when water is rich in nitrates and phosphates, while Hegde and Bharathi (1985) noticed a relationship between calcium content and dissolved oxygen content with higher concentrations recording higher diatoms. These observations are also in line with the present study. Correlation between Bacillariophyceae and temperature also shows a positive relationship. One observation noticed in the present study, in general, was the presence of low counts of Bacillariophyceae in both the systems. Literature reveals that Sipauba-Tavares et al. (2010) and Hosmani and Mruthunjaya (2012) have also reported the occurrence of this group (Dinophyceae) in very small numbers.

A comparison of bacillariophyceaeen composition between both the systems reveals that Tirukoilur lake recorded higher diversity and counts when compared to Mugaiyur lake. This again can be attributed to different climatic conditions as well as nutrient load especially silica content of the lake system.

Euglenophycean population of Mugaiyur lake were represented by eight species while in Tirukoilur lake by 11 species; while only three species were perennial in Mugaiyur lake, four species were perennial in Tirukoilur lake. As a group, Mugaiyur lake recorded higher counts from February to May recording their peak in April, while in Tirukoilur lake, higher counts were recorded from
January to May with their peak in April. Thus both the systems recorded maximum levels in April.

Literature reveals a wide range of preference with euglenoids choosing a variety of months to occur in maximum number in various water bodies of India. Thus, while Singh (1981) reported its preference in summer, Sukumaran (1989) noticed their preference in October, June, September and December and Kastooribai (1991) in September - October. However, Sivakami (1996) reported their preference in March and August. Thus, the present study is in agreement with the observation made by Singh (1981).

According to Wetzel (1983) euglenophycean development occurs when ammonia and dissolved nitrogen compounds are high while Rao (1977) and Singh and Swarup (1980) reported that there was a direct relationship between iron and euglenoids. In the present study also, there was a direct correlation between the two with euglenoids. Further, Seenayya (1971) and Hegde and Bharati (1985) also suggested that high values of free CO₂, oxidizable organic matter and chlorides supported their growth. In the present study also, euglenoids recorded a direct correlation with all the above parameters (Annexures 11-14).

Literature reveals that the genus *Euglena* and *Phacus* have been commonly recorded in the water bodies of India especially in Tamil Nadu (Sreenivasan, 1968; Franklin, 1972; Jayanthi, 1987; Sivakami, 1996). However, the genus *Lepocinclis* appears to be unique as no reference to this genus appears to be recorded in the water bodies of Tamil Nadu. In the present study, five species of protozoans were recorded. This is in agreement with the observation made by
Hutchinson (1957) who suggested that Euglenophyceae are widely distributed in open waters of lakes.

A comparison between both the lakes reveals that Tirukoilur lake recorded higher euglenophyceaeen diversity as well as count. This difference between the two systems can again be attributed to differences in local environmental conditions as well as nutrient availability.

According to Hutchinson (1967) algal blooms of *Euglena* usually occur in organically polluted bodies of water. Based on this assumption, both systems can be considered as organically polluted.

Thus, in general, among the various groups of algae, in terms of class count, in Mugaiyur lake Cyanophyceae appeared to dominate followed by Chlorophyceae, Euglenophyceae and Bacillariophyceae while in Tirukoilur lake, it was also the same. The percentage composition of each group in Mugaiyur lake were as follows: Cyanophyceae (50.43%), Chlorophyceae (24.34%), Euglenophyceae (12.99%) and Bacillariophyceae (10.67%), while in Tirukoilur lake, it was Cyanophyceae (34.23%), Chlorophyceae (28.91%), Euglenophyceae (22.39%) and Bacillariophyceae (14.41%). A perusal of literature reveals that Sivakami (1996) recorded a hierarchy of Cyanophyceae > Chlorophyceae > Euglenophyceae > Bacillariophyceae while Ganai et al. (2010) recorded a hierarchy of Bacillariophyceae > Chlorophyceae > Cyanophyceae > Euglenophyceae while Hosmani and Mruthunjaya (2012) reported a hierarchy of Cyanophyceae > Bacillariophyceae > Euglenophyceae > Chlorophyceae > Dinophyceae and Sirajunisa (2014) a hierarchy of Cyanophyceae >
Chlorophyceae > Euglenophyceae > Dinophyceae in various water bodies of India. Thus it is clear that each water body has its own composition of algal population. Nevertheless, as mentioned by Wetzel (1983) the outstanding feature of phytoplankton communities is the coexistence of a number of algal species.

In the present study, both systems recorded similarities as well as uniqueness even though both the systems were in close proximity to environmental conditions.

With regard to the variation in the algal population, Hutchinson (1967) suggested that they oscillate temporarily in abundance dominating for a period and then become extremely rare while Tilman (1982) reported that temperature, salinity and nutrient concentration play an important role influencing algal community and Chellappa et al. (2009) recorded that algal growth and development are mainly steered by available solar energy input, hydrodynamic forces such as stratification and mixing in the resulting levels of nitrogen and phosphorus. This appears to be true in the present observations in both the systems also.

6.3.2 Algal Diversity Indices (Table 28)

The Shanon Weiner diversity index of species for Mugaiyur lake it was ranged from 2.04 to 3.16 in the first year and from 2.02 to 3.08 in the second year with an overall range from 2.02 to 3.16 during the period of study. While the minimum was recorded in July the maximum was observed in February, even though it was also observed in March during the first year. The Shanon Weiner diversity index for family ranged from 1.80 to 2.46 in the first year and
from 1.82 to 2.54 in the second year with an overall range from 1.80 to 2.54; while the minimum was noticed in September, the maximum was observed in March, eventhough it was also recorded in February in the second year.

The species richness index ranged from 2.58 to 3.14 in the first year and from 2.54 to 3.04 in the second year with an overall range of 2.54 to 3.14. The minimum was accorded in August and the maximum in February eventhough it was also noticed in March.

The Shanon-Weiner diversity index of species for Tirukoilur lake system was found to range from 1.63 to 2.66 for the first year and from 1.73 to 2.78 for the second year with an overall range from 1.63 to 2.78. While the minimum was noticed in June, the maximum occurred in November for both the years.

The Shannon Weiner diversity index of family in this system was found to range from 1.24 to 2.01 in the first year and from 1.42 to 2.04 in the second year with an overall variation of 1.24 to 2.04 during the period of study. Here also the minimum levels were noticed in June and the maximum in November for both the years eventhough it was also recorded in December in the second year.

The species richness index was found to range from 1.69 to 2.50 for the first year and from 1.69 to 2.68 during the second year with an overall range from 1.69 to 2.68 during the period of study; while the minimum was noticed in July, the maximum was recorded in December for both the years. Comparing the two systems reveals that the Shanon Weiner diversity index of species, family as well as species richness index of Tirukoilur lake was on the higher side when compared to Mugaiyur lake.
According to Staub et al. (1970) a Shannon Weiner index value between 3.0 and 4.5 suggests slight pollution while a value between 2.0 and 3.0 is considered as light, between 1 and 2 as moderate and between 0 and 1 as heavy. Based on these values, both the systems can be considered as moderately polluted (between the two systems Mugaiyur lake appears to be more polluted than Tirukoilur lake).

As to the higher diversity noticed in Tirukoilur lake, Odum (1971) suggests that higher diversity means larger food chains and greater possibilities for negative feedback control which reduces oscillations and increases stability. Hence communities in stable environments have higher species diversity than communities subject to periodic perturbactous.