CHAPTER- IV

RESULTS AND DISCUSSION

4.1. INTRODUCTION

The investigation gives ample knowledge about the hydrobiology and physico chemical characters, heavy metals, bacterial and pesticide pollution of the Kolavai lake water. The analysis in which, the observations were made by means of a standard procedure. Kolavai Lake spread over an area of 894 hectares, selected as a model water body for the present investigation, is a natural perennial lake located near the GST Road in the Kancheepuram District of TamilNadu. This lake constitutes a major water body resource for agriculture, industry and fishing activities. The results are summarised and given below:

HYDROBIOLOGY

There are numerous aquatic plants like Nympea, Eicchornia, Pistea, Lemna, Vallisnaria and algal blooms along with other types of plants. In Fishes the study indicates the presence of the major carps like Catla, Rohu and Mrigal. The other fishes like Oreochromis, Anguilla, Ophio cephalus, Mystus aor, Macrones tengara, O.punctatus, Gobius giuris, Chela clupeoides and Anabas testudineus are also found in the lake. There are a number of aquatic birds like Nycticorax nycticorax, Pelecanus philippensis, Egretta gularis, Alcedo meninting, Ardeola grayii, Circus macrourus, Amaurornis phoenicurus, Halcyon smyrnensis reported to this lake. The planktons and other aquatic invertebrates and vertebrates are present in maximum number.

Four field stations were identified in the present investigation to assess the spatial variations existing in the lake. For better comparison of physico-chemical parameters in the year, the observations were made in seasons as the post monsoon (January, February and March) summer (April, May and June) pre monsoon (July, August and September) and monsoon (October, November and December).
4.2. WATER QUALITY PARAMETERS

The physico-chemical parameters of the different sample collection stations of Kolavai Lake are presented in the Tables (2a-2d).

4.2.1. TEMPERATURE

Water temperature is a controlling factor in the biological characteristics of a lake and it influences its physical and chemical nature. During the study period the surface water temperature of the study area was observed in the range from 25.8°C to 30.8°C. The maximum temperature (30.8°C) was observed in the months of May and June, 2011 and the minimum temperature (25.8°C) was observed in the months of September and October, 2011. During the study period the temperature values were generally found more or less similar in all the sampling stations. (Fig: 1)

In pre monsoon, the temperature was found lesser in all stations because of the rain and inflowing water. The station 2 was influenced by higher temperature because of its location near to GST Road. In summer it was found higher in value due to solar radiation, evaporation and due to less volume of water.

The Mean and Std.Deviation of Temperature of four sampling stations were observed as 29.6 ± 0.43, 30.4 ± 0.19, 27.3 ± 0.43, 29 ± 0.35 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)

In Chi-Square Test, the significant value (0.999) of temperature is greater than 0.05. Which is not significant at 5% level. Hence the temperature is equal in all stations in post monsoon and in monsoon. (Table 2a1 and 2d1)

In summer and pre monsoon, the significant value (0.998) of temperature is greater than 0.05. Which is not significant at 5% level. (Table 2b1 and 2c1)

Hence the temperature is more or less equal in all stations. Assessment of water quality in a region is an important aspect for any developmental activity of the region. (Jain and Seethapathi, 1996). The physical, chemical analysis is necessary to know whether the water body is fit for domestic consumption or not (Pandey and Soni,)
Water temperature plays an important role in an ecosystem. It regulates various activities of ecosystem (Katariya et al., 1995) and in Vellayani Lake the turbidity increased the temperature in pre monsoon due to excessive growth of plankton and lower volume of water (Radhika et al., 2004). In the study area the temperature is in the acceptable levels for the survival, metabolism and for the physiology of aquatic organisms. It is clear from the Tables (2a-2d) there were no significant variations in the surface water temperature across the stations over the year. The observation of surface temperature in Kolavai Lake showed similar to that of other aquatic systems elsewhere in TamilNadu. The temperature in a lake is generally influenced by the intensity of solar radiation, evaporation, fresh water influx and cooling and mixing up with adjoining water (Ajithkumar et al., 2006, Saravana kumar et al., 2008) and the surface water temperature increasing in trend from November through June. The lesser value in October was due to strong land breeze and precipitation in Uppanar estuary of Nagapattinam.

The atmospheric factors which contributes the seasonal variation in climate of an ecosystem. Jaya Raman et al.,(2003) observed a difference in surface water temperature 25°C - 30.6°C in Karmana river of Kerala. The location and vertical mixing as well as process like exchange of heat with atmosphere influences the distribution of temperature in an ecosystem.

4.2.2. TRANSPARENCY

Sacchi disc transparency of the Kolavai Lake of Chengalpet was found to be varied from 38cm to 52cm. The transparency was found to increase gradually from 42cm to 48cm and then shown fluctuation in readings. The maximum transparency (52cm) was found in summer season and the minimum transparency (38cm) was observed in the monsoon.

Transparency is a characteristic of water that measures the light penetrating through the water body. It varies with the effect of turbidity and colouration of the water body. The Secchi disc showed the transparency fluctuation in the lake during all the seasons. In general it was found least during pre monsoon and monsoon seasons. Among the stations, the station 2 had the highest transparency 52cm and the
station-3 had the lowest transparency 38cm. Radhika et al., (2004) observed an increase in turbidity during pre monsoon in Vellayani Lake, Kerala and the transparency was observed in Jaisamand Lake from 22cm to 167cm, Udaipur (Sharma and Sarang 2004). The lowest transparency of the Kolavai Lake was due to turbidity nature. Kataria et al., (1995) considered turbidity as an expression of light scattering and absorbing properties of water.

The Sechi disc depth was found least during the pre monsoon and higher during the monsoon and moderate during south west monsoon in all stations of the Periyar Lake. The transparency of water in Periyar Lake was increased due to undisturbed water which keeps the soil intact.

4.2.3. APPEARANCE

The Kolavai Lake water sample has shown its appearance as clean and clear throughout the study period except in monsoon season. But the stations-2 and 3 appeared turbid and green in the post monsoon and summer seasons. In Kolavai Lake the turbidity was found higher at stn-2 in pre monsoon may be due to anthropological activity of the region and planktons growth. At stn-1 in post monsoon it was found lesser due to undisturbed nature of water of that region and higher water level.

4.4.4. TURBIDITY

The turbidity was observed in the range from 0.9 NTU to 13.2 NTU. The highest value (13.2 NTU) was noticed in station-2 in July month and the lowest value (0.9 NTU) was noticed in station-1 in March, 2011. (Fig:2)

The Mean and Std.Deviation of Turbidity of four sampling stations were observed as 7.2 ± 4.98, 3.7 ± 4.59, 6.0 ± 5.63, 10.8 ± 2.11 in Monsoon Post monsoon, Summer, Pre monsoon and seasons respectively. (Tables-2a1,2b1, 2c1 and 2d1)

In Chi-Square Test, in post monsoon the significant value (0.000) of turbidity is less than 0.05. Which is significant at 5% level. Hence the turbidity is not found equal in all stations. (Table 2a1)
In summer the significant value (0.001) of turbidity is less than 0.05. Which is significant at 5% level. Hence the turbidity is not equal in all stations. (Table 2b1)

In monsoon the significant value (0.018) of turbidity is less than 0.05. Which is significant at 5% level. Hence the turbidity is not equal in all stations. (Table 2d1)

In pre monsoon the significant value (0.587) of turbidity is greater than 0.05. Which is not significant at 5% level. Hence the turbidity is equal in all stations. (Table 2c1)

Generally the turbidity is caused due to suspended solid materials such as clay, silt, organic matter, and plankton. Higher turbidity in pre monsoon is due to impact of boat activities with lesser volume of water.

**4.2.5. RAIN FALL**

Total Rainfall in the year 2010 was recorded as 1247mm. The highest rainfall (357.9mm) was observed in the month of November and the lowest rainfall (35.5mm) was observed in June. No rainfall was recorded from January to April. (Table-2e&Fig:3).

In 2011, the total rainfall was recorded as 1534.3mm. The highest rainfall (374.3mm) was observed in November and the lowest rainfall (9mm) was observed in May. No rainfall was recorded in January and March.

The rainfall is generally influenced by the South west monsoon and North East monsoon. They bring more rain according to the prevailing favourable climatic condition of the localities.

In Chengalpet region usually the rainfall will be more due to forest and number of lakes. In 2011, it was observed more due to the climatic condition of that time.

**4.2.5. pH**

The pH of the water sample has shown a greater variations and it was observed in the range from 7.11 to 8.25. The Kolavai Lake water was found to be
alkaline in almost all seasons and the maximum pH (8.25) was found during the summer season. (Fig:4)

pH values depends upon the carbonates, bicarbonates and hydroxyl ions. In pre monsoon the station 2 and station 4 were observed with more pH due to higher temperature and more carbonates. The metabolic activity of autotrophs may also increase the pH, because they use CO₂ and liberate O₂ thus reducing hydrogen ions. The Station1 and Station3 were observed with lower pH due to decaying vegetation and lower temperature of these regions. The pH reduces due to decomposing organic matter under low O₂ concentration at bottom of the eco system, (Kaul and Handoo, 1980). The mean values of all the four sampling stations were not exhibit considerable changes in pH.

The Mean and Std. Deviation of pH of four sampling stations were observed as 7.8 ± 0.22, 7.6 ± 0.37, 7.48 ± 0.24, 7.7 ± 0.23 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)

In Chi-Square Test, in post monsoon the significant value (0.992) of pH is greater than 0.05. Which is not significant at 5% level. Hence the pH is equal in all stations. (Table 2a1)

In summer the significant value (0.988) of pH is greater than 0.05. Which is not significant at 5% level. Hence the pH is equal in all stations. (Table 2b1)

In pre monsoon and in monsoon the significant values (0.992) of pH are greater than 0.05. Which is not significant at 5% level. Hence the pH is equal in all stations. (Table 2c1 and 2d1)

pH has direct or indirect effect on photosynthesis and growth of the plants. pH values depend upon the salinity and temperature of the water and the climatic conditions present of that area and the physical and biological conditions of water. The safest pH level of drinking water would be 7. Generally the seasonal variation is attributed to factors like removal of carbon dioxide by photo synthesis through bicarbonate degradation, dilution of sea water by fresh water influx, low primary productivity, reduction of salinity and temperature and decomposition of organic
matter (Paramasivam and Kannan 2005, Bragadeeswaran et al., 2007), Pidgeon and Cains 1987 observed that organic acids resulting from decaying vegetation might be responsible for the low pH in most aquatic eco system. Kataria et al., (1995) pointed out that the suitable range of pH is necessary for the fish survival in water bodies. The acid water reduces the appetite of fish and their growth. According to WHO (1985) the safe range of pH limit is 7 to 8.5. Therefore the water of Kolavai Lake is in the safe range of drinking and can be used for irrigation purposes. In Periyar Lake of Kerala the lowest value of pH 6.5 was observed during pre monsoon in 2003 was considered as a rare incident because of entry of inflowing water. (Krishnan J., J. G. Ray, K. S. Unni, 2003). Jaya Raman et al., (2003) observed a maximum pH in the south west monsoon and a minimum pH during the northwest monsoon in Karamana River of Kerala.

4. 3. 1. DISSOLVED OXYGEN (DO)

Dissolved oxygen is an important factor in determining the productivity of water body. It is also essential to the metabolism of aquatic organisms. The change in the DO content of water is a great limnological significance. During the study period, the DO values were observed in the range from 8 to 10.2 mg/l. The highest DO value (10.2 mg/l) was recorded at station-4 in the September. The lowest value (8 mg/l) was recorded at station-1 in the April 2011. (Fig:5)

Dissolved Oxygen was found higher in station 4 may be due to the agricultural activities, rain and inflowing water. In station 1, DO was observed low in April may be due to decomposed garbage that was brought by the drainage canal of that region, higher temperature and salinity. Even though the fluctuation in DO was observed at different stations and in different seasons, it was observed in very meagre level.

The Mean and Std.Deviation of Dissolved Oxygen of four sampling stations were observed as 8.4 ± 0.11, 8.1 ± 0.19, 9.5 ± 0.41, 9.2 ± 0.64 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)
In Chi-Square Test, in post monsoon the significant value (0.990) of DO is greater than 0.05. Which is not significant at 5% level. Hence the DO is equal in all stations. (Table 2a1)

In monsoon the significant value (0.992) of DO is greater than 0.05. Which is not significant at 5% level. Hence the DO is equal in all stations. (Table 2d1)

In pre monsoon the significant value (0.991) of DO is greater than 0.05. Which is not significant at 5% level. Hence the DO is equal in all stations. (Table 2c1)

In summer the significant value (1.000) of DO is greater than 0.05. Which is not significant at 5% level. Hence the DO is equal in all stations. (Table 2b1)

Dissolved oxygen is the sole source of oxygen for all aquatic life. DO is an important factor determining the productivity of water body. It is essential for metabolism. The changes of DO may be due to aeration of organic matter of sediments, algal activities and so on (Hasan, 2008). In Periyar Lake it was found in the range from 4.6mg/l to 8.3mg/l, and the DO increased due to rain and inflowing water. (Krishnan J., J. G. Ray, K. S. Unni, 2003). The minimum limit of DO required for fresh water as per ICMR (1975) is 5mg/l to 6mg/l. In Nirlag Lake, Kashmir it was noticed in the range from 3.1 mg/l to 12.6mg/l. The low DO can damage oxidation state of substances increasing the toxic metabolites and the pH may be altered.

4. 3. 2. BIOLOGICAL OXYGEN DEMAND (BOD)

The biological oxygen demand was observed in the range from 38mg/l to 50mg/l. The minimum value (38 mg/l) was observed in station-3 during post monsoon (March) and the maximum value (50mg/l) was recorded in station-2 during monsoon (December). (Table 2a-2d and Fig:6)

Station 1 and Station 2 with higher BOD values were due to decomposing of organic wastes, faecal matter contamination, washing of clothes and microbial growth of these regions. In post monsoon and in summer it was found higher may be due to respiration, higher temperature and low DO level of water.
The Mean and Std.Deviation of Biological Oxygen Demand of four sampling stations were observed as 10.57 ± 0.43, 10 ± 0.33, 9.9 ± 0.091, 10.12 ± 0.96 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1, 2c1 and 2d1)

In Chi-Square Test, in post monsoon and summer the significant values (0.995) of BOD are greater than 0.05. Which is not significant at 5% level. Hence the BOD is equal in all stations. (Table 2a1 and 2b1)

In monsoon, the significant values (0.927) of BOD are greater than 0.05. Which is not significant at 5% level. Hence the BOD is equal in all stations. (Table 2d1)

In premonsoon the significant value (1.000) of BOD is greater than 0.05. Which is not significant at 5% level. Hence the BOD is equal in all stations. (Table 2c1)

Biological oxygen demand is a direct measure of oxygen requirement and is an indirect measure of bio degradable organic matter. It is the amount of oxygen utilized by microbes in consuming the organic matter in water. The BOD values increases as the bio-degradable organic content increases in water. BOD values above 6mg/l in water are considered as polluted. Water bodies with BOD of 225mg/l to 323 mg/l are called septic or anaerobic systems. (Chandra sekar et al., 2003). In Taudaha Lake, Kathmandu it was found in the range from 6.5mg/l to 32mg/l. The BOD is higher due to accumulation of dead organic matter in pre monsoon and lower due to lesser temperature, which in turn retards the microbial activity Bhatt et al (1999). The fluctuation in BOD values across the stations of the study area and over the different seasons were not in significant level.

4. 3.3. CHEMICAL OXYGEN DEMAND (COD)

The water sample has shown the Chemical Oxygen Demand (COD) values from 19mg/l to 20.8 mg/l. The highest value (20.8mg/l) was noticed in the station-1 in the post monsoon and in summer season and the lowest value (19mg/l) was noticed in the station-4 in the monsoon season. (Fig:7)
Chemical Oxygen Demand was observed maximum in the stations 1 and 2 due to the decomposed organic matter brought by the drainage canal and the high anthropological activities. The washing of clothes, cleaning of vehicles and defecation activities were also found higher in these regions may be the reason for higher COD in these regions.

The Mean and Std.Deviation of Chemical Oxygen Demand of four sampling stations were observed as 20.25 ± 0.37, 20 ± 0.38, 20. ± 0, 19.9 ± 0.7 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1, 2c1 and 2d1)

In Chi-Square Test, in post monsoon and in pre monsoon the significant values (0.998) of COD are greater than 0.05. Which is not significant at 5% level. Hence the COD is equal in all stations.(Table 2a1 and 2c1)

In summer the significant values (0.997) of COD are greater than 0.05. Which is not significant at 5% level. Hence the COD is equal in all stations.(Table 2b1)

In monsoon the significant values (0.992) of COD are greater than 0.05. Which is not significant at 5% level. Hence the COD is equal in all stations.(Table 2d1)

**ORGANIC WASTES**

The organic matter present in the water bodies undergoes the degradation process. For this degradation process the oxygen present in the water is acting as a limiting factor.

Chemical oxygen demand is the amount of oxygen required in oxidizing the organic compounds present in the water. In Periyar Lake of Kerala the COD was found in the range from 3.1mg/l to 3.8mg/l, the higher values were due to drainage water and polluted river entry (Krishnan J., J. G. Ray, K. S. Unni, 2003). In River Ganga at Varanasi it was found in the range from 3.2mg/l to 26.16mg/l. The higher values were due to the organic wastes brought by the river (Singh and Rai 1999).
4.3.4. TOTAL DISSOLVED SOLIDS (TDS)

The Total Dissolved Solids were observed in the range from 315mg/l to 545mg/l. The highest value of TDS (545mg/l) was recorded at station-3 in the month of June. The lowest value of TDS (315 mg/l) was recorded at station-4 in the August 2011. (Fig:8).

The TDS was increased due to rainfall, runoff water of these regions.

The Mean and Std.Deviation of Total Dissolved Solids of four sampling stations were observed as 4.79 ± 59.0, 5.9 ± 52.61, 3.9 ± 53.38, 4.2 ± 31. in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

In Chi-Square Test, in pre monsoon and post monsoon the significant values (0.000) of TDS are less than 0.05. Which is significant at 5% level. Hence the TDS is not equal in all stations.(Table 2c1 and 2a1)

In summer the significant value (0.001) of TDS are less than 0.05. Which is significant at 5% level. Hence the TDS is not equal in all stations.(Table 2b1)

In monsoon the significant values (0.064) of TDS are greater than 0.05. Which is not significant at 5% level. Hence the TDS is equal in all stations.(Table 2d1)

Total dissolved solids are a direct measure of all the dissolved substances, both organic and inorganic in water. The high TDS indicates hard water. It results in undesirable tastes which could be salty, bitter or metallic. It could also indicate the presence of toxic minerals. Some dissolved solids come from organic sources such as leaves, silts, planktons and industrial wastes and sewage. Others include run off from urban areas, fertilizers and pesticides using in farms. Inorganic materials such as rocks and air may contain calcium carbonate, nitrogen, iron phosphorous, sulphur and other minerals. Many of these materials are also from salts, which are compounds that contain both a metal and a non metal. According to Ela W.P. (2007) Water can be classified by the amount of TDS per litre. Fresh water ≤ 1500 mg/l, Brackish water 1500 to 5000 mg/l and Saline water ≥ 5000 mg/l. In Periyar Lake the TDS was observed in the range from 19mg/l to 44.2 mg/l. The higher TDS was due to inflow...
water and monsoon. Tiwari (1994) observed TDS as 150 to 192mg/l in the Upper Lake of Bhopal. Gupta and Singh, (2000) reported higher concentration of TDS in Damodar river due to mixing of sewage and industrial wastes.

4.3.5. ELECTRICAL CONDUCTIVITY (EC)

The Electrical conductivity of water sample was observed in the range from 445 to 913micro mho/cm. The maximum value (913) was observed at station-3 in the month of June, and the minimum value (445) was found in a station 4 in the month of September 2011. (Fig:9)

The higher Electrical conductivity in Station3 may be due to voluminous runoff carried different types of electrolytes from near and distant areas. The same view was proposed by Sarojini, (1996). The minimum value of electrical conductivity may be due to rain fall. It made the dilution of the medium.

The Mean and Std.Deviation of Electrical conductivity of four sampling stations were observed as 6.7 ± 81.13, 8.2 ± 78.71, 5.6 ± 77.76, 6.07 ± 69.4 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1and 2d1)

In Chi-Square Test, in pre monsoon, summer, monsoon and post monsoon the significant values (0.000) of EC are less than 0.05. Which is significant at 5% level. Hence the EC is not equal in all stations. (Table 2c1 2b1 2d 1and 2a 1)

Electrical conductivity in water is due to ionization of dissolved inorganic solids and is a measure of total dissolved solids (Bhatt et al., 1999) and salinity. Salts in water break in to positive and negative charged ions. EC affect the quality of water and the biota. A significant fluctuation was observed in EC across the different stations in the Upper Lake in various seasons. Tiwari (1999) reported EC of 230 to 300µs at 30°C in upper Lake of Bhopal. Radhika et al., (2004) reported in Vellayani Lake of Kerala the EC value varied from 91.2µs to 320µs during the pre monsoon of the south west monsoon and 96µs to 226.6µs during the northeast monsoon. According to Sarojini (1996) seasonal EC fluctuations were closely related to evaporation and concentration of soluble salts. The electrical conductivity of lake
water largely depends on inflowing water, turnover rates and soil of the catchment areas, (Payne, 1986). It is a basic index to assess the suitability of water for agricultural purpose. (Kataria et al.,1996).

4.3.5.TOTAL CARBONATES

The total carbonates were observed in the range from 171mg/l to 275mg/l. The highest value (275mg/l) was recorded in station-3 in the month of December and the lowest value (171mg/l) was recorded in station-4 in the month of March 2011.(Fig:10)

The higher value of carbonates may be due to silt, plankton and industrial wastes. The pH of these regions may rise because of more carbonates and bicarbonates in the water. The lower value was due to higher dilution by inflowing water.

The Mean and Std.Deviation of Total Carbonates of four sampling stations were observed as 1.9 ± 17.91, 2 ± 25.31, 1.83 ± 5.95, 2.4 ± 31.45 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

In Chi-Square Test, in post monsoon the significant value (0.164) of carbonate is greater than 0.05. Which is not significant at 5% level. Hence the carbonate is equal in all stations. (Table 2a 1)

In monsoon the significant value (0.006) of carbonates is less than 0.05. Which is significant at 5% level. Hence the carbonates are not equal in all stations. (Table 2d1)

In summer the significant value (0.030) of carbonates is less than 0.05. Which is significant at 5% level. Hence the carbonates are not equal in all stations. (Table 2b1)

In pre monsoon the significant value (0.858) of carbonate is greater than 0.05. Which is not significant at 5% level. Hence the carbonate is equal in all stations. (Table 2c 1)
The alkalinity of the water depends on bicarbonates observed by (Bahura, 1976). It showed inverse relationship with pH and positive relationship with total hardness. The alkalinity decreases in summer and monsoon and increases in pre monsoon (Bhatt et al., 1999 and Trivedy). In Mandakini river the summer was characterised by high carbonates due to inflow of water (Goel, 1986).

4.3.7. TOTAL HARDNESS

The total hardness is the sum of calcium and magnesium ions concentrations. It is used to measure the capacity of water to precipitate the soap. During the study period the total hardness was found in the range from 128mg/l to 250mg/l. The maximum value (250mg/l) was observed in station-3 in the month of June and the minimum value (128mg/l) was found in the station-2 in the December 2011. (Fig:11)

The total hardness was found higher in stn 3 might be due to fertilizers, detergents, pesticides used in farms and inorganic materials from rocks. Whereas in stn 2 it was lower due to runoff water from town area. Similar observations were made in Narmada river.

The Mean and Std.Deviation of Total Hardness of four sampling stations were observed as 1.82 ± 20.66, 2 ± 36.98, 1.85 ± 19.16, 1.75 ± 39.2 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

In Chi-Square Test, in monsoon the significant value (0.000) of hardness is less than 0.05. Which is significant at 5% level. Hence the hardness is not equal in all stations. (Table 2d1)

In summer the significant value (0.001) of hardness is less than 0.05. Which is significant at 5% level. Hence the hardness is not equal in all stations. (Table 2b1)

In pre monsoon and post monsoon the significant values (0.050&0.071) of hardness are greater than 0.05. Which is not significant at 5% level. Hence the hardness is equal in all stations. (Table 2c 1 and 2a 1)
The Calcium and magnesium cause temporary hardness. Sulphate and chloride cause permanent hardness. Water with total hardness 0 to 60mg/l is considered soft. 60 to 120 mg/l is considered medium and above 120mg/l is considered very hard. The kolavai Lake water considered as hard water, because the total hardness of surface water of showed 128mg/l to 260mg/l. In Vellayani Lake, Radhika et al., (2004) observed hardness from 16.25mg/l to 30.75mg/l in surface water. Katariya (1995) found higher hardness in summer and lower hardness in monsoon in Upper Lake of Bhopal. Bhatt et al., (1999) reported total hardness of 352mg/l during summer and 280mg/l during monsoon in Taduha Lake Katmande. Increase in hardness of fresh water is generally due to anthropogenic.

4.3.8. CALCIUM (Ca)

Calcium level was estimated and given in the tables (2a-2d). The Ca values were observed in the range from 30mg/l to 52mg/l. The highest value (52mg/l) was observed in the station-3 in the month of June and the lowest value (30mg/l) was observed in station-2 in the October 2011. (Fig:12)

Calcium was found higher in summer due to higher degree of evaporation and found lower in monsoon due to rain water and inflowing water in to the lake.

The Mean and Std.Deviation of Calcium of four sampling stations were observed as 41.5 ± 7.04, 53 ± 8.84, 41.5 ± 4.79, 39.2 ± 10.9 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

In Chi-Square Test, in pre monsoon and post monsoon the significant values (0.533&0.309) of calcium are greater than 0.05. Which is not significant at 5% level. Hence the calcium is equal in all stations. (Table 2c1 and 2a 1)

In summer the significant values (0.272) of calcium is greater than 0.05. Which is not significant at 5% level. Hence the calcium is equal in all stations. (Table 2b 1)

In monsoon the significant values (0.027) of calcium is less than 0.05. Which is significant at 5% level. Hence the calcium is not equal in all stations. (Table 2d 1)
Calcium in natural water is basically leaching from Ca rich mineral rocks such as limestone or mineralization of organic matter by bacteria. Therefore Ca in natural water is different according to geographic regions or anthropogenic impact. The general acceptable limit of Ca in water is usually 75mg/l. Whereas its maximum permissible limit in water is 200mg/l (ICMR 1975). In Periyar Lake the seasonal average of Ca content in water found varied from 2mg/l to 3.6mg/l, (Krishnan J., J. G. Ray, K. S. Unni, 2003) and the Annual average amount 30mg/l of Ca was found in Nilnag Lake Kashmir and the Ca amount was found decreased in summer. Because the summer was influenced by heavy rain. This decrease attributed to the photosynthetic activity of macrophytes attaining the peak growth and production during the season. (Kaul et al., 1980).

4.3.9. MAGNESIUM (Mg)

Magnesium was observed in the range from 12mg/l to 25mg/l. The highest value (25mg/l) was recorded in the station-3 and the lowest value (12mg/l) was recorded in the station-2 in the monsoon season. (Fig:13)

Magnesium was found higher in summer might be due to rise in temperature and higher evaporation and lower in monsoon might be due to rain water. Higher Mg in water reduces the quality and gives unpleasant taste it and make unfit for domestic use.

The Mean and Std.Deviation of Magnesium of four sampling stations were observed as 16.5 ± 2.51, 21 ± 3.71, 19.75 ± 1.93, 16.5 ± 3.69 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

In Chi-Square Test, in pre monsoon and post monsoon the significant values (0.862 & 0.765) of magnesium are greater than 0.05. Which is not significant at 5% level. Hence the magnesium is equal in all stations. (Table 2c 1 and 2a 1)

In monsoon the significant value (0.478) of magnesium is greater than 0.05. Which is not significant at 5% level. Hence the magnesium is equal in all stations. (Table 2d 1)
In summer the significant value (0.630) of magnesium is greater than 0.05. Which is not significant at 5% level. Hence the magnesium is equal in all stations. (Table 2b1)

The general acceptable limit of Mg in water is usually 50mg/l. Whereas the maximum permissible limit is 100mg/l. (ICMR 1975). In Periyar Lake the seasonal average of Mg was found varied from 3.1mg/l to 6.6mg/l (Krishnan J., J. G. Ray, K. S. Unni, 2003)

4.3.10. SODIUM (Na)

The amount of Sodium was found to be fluctuating during the period of investigation. The lowest level of Sodium (22mg/l) was found during September at station-4 and the highest level (110mg/l) was found in June at station-4. (Fig:14)

In present investigation the Sodium was found to be highly fluctuating. The values were changing according to the intensity of rain and inflowing water.

The Mean and Std. Deviation of Sodium of four sampling stations were observed as 74.25±21.91, 89±19.33, 43.5±13.54, 61.25±22.47 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)

In Chi-Square Test, in monsoon and post monsoon the significant values (0.000) of sodium are less than 0.05. Which is significant at 5% level. Hence the sodium is not equal in all stations. (Table 2d1 and 2a1)

In pre monsoon and summer the significant values (0.001) of sodium are less than 0.05. Which is significant at 5% level. Hence the sodium is not equal in all stations. (Table 2c1 and 2b1)

The significant fluctuation in Na over the seasons and across the stations showed that, Na in tropical fresh water is related to differences in quality and quantity of inflow water. In Periyar Lake it was observed in the range from 1.9mg/l to 6.5mg/l. The higher value was due to evaporation and lower value was due to dilution (Krishnan J., J. G. Ray, K. S. Unni, 2003). In Lake Murray (New Guinea) it
was found in the range from 22 mg/l to 31mg/l. Na plays an important role in ion exchange and transport (Adoni et al., 1985). Allen and Arrora (1955) reported the Na is required for the growth of blue green algae. The higher concentration limits the biological diversity due to osmotic stress and in making the germination of seed difficult.

4.3.11. POTASSIUM (K)

The range of potassium in the water sample was found from 2mg/l to 12mg/l. The maximum value (12mg/l) was observed in the station-4 in the month of June and the minimum value (2mg/l) was in the station-1 in July 2011. (Fig:15).

Potassium was found higher in stn 4, might be due to development of industry and agricultural wastes. It was found reduced due to dilution by rain and inflowing water.

The Mean and Std.Deviation of Potassium of four sampling stations were observed as 7.25 ± 2.98, 9.3 ± 2.02, 2.5 ± 0.86, 4.6 ± 2.02 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1and 2d1)

In Chi-Square Test, in post monsoon the significant value (0.297) of potassium is greater than 0.05. Which is not significant at 5% level. Hence the potassium is equal in all stations. (Table 2a 1)

In monsoon the significant value (0.485) of potassium is greater than 0.05. Which is not significant at 5% level. Hence the potassium is equal in all stations. (Table 2d 1)

In summer the significant value (0.721) of potassium is greater than 0.05. Which is not significant at 5% level. Hence the potassium is equal in all stations. (Table 2b 1)

In pre monsoon the significant value (0.753) of potassium is greater than 0.05. Which is not significant at 5% level. Hence the potassium is equal in all stations. (Table 2c 1)
In Nilnag Lake at Kashmir the potassium was found varied from 0.3mg/l to 0.9mg/l. (Kaul et al., 1980). In Periyar Lake it was observed in the range from 0.9mg/l to 2mg/l. (Krishnan J., J. G.Ray, K. S. Unni, 2003)

4.3.12. FREE AMMONIA

The range of free ammonia was observed from 0.22mg/l to 2.43mg/l. The maximum value (2.43mg/l) was observed in the station-3 in the month of January and the minimum value (0.22mg/l) was also observed in the same month at station-1. (Fig:16)Ammonia is produced by microbial degradation of organic nitrogenous matter.

Ammonia was found higher in stn 2 and 3 might be due to higher anthropological activities and excretion. It was found less in stn 1 and 4 might be due to oxidation of ammonia in the medium.

The Mean and Std.Deviation of Ammonia of four sampling stations were observed as 1.27 ± 1.15, 0.5 ± 0.25, 0.61 ± 0.31, 1.5 ± 0.49 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

MAJOR NUTRIENTS IN THE WATER

Accumulation of Nitrogen and Phosphorous in natural water is more closely associated to external factors such as cultural influences, fertilization and the rate of flow (Hutchinson 1938). Nitrogen and phosphorous are the major nutrients usually limits the phytoplankton growth. Excess of these N and P triggers the Eutrophication.

Nitrogen

Total nitrogen includes inorganic forms of nitrate, nitrite, ammonia and organic nitrogen. The acceptable limit of nitrogen in water for human is 10mg/l (Nitrate or nitrate together with nitrite) or 1mg/l (nitrite alone). The maximum permissible concentration is 100mg/l. The various forms of nitrogen that affect the aquatic eco system include the inorganic dissolved forms, nitrite, ammonia and
nitrate and a variety of dissolved compounds such as amino acids, urea and composite dissolved organic nitrogen and particulate nitrogen.

Nitrite is the product of intermediate oxidation state of nitrogen, produced both in the oxidation of ammonia to nitrate and in the reduction of nitrate. Presence of nitrite in water depends on oxygen content of the water.

4.3.13. NITRITE

During the period of observation, the nitrite values were found in the range of 0mg/l to 0.47mg/l. The highest value (0.47mg/l) was recorded in station-3 in the month of December and the lowest value was observed in the stations- 3 and 4 in the month of June 2011. (Fig:17)

The Mean and Std.Deviation of Nitrite of four sampling stations were observed as 0.007 ± 0.005, 0.001 ± 0.004, 0.06 ± 0.055, 10.9 ± 21.35 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1and 2d1)

The organic matter received from the catchment areas during rainy season might be the reason for higher level of nitrite in water. It increases photosynthetic activities and eutrophication. The same view was proposed by Ashok Prabu et all.,(2008).

4.3.14. NITRATE

The water sample has shown the nitrate concentration in the range between 2mg/l and19mg/l. The highest value (19mg/l) was recorded in station-3 in December and the lowest value (2mg/l) was found in the station-4 in August 2011. (Fig:18).

Their values were found higher in rainy seasons may be due to the wash up of rain water from the agricultural lands. Nitrite was observed in low value when compared to Nitrate. In stn 3 it was decreased due to inflow of rain water and at stn 2 the entry of drainage, vegetation growth and municipal wastes.

The Mean and Std.Deviation of Nitrate of four sampling stations were observed as 9.25 ± 3.30, 12.5 ± 3.3, 5.25 ± 2.60, 11.75 ± 5.25 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1and 2d1)
In Chi-Square Test, in pre monsoon and post monsoon the significant values (0.165 & 0.316) of nitrate are greater than 0.05. Which is not significant at 5% level. Hence the nitrate is equal in all stations. (Table 2c 1 and 2a 1)

In monsoon the significant value (0.000) of nitrate is less than 0.05. Which is significant at 5% level. Hence the nitrate is not equal in all stations. (Table 2d 1)

In summer the significant value (0.312) of nitrate is greater than 0.05. Which is not significant at 5% level. Hence the nitrate is equal in all stations. (Table 2b 1)

Nitrate is the product of aerobic decomposition of organic nitrogenous matter. It enters to water bodies from fertilizers, manures, industrial water, garbage dumps and from animal feed lots.

According to ICMR (1975) the maximum permissible limit of nitrate is 20 mg/l in drinking water. In Periyar Lake it was found in the range from 1 to 3.9 mg/l in Total Kjeldal nitrogen and nitrate was found in the range 0.1 mg/l to 0.6 mg/l.

4.3.15. CHLORIDES

The chloride ions were found in the range from 21 mg/l to 152 mg/l. The maximum value (152 mg/l) was found in the station-4 in the month of June and the minimum value (21 mg/l) was found in the station-2 in October 2011. (Fig:19).

Chloride is associated with Na, K and Ca. It increases in summer season and decreases in rainy season. Cl was found higher in station 4 in summer due to evaporation and the developmental work of Mahindra World city. It was found at lower in station 2 in rainy season due to anthropological activity and high dilution.

The Mean and Std.Deviation of Chloride of four sampling stations were observed as 1.13 ± 24.29, 1.42 ± 19.40, 1.01 ± 37.26, 25.75 ± 14.72 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)
In Chi-Square Test, in pre monsoon and post monsoon the significant values (0.000 & 0.001) of chlorides are less than 0.05. Which is significant at 5% level. Hence the chlorides are not equal in all stations. (Table 2c 1 and 2a 1)

In monsoon the significant value (0.000) of chloride less than 0.05. Which is significant at 5% level. Hence the chloride is not equal in all stations. (Table 2d 1)

In summer the significant values (0.01) of chlorides are less than 0.05. Which is significant at 5% level. Hence the chlorides are not equal in all stations. (Table 2b 1)

The concentration of chloride serves as an indicator of pollution by sewage (Trivedi and Goel, 1986). According to Chandrasekar et al., (2003) the presence of Chloride concentration in a water source is used as an indicator of organic pollution by domestic sewage. Excess Chloride ions in water indicate degree of pollution and in natural water the Chloride ions are usually found associated with Na, K. and Ca and Chloride ions produce salty taste when the concentration is 100mg/l (Kataria et al., 1995). When Chloride amount is above 200mg/l in water is not suitable for human consumption. According to WHO (1985), the maximum permissible limit of Chloride ion in water is 200mg/l. In Lake Murray, New Guinea it was observed in the range from 6mg/l to 49mg/l (Osborne et al., 1987). In Periyar Lake it was found in the range from 5mg/l to 9.9 mg/l. (Krishnan J., J. G. Ray, K. S. Unni, 2003)

4.3.15. SULPHATES

The sulphate was found in the range from 1mg/l to 55mg/l. During the month of January it was found with minimum value of (1mg/l) in station-2 and it was found in maximum value of (55mg/l) in station-3 in September 2011. (Fig:20)

In Chi-Square Test, in monsoon the significant value (0.000) of sulphate less than 0.05. Which is significant at 5% level. Hence the sulphate is not equal in all stations. (Table 2c 1)

In post monsoon the significant value (0.147) of sulphate is greater than 0.05. Which is not significant at 5% level. Hence the sulphate is equal in all stations. (Table 2a 1)
In summer the significant value (0.881) of sulphate are greater than 0.05. Which is not significant at 5% level. Hence the sulphate is equal in all stations. (Table 2b 1)

In pre monsoon the significant value (0.003) of sulphate less than 0.05. Which is significant at 5% level. Hence the sulphate is not equal in all stations. (Table 2c 1)

Sulphates are found in appreciable quantity in all natural water, particularly high in arid and semi arid regions where water with high salt content. Domestic sewage and industrial effluents, automobile emissions, besides biological oxidation of sulphur species, may add to sulphate content of water.

The Mean and Std. Deviation of Sulphates of four sampling stations were observed as 2.7 ± 2.21, 1.6 ± 0.51, 21.7 ± 8.66, 10. ± 8.67 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1,2b1,2c1 and 2d1)

4.3.17. PHOSPHATES

The water sample showed the phosphate concentration in the range from 0.07mg/l to 0.51mg/l. The maximum value (0.51mg/l) was found in the station-1 in July and the minimum value (0.07mg/l) was found in the stations-1 and 4 in the months of January and July respectively. (Fig:21).

Phosphate values were observed changing in water due to addition of phosphate fertilizers from the agricultural field, wastes from the influx water and the aquatic bird’s droppings or excreta. The phosphate addition makes eutrophication in lake.

The mean values of Phosphates were 0.28±0.16 (stn-1), 0.12±0.025 (stn-2), 0.30±0.07 (stn-3), and 0.23±0.09 (stn-4).

In Periyar Lake Phosphate was noticed less than 10µg/L (Krishnan J., J. G.Ray, K. S. Unni, 2003). The phosphorous in water limits the growth of all algal form most often, but N limits the algal growth of certain species alone. All
forms of phosphates such as ortho phosphate, condensed phosphates and organically bound phosphates may present in water. Phosphorous is added to the land through fertilizers, animal manure and waste products. It is a major nutrient that triggers eutrophication and it is required by algae in small quantities. (De andela et al 1999)

4.3.18. FLUORIDES

The fluoride ions were observed in the range from 0mg/l to 0.45mg/l. The highest value (0.45mg/l) was found at station-1 in the month April and the lowest value (0mg/l) was found at station-2 in March 2011.(Fig:22).

Fluorides were found increased in summer due to high temperature and evaporation. The drainage and industrial activities were raised its level in stn 4.

Sources of Fl compounds in nature are by manmade activities and the air borne. Because of its chemical reactivity it is found in nature in a combined form. Many cases have been reported to causes endemic flurosis in human beings. Apart from water, the arid and semi arid soils are also containing Fl. It is not absorbed in bloodstream. It has an affinity for calcium and gets accumulated in the bones, resulting in the molting of teeth, pain in the bones and joint.

In Kolavai Lake the mean values of Fluorides were observed as 0.24±0.15(stn-1), 0.21±0.05 (stn-2),0.29±0.03(stnn-3),0.25±0.08 (stn-4).

4.3.19. SILICA

During the study period, the concentrations of Silica were found in the range from 1.89mg/l to 18.13mg/l. The maximum value of Silica (18.13mg/g) was noticed at station-3 during the month of July and the minimum value (1.89mg/l) was noticed at station-2 in October 2011.(Fig:23)

The large influx and withering of rock materials increased the value of Silica in stn 3. It was found low in summer due to uptake of silicates by phyto plankton for their biological activities.
The Mean and Std. Deviation of Silica of four sampling stations were observed as 2.9 ± 0.38, 5 ± 0.76, 1.3 ± 0.53, 2.4 ± 0.7 in Post monsoon, Summer, Pre monsoon and Monsoon seasons respectively. (Tables-2a1, 2b1, 2c1 and 2d1)

In Chi-Square Test, in post monsoon the significant value (1.000) of Silica is greater than 0.05. Which is not significant at 5% level. Hence the Silica is equal in all stations. (Table 2a 1)

In monsoon the significant value (0.954) of Silica is greater than 0.05. Which is not significant at 5% level. Hence the silica is equal in all stations. (Table 2d 1)

In summer the significant value (0.940) of Silica is greater than 0.05. Which is not significant at 5% level. Hence the silica is equal in all stations. (Table 2b 1)

In pre monsoon the significant value (0.403) of Silica is greater than 0.05. Which is not significant at 5% level. Hence the silica is equal in all stations. (Table 2c 1)

Silica is a significant nutrient for diatoms and may become a limiting nutrient during diatom blooms. Silicates are any mineral that contain Silica and it include quartz (SiO2), feldspars, clays and others. Much of Silica in water comes from the dissolution of silicate minerals. The source is usually the natural rock. In Periyar Lake it was found in the range from 0.01mg/l to 0.41mg/l. The Silicate removal from the water can be takes place by absorption and co precipitation of it with humic compounds and iron. (Rajasekar, 2003).

4.3.20. MANGANESE

During the study period, Manganese was not observed in any station.

The physico-chemical parameters were correlated with each other to find the relationship between them in each station and they were presented in Figures 24-31. The Temperature, BOD and COD were found positively correlated with each other because they were found rising in their values from post monsoon to summer and decreasing in monsoon. Whereas the Temperature and DO were found negatively correlated with each other.
The parameters TDS, EC and Total Carbonates were found positively correlated with each other because they were found rising in their values from post monsoon to summer and decreasing in premonsoon and again it was rising in monsoon. Whereas the Total Hardness was found rising in summer and was decreasing in pre monsoon and in monsoon in stations 1-3. The Total Hardness was also found rising with others in station-4 in monsoon. The higher values were may be due to evaporation and lower values were due to dilution.

4.4. WATER QUALITY INDEX

The water quality index was derived from the four stations of the Kolavai Lake. The WQI value was found in higher in station-3. Particularly NO₃, TDS, CO₃, Hardness, Mg, Chloride, So₄, BOD, COD, Fl were observed higher than the other stations. Whereas the pH, dissolved oxygen values were observed lesser than the other stations. The WQI is presented in table-3a and b.

Calcium was found maximum instation-1 with 63.7. The stations-3, 2 and 4 were found with values 62.3, 57 and 51.3 respectively.

Magnesium was observed in higher value in station-3. It was followed by the stations-1, 2 and 4 with values of 39, 35.5 and 32.5 respectively.

Chloride was found maximum in the station-3 and it was followed by the stations -4, 2, 1 with values of 46.6, 40.9, and 33.7.

Sulphate was observed as 53.75, 50, 45, and 31.25 in the stations -3, 4, 1 and 2.

Nitrate was found in maximum in the station-3 and it was followed by stations -4, 2 and 1 with values of 43.75, 43.75 and 36.25.

Fluoride was found in the station -3 with a maximum value which was followed by stations -4, 1 and 2 with values of 24.5, 23.75 and 21.5.

Hardness was observed maximum in the station-3, it was followed by the stations-1, 2 and 4 with values 69, 66.5, 62.91.
Carbonates were found maximum in the station-3 with 73.91, which was followed by the stations -1, 4 and 2 with the values of 67.2, 64.5 and 61.5.

Total dissolved solids were observed in higher level in the station-3 with value of 102.71 which was followed by stations -1, 4 and 2 with the values 93.1, 91.85, and 88.3.

pH was found as 64.9, 44.4, 36.5, and 31.5 in stations -2, 4, 3, 1 respectively, with maximum value in station-2.

Dissolved oxygen was observed as maximum in station-2 with 63.17, which was followed by stations-1 with 62.4, station 3 with 47.5, station-4 with 45.2.

BOD was found maximum in station-1 with a value of 218, it was followed by stations -4, 3 and 2 with the values of 211, 210, 209.

COD was observed in higher level in station-3 with a value of 249.5, followed by this the stations -4, 1 and 2 with values of 247.5, 206, 202.

The gradual development of Mahindra industrial World, Ford Ikon car factory, land fillings, entry of drainage water, Municipal wastes, Hospital wastes, garbage, anthropological activities, domestic and automobile pollution makes the changes in the water quality of the lake. The WQI was found higher in Stn 3 might be due to agricultural activities, the land filling and the anthropological activities of that region.

Water Quality Index of Irrukangudi Reservoir Virudhu nagar District has been calculated by less than 100 by K. Durai (2010).

The WQI of Kalakho Lake at Rajasthan showed the higher index values were due to continuous discharge of agricultural runoff, industrial effluents, Municipal sewage flowing in to the lake. In summer WQI was found as 460, in monsoon 599, in winter 408 at station.1 (Rashmi Sisodia, 2006).
4.5. HEAVY METALS

4.5.1. HEAVY METALS IN SAMPLES

The Kolavai Lake water contained the cadmium in an average value of 0.0027mg/l, chromium 0.0055mg/l, copper 0.105mg/l, lead 0.127mg/l, Iron 7.573mg/l and zinc 0.229mg/l.(Table 4)&(Fig:2.1)

The Kolavai Lake sediment was found to contain the cadmium in an average as 0.002mg/kg, chromium 0.771mg/kg, copper 0.471mg/kg, lead 0.127mg/kg and Iron 241.67mg/kg.(Table 5)&(Fig:2.2)

The planktons of the lake water was found to contain the cadmium 0.026mg/kg, chromium 0.104mg/kg, copper 0.605mg/kg, lead 0.316mg/kg and Iron 4.181mg/kg.(Table 6)&(Fig:2.3)

Fishes are major part of the human diet due to its high protein content, low saturated fat and sufficient omega fatty acides which are known to support good health, therefore, various studies have been taken worldwide on the concentration of different fish species by heavy metals. Fishes have been widely used as bio-indicator of pollution by metals.

The fish *Oreochromis mossambicus* muscle tissue contained the cadmium in the average values of 0.005mg/kg, chromium 0.289mg/kg, copper 0.735mg/kg, lead 0.100mg/kg and Iron 3.40mg/kg. (Table-7)&(Fig: 2.4-2.7)The maximum value of Cd (0.009mg/kg) was observed in summer and the minimum value of Cd (BDL) was observed during pre monsoon. The maximum value of Cr (0.374mg/kg) was found in monsoon and the minimum value of Cr (0.142mg/kg) was observed in pre monsoon. The maximum value of Cu (1.178mg/kg) was observed in post monsoon and the minimum value of Cu (0.115mg/kg) was found in summer.(Fig: 3.1-3.4) The maximum value of Pb (0.195mg/kg) was noticed in monsoon and the minimum value of Pb (BDL) was found in summer. The maximum value of Fe (5.325mg/kg) was observed in monsoon and the minimum value of Fe (0.550mg/kg) was found in pre monsoon.(Table7).

The fish *Oreochromis mossambicus* gill tissue contained the cadmium in an average values of BDL, chromium 0.195mg/kg, copper 0.579mg/kg, lead
0.135mg/kg and Iron 9.973mg/kg.(Table-7)&(Fig:2.8-2.11) The maximum value (BDL) and the minimum value (BDL) of Cd were observed in all the seasons. The maximum value of Cr (0.442mg/kg) was found in monsoon and the minimum value of Cr (0.009mg/kg) was found in pre monsoon. The maximum value of Cu (1.387mg/kg) was observed in post monsoon and the minimum value of Cu (0.040mg/kg) was observed in pre monsoon.(Fig:3.5-3.8) The maximum value of Pb (0.215mg/kg) was found in post monsoon and the minimum value of Pb (0.043mg/kg) was found in pre monsoon. The maximum value of Fe (12.754mg/kg) was observed in monsoon and the minimum value of Fe (7.097mg/kg) was observed in summer.

The fish Oreochromis mossambicus liver tissue contained the cadmium in an average as BDL, chromium 0.094mg/kg, copper 1.22mg/kg, lead 0.113mg/kg and Iron 13.045mg/kg.(Table-7)&(Fig:2.12-2.15) The maximum value (BDL) and the minimum value of Cd (BDL) were observed in all the seasons. The maximum value of Cr (0.153mg/kg) was found in monsoon and the minimum value of Cr (0.047mg/kg) was found in summer. The maximum value of Cu (1.754mg/kg) was found in monsoon and the minimum value of Cu (0.552mg/kg) was found in summer.(Fig:3.9-3.12) The maximum value of Pb (0.193mg/kg) was observed in post monsoon and the minimum value of Pb (0.073mg/kg) was found in summer. The maximum value of Fe (25.225mg/kg) was found in pre monsoon and the minimum value of Fe (5.094mg/kg) was found in post monsoon.

Oreochromis mossambicus KIDNEY tissue contained the cadmium in an average value with BDL, chromium 0.703mg/kg, copper 0.455mg/kg, lead 0.119mg/kg and Iron 4.578mg/kg (Table-7)&(Fig:2.16-2.19). The maximum and the minimum values of Cd (BDL) were observed in all the seasons. The maximum value of Cr (0.854mg/kg) was found in monsoon and the minimum value of Cr (0.539mg/kg) was found in summer. The maximum value of Cu (1.541mg/kg) was observed in post monsoon and the minimum value of Cu (0.024mg/kg) was observed in pre monsoon.(Fig:3.13-3.16) The maximum value of Pb (0.178mg/kg) was found in pre monsoon and the minimum value of Pb (0.074mg/kg) was found in
post monsoon. The maximum value of Fe (7.821mg/kg) was found in pre monsoon and the minimum value of Fe (3.280mg/kg) was found in post monsoon.

The mean values of heavy metals for the entire study period was represented in figures Fig 7.1-7.5 for *Oreochromis*, Fig 7.6 -7.10 for *Mrigal* and Fig 7.11- 7.15 for *Rohita*

In *Oreochromis mossambicus* the significant value (0.784) of cadmium is greater than 0.05. Which is not significant at 5% level. Hence the cadmium is equally distributed in all seasons.(Table7a)

In *Oreochromis mossambicus* the significant value (0.547) of chromium is greater than 0.05. Which is not significant at 5% level. Hence the chromium is equally distributed in all stations.(Table7a)

In *Oreochromis mossambicus* the significant value (0.154) of copper is less than 0.05. Which is significant at 5% level. Hence the copper is not equally distributed in all stations.(Table7a)

In *Oreochromis mossambicus* the significant value (0.145) of lead is less than 0.05. Which is significant at 5% level. Hence the lead is not equally distributed in all stations.(Table7a)

In *Oreochromis mossambicus* the significant value (0.518) of iron is greater than 0.05. Which is not significant at 5% level. Hence the iron is equally distributed in all stations.(Table7a)

The fish *Labeo rohita* muscle tissue contained the cadmium in an average with 0.005mg/kg, chromium 0.045mg/kg, copper 0.125mg/kg, lead 0.245mg/kg and Iron 2.138mg/kg. (Table-7) & (Fig: 2.4-2.7). The maximum value of Cd (0.014mg/kg) was observed in pre monsoon and the minimum value of Cd (BDL) was in summer. The maximum value of Cr (0.089mg/kg) was in summer and the minimum value of Cr(BDL) was in pre monsoon. The maximum value of Cu (0.194mg/kg) was in summer and the minimum value of Cu (BDL) was in pre monsoon. The maximum value of Pb (0.840mg/kg) was in monsoon and the minimum value of Pb (BDL) was
in post monsoon. The maximum value of Fe (3.125mg/kg) was in monsoon and the minimum value of Fe (0.552mg/kg) was found in pre monsoon. (Fig: 3.1-3.4)

*Labeo rohita* gill tissue contained the cadmium in an average of 0.003mg/kg, chromium 0.052mg/kg, copper 0.402mg/kg, lead 0.0015mg/kg and Iron 5.035mg/kg. (Table-7) (Fig:2.8-2.11). The maximum value of Cd (0.015mg/kg) was observed in pre monsoon and the minimum value of Cd (BDL) was in the remaining seasons. The maximum value of Cr (0.130mg/kg) was in summer and the minimum value of Cr (0.015mg/kg) was in pre monsoon. The maximum value of Cu (0.972mg/kg) was in monsoon and the minimum value of Cu (0.022mg/kg) was in pre monsoon. The maximum value of Pb (0.005mg/kg) was in monsoon and the minimum value of Pb (BDL) was in the remaining seasons. The maximum value of Fe (11.19mg/kg) was in summer and the minimum value of Fe (2.029mg/kg) was observed in pre monsoon. (Fig: 3.5-3.8)

*Labeo rohita* liver tissue contained the cadmium in an average value as 0.020mg/kg, chromium 0.0527mg/kg, copper 1.358mg/kg, lead 0.050mg/kg and Iron 11.153mg/kg. The maximum value of Cd (0.043mg/kg) was observed in monsoon and the minimum value of Cd (BDL) was found in post monsoon and in summer. The maximum value of Cr (0.098mg/kg) was seen in summer and the minimum value of Cr (BDL) was found in pre monsoon (Fig: 2.12-2.15). The maximum value of Cu (1.958mg/kg) was found in summer and the minimum value of Cu (0.205mg/kg) was found in pre monsoon. The maximum value of Pb (0.158mg/kg) was observed in pre monsoon and the minimum value of Pb (BDL) was observed in post monsoon. The maximum value of Fe (15.115mg/kg) was found in summer and the minimum value of Fe (3.887mg/kg) was found in post monsoon. (Fig: 3.9-3.12)

The fish *Labeo rohita* kidney tissue with average values of the cadmium 0.0015mg/kg, chromium 0.285mg/kg, copper 1.039mg/kg, lead 0.111mg/kg and Iron 5.129mg/kg. The maximum value 0.005 in summer and the minimum values of Cd (BDL) were observed in the remaining seasons. The maximum value of Cr
(0.982 mg/kg) was found in monsoon and the minimum value of Cr (BDL) was seen in pre monsoon. (Fig: 2.16-2.19). The maximum value of Cu (1.548 mg/kg) was found in monsoon and the minimum value of Cu (0.090 mg/kg) was found in pre monsoon. The maximum value of Pb (0.158 mg/kg) was observed in monsoon and the minimum value of Pb (0.045 mg/kg) was observed in pre monsoon. The maximum value of Fe (10.290 mg/kg) was found in summer and the minimum value of Fe (3.115 mg/kg) was observed in monsoon. (Fig: 3.13-3.16)

In *Labeo rohita* the significant value (0.264) of cadmium is greater than 0.05. Which is not significant at 5% level. Hence the cadmium is equally distributed in all seasons. (Tables 7c)

In *Labeo rohita* the significant value (0.358) of chromium is greater than 0.05. Which is not significant at 5% level. Hence the chromium is equally distributed in all seasons. (Tables 7c)

In *Labeo rohita* the significant value (0.182) of copper is greater than 0.05. Which is not significant at 5% level. Hence the copper is equally distributed in all seasons. (Tables 7c)

In *Labeo rohita* the significant value (0.429) of lead is greater than 0.05. Which is not significant at 5% level. Hence the lead is equally distributed in all seasons. (Tables 7c)

In *Labeo rohita* the significant value (0.229) of iron is greater than 0.05. Which is not significant at 5% level. Hence the iron is equally distributed in all seasons. (Tables 7c)

The fish *Cirrhinus mrigala* muscle tissue found with average values of the cadmium 0.002 mg/kg, chromium 0.095 mg/kg, copper 0.255 mg/kg, lead 0.054 mg/kg and Iron 3.101 mg/kg. The maximum value of Cd (0.008 mg/kg) was observed in monsoon and the minimum value of Cd (BDL) was found in summer and pre monsoon seasons. The maximum value of Cr (0.133 mg/kg) was noticed in summer and the minimum value of Cr (0.058 mg/kg) was observed in pre monsoon (Fig: 2.4-2.7). The maximum value of Cu (0.405 mg/kg) was found in monsoon and the
minimum value of Cu (0.107mg/kg) was found in pre monsoon. The maximum value of Pb (0.128mg/kg) was observed in monsoon and the minimum value of Pb (BDL) was observed in summer. The maximum value of Fe (3.587mg/kg) was observed in summer and the minimum value of Fe (2.345mg/kg) was found in pre monsoon.(Fig: 3.1-3.4)

The fish *Cirrhinus mrigala* gill tissue with average values of Cd 0.002mg/kg, chromium 0.235mg/kg, copper 0.247mg/kg, lead 0.025mg/kg and Iron5.532mg/kg. The maximum value of Cd (0.009mg/kg) was observed in monsoon and the minimum value of Cd (BDL) was observed in the remaining seasons. The maximum value of Cr (0.274mg/kg) was found in monsoon and the minimum value of Cr (0.173mg/kg) was found in pre monsoon.(Fig: 2.8-2.11) The maximum value of Cu (0.375mg/kg) was observed in monsoon and the minimum value of Cu (0.075mg/kg) was observed in pre monsoon. The maximum value of Pb (0.053mg/kg) was found in monsoon and the minimum value of Pb (BDL) was found in summer and in pre monsoon. The maximum value of Fe (9.574mg/kg) was found in summer and the minimum value of Fe (3.554mg/kg) was found in post monsoon.(Fig: 3.5-3.8)

*Cirrhinus mrigala* liver tissue contained the cadmium in the average values as 0.0015mg/kg, chromium 0.293mg/kg, copper 2.271mg/kg, lead 0.194mg/kg and Iron50.34mg/kg. The maximum value of Cd (0.005mg/kg) was observed in monsoon and the minimum value of Cd (BDL) was found in the remaining seasons. The maximum value of Cr (0.354mg/kg) was observed in monsoon and the minimum value of Cr (0.235mg/kg) was observed in summer.(Fig: 2.12-2.15) The maximum value of Cu (2.580mg/kg) was found in post monsoon and the minimum value of Cu (1.435mg/kg) was found in pre monsoon. The maximum value of Pb (0.352mg/kg) was observed in post monsoon and the minimum value of Pb (0.072mg/kg) was observed in pre monsoon. The maximum value of Fe (51.24mg/kg) was found in monsoon and the minimum value of Fe (21.43mg/kg) was found in pre monsoon.(Fig: 3.9-3.12)

*Cirrhinus mrigala* kidney tissue contained the cadmium in the average values of 0.001mg/kg, chromium 0.055mg/kg, copper 0.054mg/kg, lead 0.038mg/kg
and Iron 2.595mg/kg. The maximum value of Cd (0.004mg/kg) was observed in summer and the minimum value of Cd (BDL) was found in the remaining periods. The maximum value of Cr (0.075mg/kg) was found in monsoon and the minimum value of Cr (0.035mg/kg) was found in summer.(Fig:2.16-2.19). The maximum value of Cu (0.098mg/kg) was observed in monsoon and the minimum value of Cu (0.035mg/kg) was found in summer. The maximum value of Pb (0.052mg/kg) was observed in monsoon and the minimum value of Pb (0.024mg/kg) was observed in pre monsoon. The maximum value of Fe (3.235mg/kg) was found in monsoon and the minimum value of Fe (2.350mg/kg) was found in pre monsoon.(Fig:3.13-3.16)

In *Cirrhinus mrigala* the significant value (0.015) of cadmium is less than 0.05. Which is significant at 5% level. Hence the cadmium is not equally distributed in all seasons.(Tables7b)

In *Cirrhinus mrigala* the significant value (0.843) of chromium is greater than 0.05. Which is not significant at 5% level. Hence the chromium is equally distributed in all seasons.(Tables7b)

In *Cirrhinus mrigala* the significant value (0.922) of copper is greater than 0.05. Which is not significant at 5% level. Hence the copper is equally distributed in all seasons.(Tables7b)

In *Cirrhinus mrigala* the significant value (0.286) of lead is greater than 0.05. Which is not significant at 5% level. Hence the lead is equally distributed in all seasons.(Tables7b)

In *Cirrhinus mrigala* the significant value (0.907) of iron is greater than 0.05. Which is not significant at 5% level. Hence the iron is equally distributed in all seasons.(Tables7b)

The mean values of heavy metals in fishes are shown in Figures 7.1-7.15. In *Oreochromis*, the higher values of Cd and Cr were found in summer, Cu and Pb in post monsoon and Fe in pre monsoon. In *Rohita*, Cd, Cr, Cu were found higher in monsoon, Pb was in post monsoon and Fe in summer. In *Mrigal*, the higher value of Cd was found in summer, Cr and Cu in monsoon, Pb in post monsoon and Fe was in summer.
In water samples, the statistical analysis (ANOVA) showed the less significant values. Hence the heavy metals were not equally distributed in all the seasons. (In post monsoon F: 383.351, P=3.15x10^{-25}, Summer F: 384.858, P=2.98x10^{-25}, Pre monsoon F: 384.058, P=3.08x10^{-25}, in monsoon F;380.555, P=5.33x10^{-22}). The results are furnished in the Tables (9a-9d).

In sediment, the Analysis of variance (ANOVA) single factor revealed the less significant value. Hence there were differences in the distribution of heavy metals among them in the lake sediment. (F; 392.285, P=5.23x10^{-18}). The results are furnished in the (Table 10).

Heavy metals are non-bio degradable and once discharged into water bodies they can be absorbed in sediments or accumulated in aquatic organism especially in fish. Which in turn enter in to human metabolism through consumption and causing serious health hazards. Accumulation of metal in different species of fishes may be by the function of their respective membranes permeability and enzyme system. Which are highly species specific.

Fishes mostly absorbed heavy metals from their feeding diets, sediments and surrounding water resulting to their accumulation in reasonable amounts.

The factors such as the micro habitat, feeding habit, age sex and fish species are determine the accumulation of heavy metal in fishes.

Accumulation of metals was generally found to species specific and may be related to their feeding habit and bio concentration capacity. It is well recognised that heavy metal uptake occurs mainly from water, food, and sediments. However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism and the contamination gradients of water, food, sediment as well as salinity and temperature. The results of this study give valuable information of heavy metal in the selected three different fishes from the Kolavai Lake.

The essential metals such as iron, copper are in higher conc. presumably due to their function as co-factors for the activities of a number of enzymes and
regulated to maintain a certain homeostatic status in fish. The non essential metals cadmium has no biological function and its conc. in fishes is generally low. It is highly toxic. The level of chromium in different organs of the fresh water fishes and their presence could be attributed to waste water discharge from the domestic and agricultural related activities that were taken place in the investigated area. The high level of this metal at the lake could be due to local sources like hospital wastes and washing of clothes and cleaning of vehicles. In view of the higher levels of chromium, when compared to WHO limits, it could be inferred that consumption of fish could lead to health hazards in man. Cadmium in fish muscle tissue may be attributed by the phosphate fertilizers. It is the main source of cadmium in an environment. Hence the present study shows that the higher conc. of chromium, copper and iron in the muscle is due to pesticides, fertilizers, chemical and sugar mills and hospital wastes.

The conc. of lead in muscle tissue of studied fishes is due to the discharge of industrial sewage and agricultural wastes. Pb is known to accumulate in fish tissues (bones, gills, liver, kidney and scales) while the gaseous exchange across the gills to the blood stream reported to be the major uptake mechanism (Oguzie, 2003). Pb toxicity is dependent on life stage of fish, pH, Hardness of water and presence of other organic materials. (Merkini and Pozzi, 1977).

Gills act as the main site for entry of different kinds of contaminants such as heavy metals due to its continuous contact with the external medium. This organ serves a variety of physiological functions such as respiratory gas exchange, osmo regulation and nitrogen excretion. Therefore heavy metals may appear in high levels in liver and gill tissues compared to muscle tissue.

This study revealed that metals accumulation in gills and liver occurs in higher magnitude than muscle. This was reported by several investigations. Because of the presence of high levels of metallothionein protein, liver tissue acts as a target organ for heavy metal detoxification.

Higher temperature can cause higher activity and ventilation rates in fish. The increasing temperature lowers the oxygen affinity of blood and increases the rate of pollution accumulation (Grobler, 1998). A high metabolic rate may also
induce frequent feeding sessions. Which in turn might results in increased metal concentration.

In the rainy season, the bio concentration factor values could arise from the altered water chemistry which is induced by the high degree of sewage inflow at the lake. Similar results were reported by Etienne et al., (1997) in water bodies of Burkina Faso.

In water the concentration of heavy metals were present in the order of Fe>Zn>Pb>Cu>Cr>Cd. In sediment it was observed in the order of Fe>Zn>Cr>Cu>Pb>Cd. In planktons it was observed as Fe > Cu > Pb > Cr > Cd. In fishes it was in the order of Fe>Zn>Cu>Cr>Pb>Cd. In organs of fishes it was highly accumulated in liver which is followed by gills > muscle > kidney. Fe in the liver was found to be higher than any other metal studied in the fishes and it still falls within the 300mg/kg recommended limits for food fish by WHO (1994)& FEPA(2003). The Pb value obtained in the fishes were below the recommended Std. value limits of 2 mg/kg in food fish. But the observed value was recorded in the report of Daka et al (2008), from 0.01 to 0.06mg/kg in fish species and also Kannan and Krishnamoorthy (2006) reported the Pb value as 0.0083mg/kg in Pulicat Lake. The Cr value obtained is higher than the recommended permissible value of 0.15mg/kg. So this may create health problems in lungs and kidneys of humans. The recommended permissible value of Cu is 1-3mg/kg in food fish. *Cirrhinus mrigala, Labeo rohita and Oreochromis mossambica* were showed lesser than this value and thus will not create any problem. Cd is non-essential toxic metal whose recommended value according to FAO is 0.5mg/kg (1983). The studied fishes showed the values lesser than this value indicating that it will not induce Cd related problems.

Fish absorbs the metals through gills, skin or through ingestion of contaminated water or food. The concentration of heavy metal is related to several factors such as food habits and foraging behaviour of organisms. (Obasohan and Oronsaye,2004). The gills play an important role in ion regulation, gas exchange, acid balance and excretion, which signifies the key role it, plays at the interface with
the environment. (Karthikeyan et al, 2007). The muscle tissue has lower tendency to accumulate the heavy metals.

*Mrigala* is a detritivorous fish, which feeds on small organisms and forms an important link in the food web of aquatic eco system in this locality. A high metabolic rate may also induce more feeding sessions, which in turn might result in increased metal levels, (Nussey et al, 2000). Heavy rainy season dilutes the metal concentration. Fishing activities, anthropogenic activities and runoff water might have increased the cadmium level in sediment. The phytoplankton activity can also cause seasonal variation in copper; (Govindasamy and Azariah, 1999). The phytoplankton consumes more copper. (Ananthan et al, 2005).

According to S.Kamala kannan et al, (2007) the heavy metals Cd 0.01mg/kg, Cr 0.067mg/kg, Cu 0.06mg/kg, Pb 0.42mg/kg, Fe 0.26mg/kg were present in pulicat lake. In kallar khar lake it was observed as Cd 0.02mg/kg, Cu 0.25mg/kg, Pb 0.11mg/kg, Fe 1.5mg/kg. Where as in Kolavai lake the cadmium, copper and iron were found more than the Pulicat lake.

Analysis of variance (ANOVA) single way type revealed the significant differences in the heavy metals between the stations of Kolavai lake Chengalpet indicating the presence of significantly higher concentration in the water and sediment samples indicating the affinity of toxic metals to these medium.

The results of this study revealed that consuming fish from the Kolavai Lake, Chengalpet, India, may not be harmful to consumers, because the observed values of heavy metals were below the permissible limits published by WHO/FAO for human consumption. However, chromium and iron were higher than certified levels.

The content of copper, lead and iron in water were found more than the safer limit in drinking water for livestock and poultry. It may cause deleterious effects in them. So, it is a matter of concern in fish accumulation.

Based on the above finding, a close monitoring of metal pollution of Kolavai Lake is strongly advocated, in view of the possible health implication to consumer of the fishes of the lake.
4.5.2. CONTAMINATION FACTOR

Sediment were used for the analysis of contamination factor revealed that (Table 8) the Copper was observed as 0.01, Lead was found with the value 0.006, Cadmium was observed with the value 0.007, Chromium was observed in 0.008 level and Iron was observed in the value of 5.12.

Contamination factor study at Ennore creek had revealed a very high contamination factor of Cd in the surface sediments during each season. The CF of Cu in post monsoon and summer in all stations found contaminated. The Cd was found with CF 1.30, Cu 98.3(Rajkumar,j.s, 2011).

In Pulicat lake Cd, Fe and Hg were found at a elevated level (Kannan and Krishnamurthy, 2006), Rajathy and Azariah, (1996) reported the level of Zn, Cu in water, sediment of Ennore creek and Adyar estuary.

Heavy metals adsorption increases with decreasing grain size of the sediment. Thus the metal concentration is significantly enriched in the fine grained sediment rich in clay minerals (Xuetal, 2009).Sediment associated metals pose a direct risk to detritus and deposit feeding benthic organisms and may also represent long term source of contamination to higher trophic levels. (Twining et al.,2008).

4.5.3. GEO ACCUMULATION INDEX

Sediment analysis of the Kolavai Lake was found with higher geo accumulation index values. It is represented in the (Table 11). Copper was observed as 0.0021, Lead was observed as 0.127, Cadmium was found as 0.0013, Chromium was found as 0.0017, Iron was observed as 0.10.

Higher geo accumulation index was found in Habbaniya lake sediment by Ai-Saadi et al., (2002) and he reported that the Pb, Ca, and Cd concentrations were high in spring. Higher values of Pb (435µg/g), (1090µg/g) and Zn was reported by Srinivasalu et al., (2005) in sediments of TamilNadu Coast.

Muthuraj and Jaya prakash(2007) reported sediment samples from estuarine showed the order of metals as Zn>Cu>Pb>Cd, in Ennore creek. In the study area Copper was observed with 2.1 µg, Lead was observed with 1.27µg, Cadmium was
found with 1.34 μg, Chromium was found with 1.72 μg, Iron was observed with 102.7 μg.

$I_{geo}$ was originally devised for use with the global standard Shale values as background metal levels. In this study the back ground values for world crustal average metal concentration as presented by Wedephol (1995) were used. Seasonal variation in metal distribution is influenced by strong hydrodynamic and physico-chemical condition (Padmini and Kavitha, 2005). The high concentration of heavy metal in sediments may not necessarily indicate anthropogenic contamination, because of different back ground levels in parent materials and sediment properties Esen, (2010). Hamed (1998) reported that the sediment act as a reservoir for all the contaminants and dead organic matter descending from the eco system. Abdel-Baky et al., (1998) found a correlation between the concentration of heavy metal and the abundance of organic matter.

Elemental concentration in various water reservoirs have been studied in Horseshoe Lake, Illinois (Brugam et al., 2003). Lake Balton (Farkas et al., 2003), Hlavay and Polyak 2002, Nguyen et al., 2005, Wetsz et al., 2000) Lake Nakuru, Kenya (Mavura and Wangila, 2003), Lake Victoria in Kenya has been most frequently studied for pollutants and contaminants (Kondoro, 1998), Tole and Shitsama, (2000).

The application of CF and $I_{geo}$ were used to find the contents of some heavy metals in the sediments and water. The concentration of heavy metals in the kolavai ecosystem might be due to automobile exhaust, domestic effluents, and medical college wastes and also due to anthropogenic activities in and around the lake. This high content of heavy metals may increase their values in the ground water level of the area by leaching. This content of heavy metals forms the basis of the food chain in the lake.

4.5.4. BIO CONCENTRATION FACTOR

The bio concentration factor was analysed in the Kolavai Lake experimental fishes (Tables 8a & 12). Based on the seasonal values of heavy metals in fishes the BCF was calculated. In the result, Iron was observed in the range from 0.007 to 2.35, Chromium was observed in the range from BDL to 77.12, Copper was found
in the range from 0.79 to 12.07, Lead was observed in the range from 0.25 to 1.81 and Cadmium was found in the range of BDL to 3.

Metal bio concentration factor in water samples of river Ogba was studied by E.E.Obasohan and O.I.Eguavoen., (2006) Cu was observed in the range from 103.6-3140. Cd ranged from 6.67-35, Pb was observed from 38-250. The possible explanation for this could be the closeness of station to the source of river. The sewage effluents and surface runoffs from surrounding agricultural fields were might be the reason. Similar results were also reported for the water bodies in Burkina Faso, which were attributed to high influx of sewage effluents (Etienne et al., 1997).

Bio accumulation and fate of heavy metals in molluscs was studied by Moloukhia,H. and Saleem, S (2011). The result indicates that accumulations of Cd and Cr in the soft parts of the molluscs increase in concentrations in their medium increase at various time intervals.

4. 5. BACTERIOLOGICAL STUDY

During the study period the pathological investigations of the Kolavai Lake has shown in (Table 13). The total Coliform bacteria count was found in the range from 1085 to 3000 in 100ml, it was found in maximum number (3000) in summer and in minimum number (1085) in monsoon. The bacterial colonies were found in the range from 1085 to 2200 in Standard plate count method. It was observed maximum (2200) during post monsoon and minimum (1085) in summer.

The faecal coliforms were observed in the range from 85 to 1200 in 100ml, the maximum number (1200) was observed in post monsoon and the minimum number (85) was noticed in summer. The faecal streptococci were observed from 185 to 1100 in 100ml of water sample. It was found higher (1100) in post monsoon and lower (185) in summer.

Tests of significance between the stations of Kolavai Lake Chengalpet were carried out by using ANOVA (one way type). The results are furnished in the Table 14a-14d.
It revealed that the Std. plate count in four seasons, (Table 14a) showed significant differences among the seasons (F ≤ 5). (F: 3.88851.74, P = 8.19X10^{-28}).

In Total coliforms analysis, it showed statistically significant differences between the seasons (F ≤ 5). (F: 1.09233.17, P = 2.55X10^{-42}). The results are given in the Table 14b.

In Faecal coliforms analysis, it showed statistically significant differences among the seasons (F ≤ 5). (F: 44579.51, P = 2.021X10^{-38}). The results are furnished in the Table 14c.

In Faecal streptococci analysis, it also showed statistically significant differences between the seasons (F ≤ 5). (F: 2552.49, P = 392X10^{-35}) The results are furnished in the Table 14d.

The bacterial studies indicated that the Kolavai Lake was polluted by faecal coliforms. The rain water, runoff water, sewage entry, defecation and garbage were the causative factors for this bacterial pollution.

In Perumal Lake at Cuddalore, TamilNadu (Usha, 1999) the result indicated that the Std plate count was higher during rainy season, because of soil and sewage gain entry in to it. Faecal coli forms were found maximum in Therasapuram, higher in Cherai beach, Cochin back water, Port Blair bay, Andaman and Nagore. (Goyal et al., 1977).

Population of aquatic microbes is influenced by many environmental parameters and it varies with time and the station of sampling. The increase in coli forms in monsoon may be due to the rain water that drained in to the lake, as it was the major bacterial population in the lake water. (Quereshi and Dutka, 1979) Higher population in summer may be due to less available dilution (Badge and Varma, 1982)

The runoff water may suddenly increase and reach the lakes very quickly. Araujo et al., (1989). Faecal coli form and faecal streptococci ratio of all the sampling sites showed more in station 1 and in station 4 may be due to contamination by animal and human faecal matter.
Analysis of variance (ANOVA) revealed significant differences in the bacterial types between the stations of Kolavai lake Chengalpet. It is indicating the presence of significantly higher concentration of them in the water samples shows the affinity of these microbes to medium. Analysis was carried out by using ANOVA one way type.

In kodaikanal Lake the total coliforms were found as 44-53 in pre monsoon, 46-60 in monsoon, 33-40 in post monsoon and in summer 46-50 (Raj kumar-2006). In Yercaud Lake it was observed as 85-135, 110-180, 79-110, 94-140 respective with seasons (S.Raj kumar-2006). The faecal coliforms were found in the range 29-35, 33-46, 17-27, 27-33 in kodaikanal Lake and in yercaud Lake it was observed in the range 62-86, 70-110, 63-79, 63-94 in the respective seasons. Whereas in Kolavai Lake, it was found more than these values indicates that it is highly bacteriologically polluted.

McLellan et al. (2001) stated that faecal pollution indicator organisms can be used to a number of conditions related to the health of aquatic ecosystems and to the potential for health effects among individuals using aquatic environments.

4. 7. PESTICIDES STUDY

Chemical risk assessment of the whole range of fresh water aquaculture fish from Kolavai Lake never been studied in Chengalpet. The objective of the present study was to assess the level of pesticides, heavy metals and bacterial pollution in fresh water aquaculture fish and water in main production Districts of Kancheepuram.

The pesticides analysis revealed that the water and the sediment were not found to possess the DDT, Aldrin, Endrin, Carbofuran and Malathion. (Table15).

The pesticides analysis in fishes revealed that the fish muscle tissues were not found to possess the DDT, Aldrin, Endrin, Carbofuran and Malathion. But the bottom feeder C.mrigala alone was found to possess the chlorophyri phos in the range from 37ppb to 72ppb. The highest value (72ppb) was observed in monsoon and the lowest value (37ppb) was observed in summer.
The bottom feeder (Mrigal) alone polluted with Choloro phyri phos because of the agricultural pesticides that entered from nearby fields. Whereas the DDT, BHC are not used by the farmer from long back. So it may be the reason for their non availability in fishes.

In Kolleru Lake, (Sreenivasa Rao amaraneni, 2004) the result indicated that the pesticides concentration in fish farm decrease in order as sediment>fish>water. The maximum was found in fish farm 1 and 5-8. This may be due to intensive use of pesticides in the farms.

Hasan et al., (2010) in Bangladesh study revealed that the poultry, fish, vegetables, lake water were polluted by the pesticides. DDT was found in the level 121.793µg/l.

Pollution of an aquatic system occurs by many ways like, organic and inorganic chemicals, oils, detergents, radioactive elements and pesticides. However, the magnitude of pesticide pollution should be much greater than that of non-pesticide pollutants, because of the extensive manufacture and applications of these chemical compounds in recent times. The future estimates on estimates on pesticides for purposes of public health will be about 8000 tons for BHC (Krishna murthy and Dikshith, 1982). The pesticides normally used for plant protection and for destroying vector borne diseases are categorised in to three major groups based on the reactive groups present in the original molecule as Organochlorides (OC), Organophosphates (OP) and Carbamates.

**ORGANOCHLORIDES**

They are persistent pesticides, like DDT, BHC, Endosulphan, Aldrin, Dieldrin, Endrin etc., being readily soluble in fats, in fat deposits of man and other animals. The rapid elimination of OC residues in tissues is not possible, since they are not metabolised enough in the body. These compounds are known to undergo biological magnification and accumulate in the ecosystem. These pesticides could interfere with nerve impulse transmission through neurons and synopsis by way of altering ionic movements.
CARBAMATE PESTICIDES

The carbamate pesticides like carbaryl, carbofuran, aldicarp etc., are relatively more soluble in water. In most cases, when ingested they are rapidly excreted. Normally they do not accumulate in tissues. They possess anti cholinesterase activity and were known to produce behavioural change. These insecticides are found to inhibit the action of AChE in insects.

ORGANOPHOSPHORUS PESTICIDES

They are toxic compounds having a phosphorus atom. The first OP compound to be synthesised is Tetra ethyl pyrophosphate followed by parathion, malathion and others. These are found to inhibit esterases in living systems and AChE in synaptic nerve transmission.

The concentration of various pesticide in the Kolavai Lake sediment and in fishes were found below the detectable levels (BDL) except the pesticide the chloro pyrophos. Which was also observed below the WHO Guide lines limits. It was found higher in monsoon season. This pesticide contamination in the lake may be due to the use of this pesticide in nearby agricultural fields and also indirectly by influx water. It may create various effects like mass mortality, changes in behaviour, low survival rate and morphological and physiological changes in the organ system of fishes. It may lead in cough, cold, bronchitis, cancer in skin, eye, and kidney and in prostrate glands in Human. According to WHO, the maximum permissible limits of DDT in water is 0.2µg/L, and for the aldrin and eldrin is 0.05µg/L. The pesticide chloro pyriphos was observed in fishes at meagre level. This situation suggests that there is a very low risk of pesticide residue in fish which are sold at markets and this small amount of pesticide residue exist in fish may be totally dissolved by the time they arrive at markets or by cooking process.

With the gradual development of industry, intensive use of pesticides and discharge of untreated domestic sewage may further exacerbate the situation in coming years. So careful monitoring is essential to prevent the pesticide pollution at this movement.
4.8. CONCLUSION

From the study, it is very clear that the water of Kolavai Lake is moderately polluted, because some physico-chemical parameters and some heavy metals values were not in par with the permissible limits of B.I.S and WHO. The study also found that the total and faecal coli forms contamination levels were higher than the permissible limit. The Fish muscle tissue samples were also found contaminated with chloro pyriphos pesticide. It is revealed that the factors responsible for the water quality degradation of this lake were mainly due to the anthropological activities, contaminated water from the commercial establishments and private and Government hospital wastes. So the water is not suitable for drinking of both human and cattle.