2.1 The study area

Mysore is the second biggest city in the State of Karnataka. It lies 130 km from the State Headquarters, Bangalore. The total area of Kukkarahalli the Lake is about 104 hectares and water spread area Lake is 49 ha. It covers an area of more than 40 sq.km and is situated 763 meters above sea level surrounded by hill ranges from north to south, it is known as the 'City of Palaces' also known as Royal City. Kukkarahalli lake is located in the heart of the Mysore city, near the campus of the University of Mysore called Manasagangothri. It is one of the largest water bodies in Mysore district, Karnataka State, India. The north eastern part of the lake foreshore area is well wooded, the western boundary is fenced and there are few academic institutions near the western boundary of the lake. Kukkarahalli Lake is bounded by Mysore - Hunsur road at North and at the South by Saraswathipuram residential area. At the Eastern side there is administrative building called Crawford Hall of the University of Mysore and at Western side, UGC Academic Staff College and Guest House are located. Two famous lakes of Mysore City are the Karanaji Lake and the Kukkarahalli Lake.

Kukkarahalli Lake is located at 12. 18’ 18” N, 76. 32’ 60” E, in the heart of Mysore city within the campus of Mysore University. Mummadi Krishnaraja Wodeyar (1794–1868) of the Mysore Dynasty was responsible for getting the lake created, in the year 1864, to provide water for irrigation to about 4000 ha (10,000 acres) of land outside the city. Being part of the prestigious Mysore University campus, this lake is instrumental for more than hundred scientific papers. The Lake drains a catchment area of more than 414 square kilometers (160 sq miles) and the water body spreads over 62 hectares. Devan poornaiah feeder canal, 27km (17miles) long, which passes through Hinkal, Bogadi, Kudremala and Manasagangotri outfalls into the Lake. The Lake is “J” shaped, maximum depth of lake is reported to be 5 m(16 ft).

The extent of foreshore area is about 55 hectares, plantations of eucalyptus, acacia, teak and coconut are observed on the foreshore area. Moreover, other varieties of trees included are banyan, tamarind, gobli, palm, ashoka and other mixed species. A small garden has been developed near the entrance of the lake. The lake was once a big attraction to bird watchers. A beautiful small island in north-west and the wooded fringes of the lake support a large number of birds. And also these lakes are popular picnic spots and are frequented by nature lovers as they attract a number of migratory birds. Large number of academicians, students, citizens and tourists visit the lake, and has inspired many local poets and writers. According to naturalist, about 180 species of birds (a large number of them migratory birds, including birds from Siberia) and about 10,000 to 15,000 of them visit the lake during every winter mainly to roost. Organized bird watching expeditions around the lake used to be
actively pursued by the Mysore Amateur Naturalists (MAN) Association. On the south, a huge earthen bund has been constructed and people taking a walk in the morning and in the evening. The narrow path, about 3 m wide has on either side plantation of Ashoka trees at intervals, interspersed with benches. In the past, water to Kuakkarahalli lake was supplied by the Purnaiah Canal stretching about 22 km which used to divert the excess rain water from the lake for maintaining the level of the lake with fresh water over two decades, sewage and excessive land encroachments (mostly illegal) and blockage of water flow sources almost led to the eutrophication of the lake. Dewan Poornaiah feeder canal, 27 km (17 miles) long, which passes through Kudremala, Manasagangotri, Hinkal and Bogadi, outfalls into the lake. Sandy loam to clay loam forms the dominant geological condition of the lake. On the northern side another temporary bund hold back the direct flow of domestic sewage into the lakes. Over the years the lake has deteriorated. The main causes are the inflow of untreated sewage water from Padavarahalli and Jayalakshmipuram areas of Mysore city. With the aid of Asian Development Bank (ADB), State Government agency of (K.U.I.D.B) successfully diverted the sewage water inflow from the tank to treatment plant. Improper planning of new extension and encroachment has destroyed the feeder canal of the lake. The restoration of the lake without restoring the feeder canal is resulting into fast eutrophication, but often, timely rain is saving the lake. And now after trying many other methods, the Mysore University has undertaken the task of clearing algae and other weeds from the water surface, also they have employed a `sand sucking boat' to clear the dead plankton, weeds and the dead algae which have made the place stinky. The lake is under chemical treatment to remove the foul smell emanating from the decay collected on the water surface. In recent years, with the lake getting into a eutrophic state, the number of birds visiting the lake has substantially decreased. Now, the number of birds visiting the lake has reduced to about 2,000. They are found to breed in the isolated bird island with this lake. The birds now found in the lake are Spot-billed Pelicans, Little Cormorant, Painted Storks, Openbill Storks, Eurasian Spoonbills, Black-crowned Night Herons and Oriental Darters. Nearly 30 species of birds breed in the environs of this lake, on the surrounding trees provide roost to birds. Ready dispersal via water birds certainly appears to promote zooplankton diversity in this water body system.

This canal was systematically destroyed by human activities like constructions of road and petrol bunks, by this time untreated sewage from the catchment area started to flow into the lake. Thus, the gradual reduction in fresh water inflow was balanced by increased amount of sewage flow. Several steps are being taken to restore the lake to its old beauty. The sewage inflow is being diverted and the water weeds are cleared under ADB assistance as a part of restoration of this lake.
2.2. Description of sampling sites:

For better scholarly output, the sites are chosen scientifically, based on different aquatic habitats. The sampling points were selected for analysis of zooplankton from October 2010 to May 2012. Five sampling points were selected for this purpose from the five sides of the lake along the edge from the places of human activities. The morphologic characteristics, aquatic weeds, fishing places, and migratory birds etc., were considered during the selection of the sampling sites, so as the water samples represent the entire lake. The maps of each sampling sites were show the exact location of sampling points and other features were done at five different sites around the lake as mentioned in the (Fig.1). The water samples for both physico – chemical and zooplankton analysis were collected simultaneously in all sampling sites.
S1 – Sampling site, at the South-East of the Lake
S2 – Sampling site, at the North – East of the Lake
S3 – Sampling site, at the North – East end of the Lake
S4 – Sampling site, at the North – end of the Lake
S5 – Sampling site, at the South – East of the Lake

Fig.2.1: Map showing sampling Sites of Kukkarahalli Lake.
2.2.1.1 Site – I : This site is situated at the North side of the lake, here the human activities are more due to fishing. The site water is covered with fish scales, plastics and other foreign particles, debris and also with aquatic algae (Plate. 2.1).

2.2.1.2 Site – II : The site is situated on the way parallel to Hunsur road. Here, the lake expresses its full fledged deepness. Here we see water out-let which opens to much sewage. This sampling site is situated in north side of the Kukkarahalli Lake and here most of the sewage enters to the Kukkarahalli Lake from the Paduvarahalli residential area. So that this part of the lake has indirect contact with the foreign particles like plastic covers, flowers, food particles etc,. Also we notice the presence of aquatic birds and insects (Plate.2.2).

2.2.1.3 Site - III: The site is situated at the South end of the lake, the water is flourished with grass as well as aquatic algae, the boating activity is completely stopped in the lake, so wooden boats are found in this site and no trees are found in this site (Plate.2.3).

2.2.1.4 Site-VI: The sampling site is situated at the East side of the Kukkarahalli Lake. Many trees are found here and the water is covered with dead leaves and also with aquatic algae. The site is comparatively free from human intervention and other anthropogenic activities (Plate.2.4).

2.2.1.5 Site-V: The sampling site is located at the corner-side of the island. Many trees are found here and this island seasonally works as a bird sanctuary. Here, water is flourished with grass as well as aquatic algae. And also many trees and aquatic birds are found, and also this site is occupied with bird droppings and organic matter decomposition. Water of this area is completely occupied with the sunlight in day time, so that the water temperature is always high (Plate.2.5).
Plate 2.1. Collection of water samples at site – 1
Plate 2.2. Collection of water samples and Zooplankton samples at site-II
Plate 2.3. Collection of water samples and Zooplankton samples at site -3
Plate 2.4. Collection of water samples and Zooplankton samples at site -IV
Plate 2.5. Collection of water samples and Zooplankton samples at site - V
2.3. Sample collection

Surface water samples were collected from five different sampling sites as shown in Fig 1. For the analysis of the physico-chemical parameters the surface water samples were collected in five-liter plastic canes, early in the morning (6-8 am) from each site, every month from October 2010 to September 2012. The water quality analysis of the lakes gives the exact nature, cause of the pollutants, if any. The physical parameters such as temperature, conductivity and turbidity play an important role in lake productivity. The levels of chemical parameters including the pH, dissolved minerals, dissolved gases and nutrients decide the quality of lake water.

2.4. Collection and Estimation of Physico-Chemical parameters:

Monthly, surface water samples were collected early in the morning between 6-8 AM from each sampling site, from October 2010 - September 2012. In the field itself, Air temperature, Water temperature, Field pH was measured. Collected samples were brought to the laboratory and the following physico-chemical parameters were determined: Lab pH, Conductivity, Turbidity, Dissolved Oxygen, CO₂, Hardness, Chloride, Phosphate, Sulphate, Nitrate, and Alkalinity by employing the standard methods as described in [Trivedi and Goel, 1986; and APHA, 1992].

2.4.1 Temperature (°C)

Measurement of temperature is an important water parameter required to get clear idea about self-purification of lakes. Soon after collection of surface water sample the air temperature and water temperature were measured based on the rise in the mercury levels on the temperature sensitive electrodes.

2.4.2 Field pH

pH is defined as the intensity of the acidic or basic character of given sample at a given temperature. It is the negative logarithm ion concentration. pH values from 0 to 7 are diminishingly acidic, where as values of 7 to 14 are increasingly alkaline. At 25°C, pH7.0 is neutral. The pH was recorded with the help of the pH meter (model H 196107) with glass electrode [HANNA Instruments, Italy]. The electrode was calibrated against pH 4.0 and 7.0 buffer. Each time before measurements, after the calibration the electrode was dipped into the plastic canes containing the collected water sample till a steady and quiescent pH reading was obtained.
2.4.3 Dissolved Oxygen (DO, mg/L)

The DO was fixed in the field itself. For this, 300ml BOD Bottle were filled with surface water samples without air bubbles and 2ml of Manganeous Sulphate (MnSO₄) and 2ml of alkaline Potassium Iodide (KI) was added and the bottle was closed with glass stopper and shacked for a minute.

The Iodine precipitate formed was dissolved by the addition of 2 ml concentrated sulphuric acid (H₂SO₄) to already fixed surface water samples. Fifty ml of sample was titrated against 0.025N Sodium-thiosulphate using 1% freshly prepared starch solution as an indicator and the end point was determined by the disappearance of the blue color. Dissolved oxygen in water affects the oxidation – reduction state of many of the chemical compounds. It is extremely useful in self purification of water bodies. The concentration of dissolve oxygen was calculated using the following formula:

\[
\text{DO mg/L} = \frac{\text{MBR} \times N \times 8 \times 1000}{V_2 \left( V_1 - V/V_1 \right)}
\]

Where,

- **MBR** = Mean Burette Reading
- **N** = Normality of Sodium thiosulphate (0.025,)
- **V₁** = Volume of sample bottle after placing the stopper (300 ml)
- **V₂** = Volume of the part of the contents titrated (50 ml)
- **V** = Volume of MnSO₄ and KI and H₂SO₄ added (2+2ml)

On return to the laboratory, to determine the following physico – chemical parameters, all the surface water samples collected were filtered using cotton to remove algae, large debris etc,. This finally filtered sample was used for the determination of the following physico-chemical parameters, in the laboratory.

2.4.4 Lab pH

The pH of the surface water samples were measured again in the laboratory using pH meter (Model 32, Systronics India Ltd, Bangalore).

2.4.5 Conductivity (µS cm⁻¹)

Conductivity is a numerical expression of the ability of an aqueous solution to carry ions. And the surface water samples were measured in the laboratory using micro processor controlled conductivity meter, [Model 306; Systronics India Ltd, Bangalore]. The instrument probe for the measurement was previously calibrated with 0.1M KCl solution at 25°C.
2.4.6. Turbidity (NTU)

Suspension of particles in water interfering with the passage of light is called turbidity. Turbidity was expressed using Nephelo - metric Turbidity Units (NTU) and was measured in the Laboratory using digital Nephelo-Turbidity meter (NTU). The Instruments was set up using distilled water as zero and respective range (0-1, 1-10, 10-100, and 100-1000 NTU) of Farmazine solution.

2.4.7 Free Carbon-di-Oxide (mg/L)

Free carbon dioxide in the waters accumulates due to microbial activity and respiration of organisms. The free CO$_2$ reacts with sodium carbonate or sodium hydroxide to form sodium-bi-carbonate. Completion of the reaction is indicated by the development of pink color. 100 ml of water sample was taken in a clean conical flask and two drops of phenolphthalein indicator was added. However in some of the water samples pink color appeared immediately after the addition of phenolphthalein indicator indicated the complete absence of free CO$_2$. The samples were titrated against 0.05N sodium hydroxide and the titration was continued till the pink color appeared. Three replicate samples were used for each sample. The free CO$_2$ of the surface water samples were calculated by using the following formula.

\[
\text{Free } \text{CO}_2, \text{ mg/L} = \frac{\text{MBR} \times N \times 44 \times 1000}{\text{ml of sample} \times [100 \text{ ml}]} \\
\]

Where,

- MBR = Mean Burette Reading
- N =Normality of NaOH [0.05]

2.4.8. Hardness (mg/L)

The hardness of water is the measure of the capacity of the water to react with soap. Hardness of the surface water samples were determined by titrimetric method. Fifty ml of surface water samples in triplicate for each site samples was taken in 250 ml conical flask, 1 ml of ammonia buffer solution and 100-200 mg of Erichrome Black-T indicator were added to it. The content of this flask were then titrated against 0.01M ethylene diamine tetra acetic acid (EDTA) solution and titration was continued until the end point indicated by color change from wine red to blue color. The hardness of surface water were calculated by following formula:

\[
\text{Total Hardness, mg/L} = \frac{\text{MBR} \times 1000}{\text{ml of sample taken} \times (50\text{ml})} \\
\]

Where, MBR = Mean burette reading
2.4.9. Alkalinity (mg/L)

Alkalinity of water is its acid neutralizing capacity and it is a measure of amount of strong acid needed to lower the pH of a sample to 8.3, which gives free alkalinity (phenolphthalein alkalinity) and to a pH 4.5 gives free alkalinity. The total alkalinity is the sum of hydroxides, carbonates and bicarbonates. 100ml of surface water samples in triplicate was taken in to 250 ml conical flask and 2 drops of phenolphthalein indicator was added. If the solution remains colorless alkalinity is zero, if the color changes to pink titrated with 0.1N HCl till the color disappeared. To this solution 2 drops methyl orange was added and titration was continued until the yellow color changes to pink color. The total alkalinity was calculated using the formula,

\[
\text{Total alkalinity, mg/L} = \frac{\text{MBR} \times N \times 1000 \times 50}{\text{ml of sample taken (100ml)}}
\]

Where,
- MBR = Mean Burette Reading
- N = Normality of HCl (0.1N)

2.4.10. Chloride (mg/L)

Chloride anion is generally present in waters. The presence of chloride in natural waters can be attributed to the dissolution of salt deposits, irrigation drainage and sewage discharges. Determination of chlorides in the sample, about 50 ml of the surface water sample in triplicate, for each sample, was taken in to 250 ml comical flask and 2 drops of phenolphthalein indicator was added. or three conical flasks and 2 ml of 5% potassium chromate was added to each of them. The contents of these conical flasks were titrated against 0.02 N silver nitrate solutions. The titration was continued till the end point indicated by color change from yellow to brick red precipitate. The chloride content of the surface water samples were calculated by the following formula:

\[
\text{Chloride (mg/L)} = \frac{\text{MBR} \times N \times 35.5 \times 1000}{\text{ml of sample taken (100ml)}}
\]

Where, MBR = Mean Burette Reading
- N = Normality of AgNO₃ [0.02N]

2.4.11. Inorganic phosphate (mg/L)

Inorganic phosphate content of the surface water sample was determined by using stannous chloride method as described in Trivedi and Goel (1985). Phosphorus is a nutrient for plant and animals and also it controls algal growth and primary productivity. About Fifty ml of samples, standard and blank were taken in 100 ml capacity conical flasks (Borosil). 2 ml of ammonium molybdate and 5 drops of stannous chloride was added.
Finally, samples were mixed thoroughly and the intensity of blue color obtained is proportional to the amount of phosphates was noted (APHA, 1985) and the optical density of these samples were measured at 690 nm using photoelectric calorimeter.

For the preparing standard graph, the standard solution was prepared by using anhydrous di-potassium hydrogen phosphate. For this, 10 different concentrations (0.1 to 1.0 mg/L) of the standard phosphates solution were taken in ten different conical flasks; volume in these flasks was made up to 50 ml using distilled water. Similar procedure was followed for the determination of OD of the samples. The standard curve was plotted using concentration (mg/L) v/s absorbance (nm). The concentration of phosphate was determined from the standard graph and also calculated by using following formula:

\[
\text{Concentration of phosphate, mg/L} = \frac{\text{O.D. of sample} \times \text{concentration of standard}}{\text{O.D. of standard taken}}
\]

2.4.12. Nitrate (mg/L)

Nitrate is the most highly oxidized form of nitrogen compounds commonly present in natural waters, it is the product of aerobic decomposition of organic nitrogenous matter. Nitrate content of the surface water sample was determined by Brucine method as described in Trivedi and Goel (1986). Ten ml of the surface water sample from each site was taken in test tube kept in cold water bath to which 2ml of sodium chloride and 0.5 ml of Burine sulphonilic acid solution was added. A blank was also prepared in a similar manner using 10ml of distilled water instead of water sample. Next, these test tubes were heated on water bath for 20 minutes after cooling. The optical density of the sample was measured at 410nm using photoelectric calorimeter (Systronics Ltd, Bombay).

For the preparation of standard graph, the standard nitrate solution of 1mg/L was prepared using potassium nitrate. Ten different concentration (0.1 to 1.0) mg/L) of the standard nitrate solution were taken in 10 different test tubes. Volume in these test tubes was made up to 10 ml using distilled water and the same chemical solution were added employing the same procedure as far as the sample. The optical density of these standard solutions was measured at 410 nm. The standard curve was plotted using concentration (mg/L) nitrate solution against absorbance (nm). The concentration of nitrate was determined from this standard graph, and also the nitrate content of the surface water samples were calculated by using the following formula:

\[
\text{Concentration of Nitrate, mg/L} = \frac{\text{O.D. sample} \times \text{concentration of standard}}{\text{O.D. of standard}}
\]

Determination of nitrate concentration from the standard graph and using the formula, gave similar results.
2.4.13. Sulphate (mg/L)

Sulphate ions usually occur in natural waters. They contribute to the permanent hardness. Sulphate ions are precipitated as barium sulphate in acidic medium with barium chloride. The absorption of light by this precipitated suspension is measured spectrophotometrically at 420 nm. Sulphate content of the surface water sample was determined by turbidimetric method as described in Trivedi and Goel (1986). Hundred ml of surface water sample from each site was taken in a 250 ml borosil conical flask. Five ml of conditioning reagent [conditioning reagent : mixed 50 ml of glycerol with a solution containing 30ml concentrated hydrochloric acid, 300 ml distilled water,100ml 95% ethyl alcohol and 75g sodium chloride.] and 10 mg of Barium chloride crystals were added to this flask. A blank was also prepared in a similar manner using 100 ml distilled water instead of surface water samples. The optical density of these was measured at 420 nm using photoelectric calorimeter [Systronics Ltd, Bombay].

For preparing standard graph, a standard sulphate solution was prepared by using anhydrous disodium sulphate. Ten different concentration [5, 10, 15, 20, 25, 30, 35, 40, 45, 50 mg/L] of the standard sulphates solution were taken in 10 different conical flasks. Volume in these flasks was made up to 100 ml using distilled water. Similar procedure was followed as for the determination of OD of the samples. The standard curve was plotted using concentration (mgL\(^{-1}\)) v/s absorbance (mm). The concentration of sulphate was determined from this standard curve and also using the following formula:

\[
\text{Concentration of sulphate (mg/L)} = \frac{\text{OD of sample} \times \text{concentration of standard}}{\text{O.D of standard taken}}
\]

Determination of Sulphate concentration from the standard graph and using the formula, gave similar results.

2.5 Collection of water samples for estimation at different Zooplankton groups:

For the analysis Zooplankton groups like Rotifers, Cladocerans, Copepods (Calanoids, Cyclooids and Harpacticoids) and Ostracods, samples were collected randomly in different locations of the lake during early hours of the day 6.00AM – 8.00AM for a period of two year October 2010 to September 2012. The zooplankton net was made by the bolting nylon silk (mesh size 50nm) was used for collection of zooplankton. This net was conical shape and reducing cone with the bottle at its end. For quantitative analysis collection of zooplankton, the net is towed horizontally and obliquely in surface water of the study area. For quantitative analysis, ten bucket full of water (one bucket = 10 liters) samples were collected from each sampling sites and filtered out through the net. After transferring the sample in air tight plastic bottles, it was kept carefully with labeling and
preserved immediately using 4% formaldehyde. After returning to the laboratory 1 ml from this concentrated zooplankton sample from each sampling sites, were observed under the microscope (40X) (Olympus Cx21). Systematic identification and counting was done by using key given in [Edmondson, 1959; and Battish, 1992].

2.6 Enumeration of Zooplankton:

For quantitative zooplankton study, a Sedgwick Rafter cell was used which is 50mm long, 20mm wide and 1mm depth. One ml from the concentrated sample from each sampling site was transferred into Sedgwick Rafter counting chamber, and the air bubbles were avoided while transferring the sample to the cell. Moreover, before counting the zooplankton, it was ensured that all the organisms have settled down. Every sample was counted for the zooplankton at least five times and an average was taken for the samples of each month for two year, during 2010-2012. The qualitative and quantitative analyses of zooplankton were performed using standard methods [Needham and Needham, 1962; Edmonson, 1965; Tonapi, 1980; Adoni et al., 1985; Michael and Sharma, 1988; Battish, 1992; Korovchinsky and Smirnov, 1998; Danapati, 2000 and Altaff, 2004].

The abundance of zooplankton was carried out by using the following formula:

\[
\text{No: of Organisms/m}^3 = \frac{C \times V_1}{V_2 \times V_3}
\]

Where,

- \(C\) = No: of organisms counted
- \(V_1\) = Volume of concentrated sample (50 ml)
- \(V_2\) = Volume of sample counted (1 ml)
- \(V_3\) = Volume of grab sample (0.1 m³)

Finally, to obtain organisms/ L, the number of organisms per m³ was divided by 1000.

2.7 Diversity of zooplankton groups:

Species composition of four groups of zooplankton was scored in the same sample after determining the abundance of zooplankton. Different species of Rotifer, Cladocera, Copepod and Ostracod were separated under binocular stereomicroscope and mounted on glass slide with eosin and observed under compound microscope. The identification of zooplankton was based on morphological and taxonomic key characters described by [Edmondson, 1959; Battish, 1992; Michael and Sharma, 1988; Dussart and Defaye 1995; Dhanpathi, 2000; and Altaff, 2004].
2.8 Ecological indices:

Eight diversity indices such as Dominance, Shannon-Wiener index (1949), Simpson (1949), Evenness, Menhinick (1964), Margalef (1968), Fisher_alpha (Fisher et al., 1943) and Berger-Parker (1970) have been calculated using the PAST software program.

2.8.1. Index of Dominance (C)
\[ C = \sum (n_i/N)^2 \]
Where,
\( n_i \) = number of individual for each species
\( N \) = total of important species

2.8.2. Shanon index of general diversity (H)
\[ H = -\sum (n_i/N \log(n_i/N)) \] or \[ H = -\sum P_i \log P_i \]
Where,
\( n_i \) =importance value for each species
\( N \) = Total of importance values
\( P_i \) = importance of probability of each species = \( n_i/N \).

2.8.3. Simpson Dominance Index (1-D)
\[ D = \sum (n(n-1)/N(N-1)) \]
\( n \) = the total number of organisms for particular species
\( N \) = the total number of organism of all species

2.8.4 Eveness index (e)
\[ E = H/\log S \]
Where,
\( H \) = Shanon index
\( S \) = number of species

2.8.5 Richness Index (d)

2.8.5.1 Menhinick's species index (D)
Since the larger the sample, the more species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. This particular measure of species richness is known as D (Whittaker 1977). The Species Diversity Index was calculated by using the formula given by Menhinich (1964).

\[ D = \frac{S}{\sqrt{N}} \]
Where,
\( D \) = Menhinich’s diversity index
\[ S = \text{Total number of species in the sample} \]
\[ N = \text{Total number of individuals in the sample} \]
\[ \sqrt{N} = \text{Total number of organism(density)}. \]

### 2.8.5.2 Margalef’s Index (d)

Margalef’s d value is a measure of species richness, which is expressed by the equation, Richness Index (d) is given as:

\[ d = S - 1/ \log N \]

Where,

- \( d \) = Margalef’s diversity index
- \( S \) = Total number of species
- \( N \) = Total number of individuals.

### 2.8.6. Fisher_alpha index

The Fisher index is a parametric index of diversity which assumes that the abundance of species follows the log series distribution and is expressed as:

\[ ax, ax^2/2, ax^3/3, \ldots, ax^n/n \]

### 2.8.7. Berger- Parker Dominance Index

The Berger-Parker Dominance Index is a simple measure of the numerical importance of the most abundant species.

\[ d = \frac{N_{\text{max}}}{N} \]

Where,

- \( N_{\text{max}} \) = The number of individuals in the most abundant species
- \( N \) = The total number of individuals in the sample.

A reciprocal of the Index 1/d is often used so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

### 2.9. Statistical analysis:

Following statistical tests were carried out with the help of SPSS 14.0 version.

#### 2.9.1. Students Newman Kuels Test (SNK-test)

This is one way ANOVA post hoc test, for making multiple comparisons amongst the means.

#### 2.9.2. Correlation

Relationship between the Physico-chemical parameters and four groups of zooplankton variables were examined using Pearson’s correlation coefficient. This is calculated after log 10 transformation of all the calculated data.
2.9.3. **Multiple Regression Analysis** – This was used with four groups of zooplankton variables as dependant variables and Physico-chemical parameters as independent variables to understand which of the Physico-chemical parameter was affecting the zooplankton variables.

2.9.4. **Correlation**

Correlations were examined using Pearson's correlation co-efficient. Values of Pearson's correlation co-efficient, calculated after log$_{10}$ transformation, and were generally used to help interpret the results, described in this thesis.

**Results Obtained by using these methods have been given in next chapter 3 and also have been discussed as appropriate in chapter 4.**