Chapter One

Introduction

1.1 Background

71% of the earth's surface is covered by water. Of the total water 97% remains in seas as salt water and remaining 3% exists as freshwater in rivers, lakes, streams, reservoirs, glaciers etc. (wetzel, 1903)

The land locked Himalayan Kingdom of Nepal has a fascinating geography, climate and altitude. Nepal is a small country with an area of 1,47,181 sq.km. It lies between India in the South and China in the North and stands between latitude of 26^o22' to 30^o27' North and it's longitude between 80^o4' and 88^o12' East. It extends 885 km. along east-west with an average width of 193 km. along North-South.

Within this limited area, there exists a remarkable altitudinal variation ranging from plain in the south with hot tropical climate to mountain region of temperate climate and very cold alpine in Himalayan region. The southern Terai region is an extension of Indo-Gangetic plains, on it's North lies the Churia range. It's average elevation range between 300m to 500m, which at places, reaches about 1800m (Rao & Gupta, 1998). North of the Churia range, lies on Mahabharat hills, with rugged terrains, deep valleys and incised rivers. On the north of Mahabharat lies the Himalayan range that contains snow throughout the year.

In Nepal, rainfall occurs due to the south west monsoon, which lasts from June to September. The humid monsoon air stream blowing from the Bengal is forced to rise as it meets the Himalayas as a result heavy rainfall occurs.

According to Department of Hydrology and Mateorology, Nepal receives about 1500 mm rainfall during good monsoon regime.

1.2 Water Resource of Nepal

The beautiful kingdom of Nepal is blessed by nature with a varying array of water bodies having immense treasure of fish fauna. The country has two types of aquatic environment (Lotic- running water and lentic-the standing water) which is the major resource after land.

Nepal has considerably vast water resources in the form of rivers, lakes, ponds and reservoirs and is the second richest country in the world possessing about 2.27% of world's water resource. In Nepal there are more than 6000 rivers with total length exceeding 45,000 km.

Shrestha (1981) referred the total area occupied by water to be about 5,76011 hectare i.e. about 5.5% of total land area and it is in the form of lakes, ponds, rivers, and reservoirs. The report of ADB/N (1982) APROSC (1985) has reviewed the water area occupied by different village ponds to be 6000 hectare, 5000 hectares by lakes, 395,00 hectare by rivers and 1380 hectare by reservoirs. NPC (1980) estimated the total area occupied by irrigated rice fields to be 606,623 hectares.

1.3 River System in Nepal

Rivers of Nepal are classified into three categories on the basis of their origin. The first group of rivers have their sources in snow and glaciers.

The Mahakali, the Karnali, the Saptakoshi and Gandaki are the four rivers in the first category. The second group of rivers originate in the middle mountains, which are mostly rain fed. Bagmati, West Rapti, Mechi, Kankai, Kamala and Babai are the rivers in the second category. The rivers of third category originate in the Churia southern face of the Mahabharat or in the Terai. These rivers have small catchment area. In the dry season discharge of these rivers becomes nominal, while several rivers dry up. Tilawe, Sirsia, Manusmara, Hardinath, Sunsari, Banganga are some of the rivers of this category.

There are four major rivers systems in Nepal, which drain out the country. They are Saptakoshi in the east, Saptagandaki in the central, Karnali in the west and Mahakali in the far-west. The Saptakoshi, Saptagandaki and Karnali cross Himalayas and originate from the Tibetan plateau. Each river system has seven tributaries which are fed by snow and glaciers melt from Tibetan plateau and Himalayas. Thus, these river systems are Saptakoshi, Saptagandaki and Saptakarnali.

1.3.1 The Saptakoshi River System

Koshi is the greatest river system of Nepal from the point of view of drainage area. It is as big as Indus and Bhramaputra rivers of India. It flows particularly in the eastern Nepal. The seven tributaries of Koshi river system are the Arunkoshi, the Dudha Koshi, the Indrawati, the Likhu, the Sunkoshi, the Tamakoshi and the Tamar.

1.3.2 The Karnali River System

Karnali rises in the Tibetan region of China near Lampiya Dhura, passes between India and Tibet. It enters Nepal in a gorge through the Lekh. It is said to be the major river system in the western Nepal. The seven Tributaries of Karnali river system are the Saptakarnali, the Burhi Ganga, the Humla Karnali, the Mugu Karnali, the Seti Karnali, the Sani Bheri, the Thuli Bheri and the Tila.

1.3.3 The Gandaki River System

The Gandaki river arises from south of Mansarovar and Rara lake. It flows between Dhaulagiri and Gosaithan. Burhi Gandaki, Marsyngdi, Seti and Trisuli Ganga join it in the mid land part. It flows through Churia hills makes it's way at Tribenighat and appears in the plains forming Narayani river. The tributaries of this river system are as the Burhi Gandaki, the Kaligandaki, the Modi, the Myagdi, the Marsyangdi Khola, the Seti Khola, and Trisuli Khola.

1.3.4 The Mahakali System

It makes the western border of Nepal and starts from Milan glaciers of India and Lipu Lekh of Nepal. It goes south west making numerous oxbow lakes in Indian territory. It has 182 sq. km. drainage area.

1.4 Lakes, Reservoirs and Ponds

Numerous natural and semi-natural lakes are present in Nepal. They are source of food & recreation. Lakes may be classified geologically as glacial, tectonic and oxbow lakes. In general, lakes of Nepal are of two types. One of them is the type of lake which does not freeze at any time of year. Such lakes are located in valleys of mid-land Nepal. The other type includes lakes which partly and fully freeze at least a part of the year. Such lakes are usually situated at higher elevation. The important lakes falling in the first category are Fewa, Rupa, Begnas, Dipang Tal, Maidital, Kalchhuman Tal, Dudh Pokhari (Gorkha), Satyabati Tal (Palpa), Kasara Tal (Chitwan), Madan Tal (Palhi), Barakunde Tal (Twelve sided, Dang), Shyarpu Tal (Jajarkot), Surma sarobar (Bhajhang), Khaptad Tal (Doti), Taudaha and Katuwal Daha (Kathmandu). The lakes of second category freeze during winter which are Rara or Mahendra Tal (in Mahalangur Himal).

The eutrophic lakes of Nepal have greenish or brownish water. The water in such lake is never transparent and are laden with nutrients. The lake Rani Tal of Kanchanpur is of this category. The oligotrophic lakes comprise the largest expanses of water body in Nepal. Generally the oligotrophic lakes have transparent water, lack much dissolved nutrients and thus have little planktonic algae. In such lakes the upper layers of water are sufficiently rich in dissolved oxyen to maintain aquatic life thoughout the year. The lake Rara or Mahendra Tal is an ideal example of oligotrophic lake. This lake was formed due to river capture in geological past.

Reservoirs are constructed for hydroelectric power generation, irrigation and drinking purposes.

Pond is a small shallow body of water in which aquatic plants usually grow in abundance. The ponds may have any dimensions, although a depth of more than 30 feet is rare to find. An ideal depth may be between 6-7 feet from the point of view planktonic production. The Source of water supply to the pond may be from spring, rivers, lakes, reservoirs, canals, rain water etc.

Ponds are important not only for ecological and hydrological processes but also for the economical, sociological, recreational, religious and aesthetic values.

These ecosystems support the world most productive environment. Ponds provide wood, fodder, energy feed resources, very popular recreational sites, landscapes and store large quantity of water during dry season. Ponds provide valuable aquatic plants used as vegetable fruits and fibers for making mats and cloth, raw material for synthesizing local medicines and grasses for hatching. Some ponds like Gangasagar, Dhanusasagar, Ratna Sagar have great religious significance.

Pond water is the key natural resource supporting the economic development in Asian region particularly to a poor country like Nepal where people are undernourished and the source of proteinous food is extremely low. The Physico-Chemical factors of pond water are important from the point of view of planktonic production which inturn are directly related to fish production. Ponds provide critical habitats for many species of flora and fauna. Countless mammals, birds, reptiles, fishes, amphibians and invertebrates species depend on these habitats for their survival. Their value is further evidenced by the fact that ponds can produce up eight times as much plant matter as wheat field. This productivity depends on the proper ecological functioning of ponds. Both in Industrialized and developing countries, ponds are the scene of activities and practices that are not always compatible with the very existence of these sites. (Ansari, 1996)

The fauna of aquatic environment may be classified into:

a) Temporary fauna, consisting of the animals passing only a part of their lives in water. e.g. Ephemeroptera, Hemiptera, Plecoptera, Odonata, Trichoptera etc.
b) The permanent fauna, consisting of those animals, ending their whole lives in water e.g. Zoopolankton, Nematoda, Oligochaetes, Molluscs etc.

The most important organisms found in ponds are benthos. The term benthos meaning all bottom dwelling organisms from the upper most water bearing portions of beach to the greatest depth. The benthos vary widely with different conditions of bottom both at the some level and so marked that it is difficult to discuss them as a whole.

Zooplanktons are the most important organisms found in pond ecosystem. They are Microscopic, free swimming animals belonging to the taxonomic groups i.e. protozoa, rotifera, cladocera, cyclopoda, copepoda etc. They are endowed with many remarkable features and are often armoured with spines, which hamper their predation by higher organisms. They constitute an important link between primary producers and consumers of higher order in aquatic food web. They feed upon phytoplanktons and which inturn form the food of fishes.

1.5 Scope of the Study

For the present dissertation work, the village pond "Dauna" located at Panga, Ward no. 11 of Kirtipur Municipality was selected because the researcher expects good results from this pond. Pond "Dauna" is located beyond the human crowded Kirtipur town in a very much peaceful area, and is not even exposed to most of people of Kirtipur. The scenic beauty provided by the beautiful vegetations including beautiful flowers encircling the pond, has not yet been able to attract most of the people to provide it's recreational and aesthetic value because of the poor physical conditions and lack of maintenance and information about it. Therefore, the present study was conducted, to study the Physico-Chemical and biological parameters in terms of pond productivity and to suggest the necessary steps to be performed to convert the pond in to the fish culture pond. So that together with it's recreational value the pond would be used to generate money from visitors. The depth, size, soil type, topographical feature of the pond are appropriate, which is a possibility for best fish culture and generation of money after suggesting necessary steps to improve pond productivity through scientific study.

1.6 Limitations

1. The limitations of the present study are as

a) Because of the time limitation, the researcher was not able to deal with many physical, chemical parameters and among biological parameters only zooplanktons were included in the study.

b) Because of the time limitations, the conditions of various animals including fishes could not be carried out.

1.7 Objectives of the Study

b. The main objectives of the present study were

1. To investigate the water quality of the pond
2. To investigate the abundance and distribution of zooplanktons of the pond.
3. To investigate the fluctuation of Physico-Chemical parameters and their effects on abundance and distribution of zoopalnktons of this pond.
4. To know the possibility of fish culture in this pond

1.8 Justification of the Study

Following points justify the purpose of the study.

1) Though, Nepal has large number of lentic and lotic water bodies, only a few study has been done in the field of limnology.

2) As the zooplankton form the major food of fishes and their larvae and production of zooplankton in a pond and water quality are closely related, therefore, the study on the production of zooplankton in relation to Physico-Chemical parameters may contribute to fish culture practice.

3) Knowledge about the effect of Physico-Chemical parameters on abundance and distribution of zooplankton is very important from the point of view of pond productivity.
4) To study whether, the pond "Dauna" is suitable for fish culture or not.
5) Data could be easily collected and the study was suitable from the point of view of time and cost.

Chapter Two

Literature Review

The study of freshwater ecosystem is known as limnology. The word limnology was derived from the Greek word "Limne" which means lakes or ponds. Limnology was first defined by the Swiss Professor Forel (1892) as oceanography of lakes and he has been known as father of Limnology. In other words Limnology can be defined as the branch of science which deals with the study of freshwater ecosystem of all kinds of lakes, reservoirs, streams, ponds, marshes, bogs, etc. physically, chemically and biologically.

Forel (1892) worked on Swiss lakes and published a book "Le Lemon" in three volumes. The first text on limnology was also published by Forel in 1901. "The Science of Lakes" is an inspiring book written by him, which proves as impetus for investigations on freshwaters. The pioneer workers as Welch (1952) and Ruttner (1953) wrote books on limnology and laid down firm foundation of this branch of science. Later on several books on limnology were published by several workers. Hutchinson (1975) published "Treatise on limnology". The book limnology was published by Wetzel (1975) and in the same year Cole published "Text book on Limnology."

Thienemann (1925) was associated with Limnology studies particularly those relating the classification of lakes based on oxygen concentration and species midge (chironomidae) of bottom mud.

Hynes (1970) has shown his long term interest on running water by publishing a book on freshwater ecology.

The physical limnology was studied in Switzerland and Scotland and study of microbial limnology was rooted in Russia (Goldman 1983).

The Limnological studies of freshwater have been done from time to time by several investigators.

Hall, Davis, and Volenta (1963) were the workers who outlined the results of Physico-Chemical analysis of Zambezi Majabique manmade lake in the province of Holland.

Hopkins (1971) Studied the annual temperature regime of small stream in New Zealand.

Huntsinger and Moslim (1972) studied comparative limnological characteristics of basins of eagle lake, California (USA) and discussed most of the bio-Physico-Chemical conditions of each lake.

Hoenel and Johnson (1972) investigated the characteristics of Great Bear Lake in relation to productivity and phytoplankton biomass, correspondingly with Physico-Chemical parameters.

Holman et. al. (1975) studied the chemical and biological characteristics of water column in lake Tohae.

Barbato (1983) studied on the Physico-Chemical characteristics of water as it's plankton, benthos and fish population of Frossion in Italy.

Campos (1988) did the qualitative and quantitative analysis of seasonal variation of phytoplanktons and zooplanktons in lake caurgue. (chile)

Taylor and Mariam (1988) studied on the size structure and productivity of plankton community of an Ethiopian rift valley lake.

Iwakuma et. al. (1989) studied on primary production of phytoplankton and secondary production of Daphnia and Chaobid in Eutrophic pond of Japan.

Malin (1989) did some limnological works on pelagic and near shore plankton communities of lake Adape in France.

Lair and Ayadi (1989) studied on seasonal succession of planktonic events in a lake of France.

Limnological studies of Indian freshwater were started by early part of the century. Since then, lots of works have been done by various workers.

Hutchinson (1932) initiated the study of limnology in Kasmir lakes.

Pruthi (1933) reported seasonal changes in the physical and chemical conditions of the water in tank in Indian Museum compound.

Phillpose (1940) studied ecology and succession in a permanent pool at Madras city.

Ganapati (1941) made divergent limnological investigations on freshwater ponds of Madras city.

Chacko and Krishna Murthy (1954) studied ecology of plankton of three freshwater ponds of Madras city.

Singh (1956) studied on limnological relations of Indian inland waters with special reference to the algal blooms. In the same year Das and Shrivastava studied on plankton from freshwater ponds and tanks of Lucknow.

Shah (1958) did the some works on Physico-Chemical qualities of Calcutta sewage.

George (1961) made ecological observations of Physico-Chemical nature of water, zooplanktons, and rotifers of certain shallow ponds of Delhi.

Nayar (1965) studied ecology of rotifer population in two ponds of Pilani, Rajstan.

Banerjee (1967) studied water quality and soil conditions of fish ponds in some state of India in relation to fish production.

Zutshi and Vass (1972) studied limnology of high altitude Kasmir Lake.

Kant and Kachro (1975) recorded the diurnal changes in the temperature and PH of water movement of plankton in Dal lake of Srinagar, India.

Sharma (1980) studied the plankton and productivity of Udaipur water in comparison to selected water bodies of Rajstan.

Karki (1988) worked on some limnological aspects of selected closed water ecosystem of Udaipur India.

Ayyapan et. al. (1988) studied the variation in water quality, primary production and planktons of a peninsular tank of Orissa India.

Kumari and Abudulazizi (1989) studied the limnology of temple pond in Kerala.

Vass and Langler (1990) studied the changes in primary production and trophic status of Kashmir Oxbow Lake.

Mazhar et. al. (1992) studied the limnology of Dorania river at Bareily.

Pandey at. al. (1992) studied the limnological status at an ancient temple pond of Deogarh, Bihar.

Sen et. al. (1992) studied the physicochemistry, nutrient budget and the factors influencing primary production of a tropical lake at Ranchi.

Agrawal et. al. (1995) studied the effects of temperature and redox-potential on biology of Sagar lake.

In contrast to work done in other countries limnological studies in Nepal did not receive much attentions. Only in last few years some detailed works in limnology in Nepalese waters have come forth. Hiriono (1955) has published a few papers concerning to the Nepalese algae. Later on foster (1965) has also published few papers on Nepalese algae.

Brehm (1953) was the first lemnologist who studied some aquatic fauna along with the limnological studies from Kalipokhari, eastern Nepal. Loffle (1969) made limnological investigations of high mountain lakes of "Khumbu Himal".

Hickel (1973) studied planktons of the lake Pokhara valley. He also studied the physical and chemical properties of plankton from the Phewa, Bagnas, Rupa and Khoste lake in 1967 - 1968. Hickel (1973) has also studied the phytoplankton in two ponds of Kathmandu valley.

Ferrow (1978) studied limnology of Pokhara valley lake and it's implication on fishery and fish culture practices.

The limnology of Bagmati and Trisuli rivers has also been studied to some extent by Shrestha et. al. (1979)

Pradhan (1982) carried out preliminary study of Syarpu Daha (Rukum) a mid hill lake of Nepal.

Mandal (1992) conducted limnological investigation in two ponds in relation to seasonal variation of primary productivity and physical factors. A preliminary study of three small water bodies of Kathmandu valley was conducted by the zoology department of T.U., Kathmandu. (Singh, 1978, Shah, 1979 and Joshi, 1980)

Bhattari (1996) studied on hydrological characteristics and primary productivity of Kamal Pokhari, Bhaktapur.

Khadka (1996) studied some parameters of pond Nagdaha, Lalitpur.

Rai (2000) conducted detailed study on limnological characteristics and seasonal abundance of zooplanktons and phytoplanktons from Phewa, Begnas and Rupa Lake in Pokhara valley and reported 26 species of phytoplanktons and 80 species of zooplanktons.

Besides, various limnological works for M. Sc. Dissertation have been done and submitted to the Central Department of Zoology, Tribhuvan University of Kathmandu, by Sharma (1990), Upadhya (1991), Kushwaha (1991), Chherti (1992), Mandal (1992), Kumar (1994), Mahato (1994), Shrestha (1994), Shah (1994), Dangol (1994), Kushwaha (1996), Shrestha (1997), Shah (1998), Shah (1999), Gautam (2003), Shrestha (2004) and Sharma (2004).

Chapter Three

Materials and Methods

3.1 Materials

The materials i.e. the equipments and chemicals used in present study were as follows:

3.1.1 Physical materials

Glass wares

Conical flasks, Burettes, Glass jar, Beakers, Pipettes BOD bottles, droppers, Glass rods, Measuring cylinders and Standard Mercury thermometer.

Laboratory instruments

pH meter, Weighing balance

Other requirements

Burette stand, Plastic bucket, Measuring tape

Chemicals

Winkler's A Solution or $MnSO_4$ Solution, Winkler's B Solution or Alkaline Iodine Solution, Magnesium Sulphate, Potassium Iodide, Sodium Thiosulphate, $Conc^n$ H_2SO_4, Starch Sol^n, Sodium Hydroxide, Phenolphthalein, Methyl orange, HCl, Eriochrome Black - T, Buffer solution, EDTA solution

3.2 Study Area

The present dissertation work was performed in a small village pond "Dauna" located in Panga, Kirtipur. Kirtipur is a small historical town located in South-west of Kathmandu city about 6 km away from it. The town Kirtipur is famous for historical temples, old shrines and people with their old traditional customs. There are many ponds in the Kirtipur area constructed long before. These ponds have been used by the local peoples for various purposes mainly for bathing, irrigation, washing clothes, drinking water to the cattles. Most of these ponds lack inlet and outlet for the entry and exit of water. Therefore, these ponds depend only on rain water for their water source. But some ponds receive tap-waters from surrounding areas. Because of the lack of proper maintenance silting have occurred in these ponds which have resulted in the raising of level of bottom of most of these ponds. Some of the ponds have dried entirely because of the lack of water supply. The water of most of the ponds is dirty and polluted because of the kitchen wastes. Sometimes local people try to rear fishes in these ponds but fishes could not survive for long period because of excessive growth of phytoplanktons and contamination.

3.3 Description of the study Pond

The small village pond "Dauna" where the present Dissertation work entilled "A study on the effects of some Physico-Chemical parameters on the abundance and distribution of zooplanktons was conducted is located in the Kirtipur municipality, ward No. 11, Panga. The pond lies towards the southern part of Panga in a depression like area, surrounded from three sides by the highlands. The pond is roughly rectangular in outline having length of 50 meters, 15 meter in width and 1.5 meter deep with water coverage of 70%. The pond is divided into three parts in which two are large and one small by the partition of narrow lands with vegetation. From outer three sides the pond is surrounded by the vegetation consisting of shrubs and trees.The fourth side is open. The source of water is mainly rain water and the percolated water from surrounding crop lands. The pond receives some water from a tap which is located about 200m away from it. The pond lacks outlet for the exit of water. The water surface of the pond is almost entirely covered by the floating plants and in some places water surface is open. The loss of water from the pond is only due to evaporation. The pond has been used by the local people for recreational purposes because of the beautiful vegetation and climate of pond area. The pond has been looking after by the local youth club named Surya Jyoti Club. According to them various species of carp fishes have been rearing in this pond.

3.4 Sampling sites and study period

For the regular sampling programme, three sampling sites were selected at different places of the pond as station A, station B and station C. The sampling station A was located at the western corner, station B at the middle part of the pond and station C at the eastern corner of the pond. Samples from these three stations were collected and pooled to represent the mean average value. Altogether 12 observations were done fortnightly for a period of six months from 3rd July to 18th December 2002.

3.5 Physico-Chemical Analysis of Water

For the analysis of physicochemical parameters, the standard methods after Trivedi and Goel (1966), Adoni (1885) and APHA (1998) were followed. The reading of depth, transparency, temperature, hydrogen ion concentration (pH), dissolved oxygen DO, free CO_2, Total alkalinity, total hardness dissolved calcium and chlorides were done in the morning time between 8 to 10 A.M.

Water Colour

For observing the colour of pond water, small quantity of water was kept in a petridish and the petridish with water was placed over a white paper and then the colour of the water was viewed.

Depth

Depth of the pond water was measured by using a nylon rope. The rope was tied with a weight at it's one end and then it was lowered in the water body till it reaches the bottom. The length of the rope under water was measured with the help of a measuring tape.

Transparency

Transparency of pond water was measured by the use of secchi disc. The secchi disc is a metallic plate with 20 cm. in diameter having four alternate black and white quadrants on upper surface. At the centre of the dish the hook is tied with a graduated rope. The arithmetic mean of the distance at which the dish just disappeared from view of descent and that at which it reappeared was noted as secchi disc transparency. The mean of just disappearance and reappearance was recorded as the depth of visibility in cm.

i.i. Transparency (D) = (x + y)/2

where x = just disappearance

y = just reappearance

Temperature

Both the air and the water temperature were recorded by using a mercury thermometer graduated upto 50^{o}C with a precision of 0.1^{o}C. The water temperature was recorded simply by dipping the thermometer bulb into the water body and reading was recorded.

Hydrogen ion concentration (pH)

Hydrogen ion concentration i.e. pH of pond water was recorded by the use of a portable pH meter.

Dissolved Oxygen (DO)

Dissolved oxygen of pond water was determined by using Winkler's modified method. This method is based on the following principle.

A BOD bottle of 250 ml capacity was filled with water sample, and care was taken to prevent the entry of any air bubbles into the BOD bottle. One ml. of each $MNSO_4$ and potassium iodide solutions at the interval of one minute were added into the BOD bottle and the bottle was made air tight by placing stopper. The mixture was shaked well by inverting the BOD bottle. The brown precipitate appeared was allowed to settle sufficiently and then after few minutes 2 ml. of conc. H_2SO_4 was added into it and shaken well till the precipitate was completely dissolved. Then, 50 ml. of sample was pipetted out into a conical flask and two to three drops of starch was dropped into it and then the mixture was titrated against sodium thiosulphate solution taken in burette till the colour of the sample solution disappeared. The volume of the titrant at the end point was noted. Three readings were noted and mean of which was later converted into mg/lit by following formula.

$$\text{Dissolved oxygen, mg/lit} = \frac{(\text{Ml x N) of titrat x 8 x 1000}}{\frac{V2(V1 - V)}{V1}} = \text{ppm}$$

Where, V1 = volume of sample bottle

V2 = Volume of content titrated

V = volume of $MnSO_4$+KI added.

Free Carbon dioxide (CO_2)

For the determination of free CO_2 present in the water, 50 ml. of sample was taken in a conical flask, few drops of phenolphthalein as indicator was dropped into it. If the sample didn't turn pink indicated the presence of CO_2 and then the sample was titrated against (0.05 N) NaOH solution. The sample was titrated until the pink colour reappeared and volume of the NaOH consumed was noted. Three to four reading were noted and the mean value of NaOH consumed was taken. Then, the free CO_2 in mg/lit was calculated by using following formula.

$$\text{Free } CO_2 \text{ in mg/lit} = \frac{(\text{ml x N}) \text{ of NaOH x } 1000 \text{ x } 44}{\text{ml. of sample titrated}} = \text{ppm}$$

Total Alkalinity

For the determination of total Alkalinity, 50 ml. of sample was taken in a conical flask, 2 to 3 drops of each phenolpthalein and methyl orange was dropped into it and then, the sample was titrated against HCl (0.1 N). At the end point the yellow colour of the sample was changed into pink and the volume of HCl consumed was noted. Three such readings were noted and mean value is taken to calculate total Alkalinity by using following formula.

$$\text{Total alkalinity mg/lit} = \frac{(\text{ml x N}) \text{ of HCl x } 1000 \text{ x } 50}{\text{ml. of sample ttirated}} = \text{ppm}$$

Total hardness

For the determination of total Hardness of pond water the EDTA titrimetric method was followed. 50 ml. of sample was pipetted out into a conical flask and one ml. of buffer solution was added into it. 100 - 200 mg of Eriochrome black-T indicator was added and the mixture was shaken well. Then, the sample was titrated against EDTA solution (0.01 N). At the end point the colour of the mixture changed from wine red to blue and volume of EDTA solution consumed was noted. Three reading were taken and the mean value was used to calculate the total Hardness in mg/l by using following formula.

$$\text{Total Hardness as CaCo3 mg/lit} = \frac{\text{ml. of EDTA used x } 1000}{\text{ml. of sample}} = \text{ppm}$$

Dissolved Calcium (Ca)

For the determination of Calcium present in the pond water, EDTA method was followed .50 ml. of sample was pipetted out into a conical flask and one ml. of I N, NaOH solution was added into it. 100 to 200 mg of mureoxide indicator was added as a result the colour of the mixture was changed to pink. The mixture was then titrated against 0.01 N EDTA solutions. At the end point the pink colour changed to purple and the volume of EDTA consumed was noted. Three burette readings were taken and mean value was used to calculate the Calcium in mg/l by following formula.

$$\text{Calcium mg/lit} = \frac{\text{ml. of EDTA x 400.8}}{\text{ml. of sample titrated.}} = \text{ppm}$$

Chlorides

For the determination of chlorides present in pond water, 50 ml. of sample was pipetted out into a conical flask, added 5 drops of potassium chromate indicator as a result the colour of sample changed to yellow. Then, the mixture was titrated against standard silver nitrate solution until yellow colour changed to brick red at end point. The volume of $AgNO_3$ consumed was noted. Three such readings were taken and mean value was used to calculate the chlorides in Mg/l by following formula.

$$\text{Chloride in mg/lit} = \frac{\text{ml. of titrant used x N x 35.46 x } 10^3}{\text{ml. of sample titrated.}} = \text{ppm}$$

Where N = Normality of titrant (0.014 N)

3.6 Biological Analysis of Water

Zooplanktons

For the estimation of zooplankton, known volume of water sample (10 liters) was collected by a bucket and filtered through a plankton net of bolting silk No 25. The sample remained at the cap of plankton net was transferred into the Petridisc and diluted by 20 ml distilled water and transferred into a plankton tube. Then, the sample was preserved in 5% aqua formalin. For qualitative and quantitative analysis Sedge wick rafter cell with 1 ml. sample was used and identification of zooplankton was carried out to generic level and possibly to species level by using the keys and monographs of Edmondson (1953), Needam and Needam (1962), Michael (1973), Pennak (1975) and APHA (1998).

In Sedge-wick rafter cell (100 chambers) the rectangular cavity (50 x 20 x 1mm) contains exactly 1 ml (1000 mm^3) of water sample. The width of the field of microscope was found by the help of ocular and stage micrometers. After putting sample (1 ml.) into the cell, it was covered by the cover slip diagonally on the cell cavity. Preventing the entry of bubbles, Microscope was focused on the one edge of the cavity and slide was moved horizontally, simultaneously counting the planktons using the magnification of microscope 15×10 (150). In this way 3 - 6 such strips or transects were observed and calculation was done by following formula.

V = t x d x w x l

Where, V = vol. of sample observed (mm^3)

t = no. of the transects observed.

d = depth of the cell cavity (mm)

w = width of the microscope field (mm)

l = length of the cell cavity (mm)

and Organisms $1^{-1} = n(\frac{V}{v})\times(\frac{1}{C})\times10^3$

Where, n = total no. of individual in observed transects.

V = volume f the sample in counting cell (mm^3)

v = volume of observed transects (mm^3)

C = concentration factor = $\frac{\text{original vol. of sample (ml)}}{\text{vol. of sample concentrate.}}$

Chapter Four

Result

The Physico-Chemical and Biological Parameters were observed for a period of six months (3rd July to 18th July 2002). Observation was done fortnightly and total of twelve observations were recorded.

4.1 Physical Parameters

Nature of the day

Observations were carried out in sunny, foggy and cloudy days. 3rd November and 18th November were cloudy days, 3rd December and 18th December were foggy and remaining days were sunny.

Colour

The water colour changed gradually from brownish green to light green and green. Brownish Green colour was observed from 3rd July to 18th August, light green from 18th August to 3rd October and green colour from 18th October to 18th December.

Depth

The depth ranged from 50 cm to 68 cm with an average value of 59 cm. Minimum depth i.e. 50 cm was recorded on 18th November and maximum of 68 cm was noted on 18th July.

Transparency

The transparency of pond water raised from 18 cm to 27.5 cm with an average of 22.75 cm. Maximum value (27.5 cm) was recorded on 3rd September and minimum (18 cm) on 18th October. The transparency coefficient was calculated in which the maximum value of 0.094 and the minimum of 0.061 were recorded on 3rd July, 16th October and 3rd September respectively. The average value was 0.074.

Temperature

The air temperature ranged from 21^oC (on 3rd Nov.) to 26^oC (on 3rd July) with an average value of 23.67^oC while the water temperature varied from 20^oC (on 3rd Dec.) to 26^oC (recorded on 3rd September) with an average value of 22.91^oC.

4.2 Chemical Parameters

The important chemical parameters as dissolved oxygen (DO), free carbon dioxide (CO_2), Hydrogen ion concentration (pH), total alkalinity, total Hardness, dissolved calcium and chlorides were analyzed and recorded.

Hydrogen ion Concentration (pH)

The pond water was found acidic, neutral as well as alkaline during the study period. The pH value was maximum (i.e. 8.6) on 3rd October and minimum (i.e. 6.2) on 3rd November with an average value of 7.4.

Dissolved Oxygen (DO)

The dissolved Oxygen is of paramount importance to all living aquatic organisms and is available to water by absorption from atmosphere and by photosynthetic activities of aquatic autotrophs. The former is purely a physical process and the later is a biological process.

The dissolved Oxygen in the present study fluctuated from 4.3 ppm (18th October) to 8.4 ppm (18th July) with an average value of 6.35 ppm.

Free Carbon-dioxide (CO_2)

Free carbon dioxide generates in water through respiration and decomposition of organic matter. It also occurs by diffusion from the atmospheric air. Free carbon dioxide was noted regularly during the study period. The maximum value of free CO_2 i.e. 30 ppm was noted on 3rd September and minimum 4 ppm was noted on 3rd July. The average value was 17.0 ppm.

Total Alkalinity

Alkalinity of water is it's capacity to neutralize a strong acid and is characterised by the presence of all hydroxyl ions capable of combining with the hydrogen ion. In most natural waters both carbonates bicarbonates are present and alkalinity is calculated as total alkalinity. In the present study, total alkalinity was noted throughout the study period in which the maximum value was (69 ppm) on 18th October and minimum (33 ppm) on 3rd July. The average value of total alkalinity recorded was 51 ppm.

Total Hardness

Hardness is the property of water which prevents the lather formation with soap and increases boiling point of water. Temporary hardness is caused by these by-carbonate and carbonate salts of cat-ions and the permanent hardness is caused by the sulphates and chlorides of metals. The hardness caused due to calcium and magnesium salts is called total hardness.

In the present study total hardness was recorded throughout the study period. The maximum value of total hardness was 54ppm. recorded on 18th December and minimum value was 35ppm. noted on 3rd July and the average value was 44.5ppm.

Calcium (Ca)

Dissolved calcium was found to occur throughout the study period. The maximum value 16.4 ppm was recorded on 3rd September and minimum value (7.5 ppm) was on 18th October. The average value was 11.5 ppm.

Chloride (Cl)

Chlorides occur naturally in all types of water. The main source of chlorides in the water is the discharge of domestic sewage. Dissolved chlorides was recorded though out the study period with an average value of 29.5 ppm. The maximum value of chloride was found to be 38 ppm on 3rd September and minimum (21 ppm) on 18th August.

4.3 Biological Parameters

The term plankton was first proposed by the oceanographer victor Hensen in 1887 to describe the free floating and drifting microscopic organisms having little or no resistance against water current and living free floating and suspended in natural waters.

On the basis of size, planktons can be classified into Megaloplankton, Macroplankton, Microplankton, Mesoplankton, Nanoplankton and Ultraceston. On the basis of their ability to carryout photosynthetic activity, they are classified into two major groups as Zooplanktons (animal plankter) and phytoplantons (plant plankter).

Phytoplanktons

Phytoplanktons are the planktons of plant origin consisting of the members from all major taxonomic phyla such as chlorophyceae (green algae), Myxophyceae (blue green algae) and Bacillariophyceae or diatoms (unicellular algae). These are microscopic organisms measuring about 0.02 u in length. Phytoplanktons usually bear chlorophyll responsible for photosysnthetic activity for primary productivity of the pond.

Zooplanktons

Zooplanktons are the minute, passively floating planktons of animal origin, totally depending upon the phytoplanktons for their food. The zooplanktons form the intermediate link between primary and tertiary trophic levels in an aquatic ecosystem. They are abundant in the shallow areas of reservoirs but only few species are abundant in the open water.

In the present study six different groups of zooplanktons were recorded and were analyzed qualitatively and quantitatively.

Protozoa

Among protozoa, two genera i.e. Paramecium and Vorticella were recorded. Paramecium was recorded throughout the study period while vorticella was absent on 18th August, 3rd September and 18th October. Maximum no of Paramecia were 83 no./lit. and minimum no. was 30 no./lit. recorded on 18th November and 18th December, respectively. The average no. of paramecium was recorded as 53.33 no./lit. The vorticella were found with average value of 16.0 no./lit. Their maximum number was 28 no./lit on 3rd December and minimum number was 8 no./lit. on 3rd August. The highest protozoans count was 104 no/lit and lowest count was 42 no./lit recorded on 18th november and 18th August respectively. The average value was of 69.33 no./lit.

Among rotifera two genera i.e. Keretella and Brachionus were recorded throughout the study period. Keretella was found in an average value of 170.16 no./lit. Maximum no. of Keretella (i.e. 245 no./lit) was recorded on 3rd July and minimum (i.e. 137 no./lit) was on 18th December. The Brachionus was found with an average value of 63.41 no./lit. The maximum Brachionus count was 168 no./lit and minimum count was 20 no./lit on 18th July and 18th December respectively.

Ratifers were found to occur with an average value of 233.58 no./lit in which their maximum count was 378 no./lit and minimum of 157 no./lit. recorded on 18th July and 18th December respectively.

Among Cladocera two genera namely Daphnia sps. and Moina sps. were found throughout the study period. The highest count of Daphnia sps. was 175 no./lit on 3rd July and lowest count of 40 no./lit on 3rd October. The average value was 101.41 no./lit. Moina was found with average value of 42.58 no./lit. It's highest count was 85 no./lit and lowest count was 24 no./lit on 18th July and 18th December respectively. The average value of cladocera was 144 no./lit. in which the maximum count was 240 no./lit on 3rd July and minimum count was 72 no./lit on 3rd October.

Among Ostracoda one genus i.e. Cypris sps. was recorded.

Highest Cypris count was 66 no./lit on 3rd september and its lowest count was 12 no./lit on 18th Oct. The average value of Cypris was 34.83 no./lit.

Among copepoda three genera namely Diaptomus sps. Cyclopus sps. and Nauplius sps. were found. The average value Diaptomus was 11.91 no./lit. Highest no. of Diaptomus was noted on 3rd July and lowest on 3rd November. Cyclopus was absent on 3rd November. It's highest count was 195 no./lit on 3rd December and minimum was 40 no./lit on 3rd October. Cyclopus was found with an average value of 104.41 no./lit. Nauplius was found in an average value of 69.08 no./lit. Highest count was 155 no./lit on 3rd September and lowest count was 6 no./lit on 18th October. It was absent on 3rd October.

The maximum no. of copepodes were recorded on 18th December as 321 no./lit and minimum as 40 no./lit on 3rd November. They were found with an average value of 143.75 no./lit.

Chapter Five

Statistical Analysis

The coefficient of correlation (r) between various Physico-Chemical parameters and density of zooplankton population was calculated by using Karl Pearson's method.

1) Correlation (r) between density of zooplankton population and transparency.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 186693.8

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 275.9

$\sum y^2$ = 6459.81

Now, r = $\frac{12 \times 186693.8 - 8006 \times 275.9}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 6459.81 - (275.9)^2\}}}$

= $\frac{31470.2}{1862.6 \times 37.37}$

= 0.45

Probability error P.Er = 0.6745$\times \frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.45)^2}{\sqrt{12}}$

= 0.15

Since, r > P.Er

Significant, positive relationship existed between the density of zooplankton population and transparency of pond water.

2) Correlation between population density of zooplankton and depth.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 464154

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 685

$\sum y^2$ = 39468.5

Now, r = $\frac{12 \times 464154 - 8006 \times 685}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 39468.5 - (685)^2\}}}$

= $\frac{85738}{1862.6 \times 66.30}$

r = 0.69

Probability Error P.Er. = 0.6745$\times \frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.69)^2}{\sqrt{12}}$

= 0.10

Since, r > P.Er.

A significant positive relationship existed between zooplankton population density and depth.

3) Correlation between density of zooplankton population and air temperature.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 190830.5

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 284.1

$\sum y^2$ = 6753.13

Now, r = $\frac{12 \times 190830.5 - 8006 \times 284.1}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 6753.13 - (284.1)^2\}}}$

= $\frac{15461.4}{1862.6 \times 18.02}$

r = 0.46

Probability Error P.Er. = $0.6745 \times \frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.46)^2}{\sqrt{12}}$

= 0.15

Since, r > P.Er.

The significant, positive relationship existed between air temperature and density of zooplankton population.

4) Correlation between density of zooplankton population and water temperature.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 186233.5

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 275

$\sum y^2$ = 6348

Now, r = $\frac{12 \times 186233.5 - 8006 \times 275}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 6348 - (275)^2\}}}$

= $\frac{33152}{1862.6 \times 23.47}$

r = 0.75

Probability Error P.Er. = $0.6745 \times \frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.75)^2}{\sqrt{12}}$

= 0.086

Since, r > P.Er.

The relationship between population density of zooplankton and water temperature was found to be significant and positive.

5) Correlation between density of zooplankton and dissolved oxygen.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 53235.7

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 77

$\sum y^2$ = 510.1

Now, r = $\frac{12 \times 53235.7 - 8006 \times 77}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 510.1 - (77)^2\}}}$

= $\frac{22366.4}{1862.6 \times 13.86}$

r = 0.866

Probability Error P.Er. = 0.6745×$\frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.86)^2}{\sqrt{12}}$

= 0.05

Since, r > P.Er.

The relationship between density of zooplankton population and dissolved oxygen was significant positive.

6) Correlation between density of zooplankton population and free CO_2.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 114483

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 185.8

$\sum y^2$ = 3763.74

Now, r = $\frac{12 \times 114483 - 8006 \times 185.8}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 3763.74 - (185.8)^2\}}}$

= - $\frac{113717.6}{1862.6 \times 103.16}$

r = - 0.59

Probability Error P.Er. = 0.6745$\times \frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.59)^2}{\sqrt{12}}$

= 0.12

Since, r > P.Er.

The significant, negative relationship existed between the population density of zooplankton and free CO_2.

7) Correlation between density of zooplankton population and PH of water.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 60219.0

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 89.3

$\sum y^2$ = 671.01

Now, r = $\frac{12 \times 60219 - 8006 \times 89.3}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 671.01 - (89.3)^2\}}}$

= $\frac{7692.2}{1862.6 \times 8.81}$

r = 0.46

Probability Error P.Er. = 0.6745× $\frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.46)^2}{\sqrt{12}}$

= 0.15

Since, r > P.Er.

The positively significant relationship existed between population density of zooplankton and pH of pond water.

8) Correlation between population density of zooplankton and total alkalinity.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 410496

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 635

$\sum y^2$ = 35127

Now, r = $\frac{12 \times 410496 - 8006 \times 635}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 35127 - (635)^2\}}}$

= $\frac{-157858}{1862.6 \times 135.27}$

r = -0.62

Probability Error P.Er. = 0.6745×$\frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{\{1 - (-0.62)^2\}}{\sqrt{12}}$

= 0.12

Since, r > P.Er.

The significant negative relationship existed between population density of zooplankton and total alkalinity.

9) Correlation between population density of zooplankton and total hardness.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 326165

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 491.5

$\sum y^2$ = 20449.25

Now, r = $\frac{12 \times 326165 - 8006 \times 491.5}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 20449.25 - (491.5)^2\}}}$

= $\frac{-20969}{1862.6 \times 61.79}$

r = - 0.182

Probability Error P.Er. = 0.6745× $\frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.182)^2}{\sqrt{12}}$

= 0.188

Since, r < P.Er.

The negative relationship between population density of zooplankton and total hardness was not significant.

10) Correlation between population density of zooplanktons and dissolved calcium.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 104243.7

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 149.3

$\sum y^2$ = 3411.29

Now, r = $\frac{12 \times 104243.7 - 8006 \times 149.3}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 3411 - (149.3)^2\}}}$

= $\frac{55628.6}{1862.6 \times 136.53}$

r = 0.21

Probability Error P.Er. = 0.6745×$\frac{1 - r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.21)^2}{\sqrt{12}}$

= 0.18

Since, r > P.Er.

The significant positive relationship existed between population density of zooplankton and dissolved calcium.

11) Correlation between density of zooplankton population and chlorides.

Coefficient of correlation (r) = $\frac{N.\sum xy - \sum x.\sum y}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$

Where,

N = 12

$\sum xy$ = 239671

$\sum x$ = 8006

$\sum x^2$ = 5630444

$\sum y$ = 359

$\sum y^2$ = 11106.5

Now, r = $\frac{12 \times 239671 - 8006 \times 359}{\sqrt{12 \times 5630444 - (8006)^2\}\{12 \times 11106.5 - (359)^2\}}}$

= $\frac{1898}{1862.6 \times 66.30}$

r = 0.015

Probability Error P.Er. = 0.6745$\times \frac{1-r^2}{\sqrt{n}}$

= $0.6745 \times \frac{(0.015)^2}{\sqrt{12}}$

= 0.19

Since, r < P.Er.

The positive relationship between population density of zooplanktons and chlorides was not significant.

Fig. 1. Fortnightly variation of Depth (From 3rd July 2002 to 18th Dec. 2002)

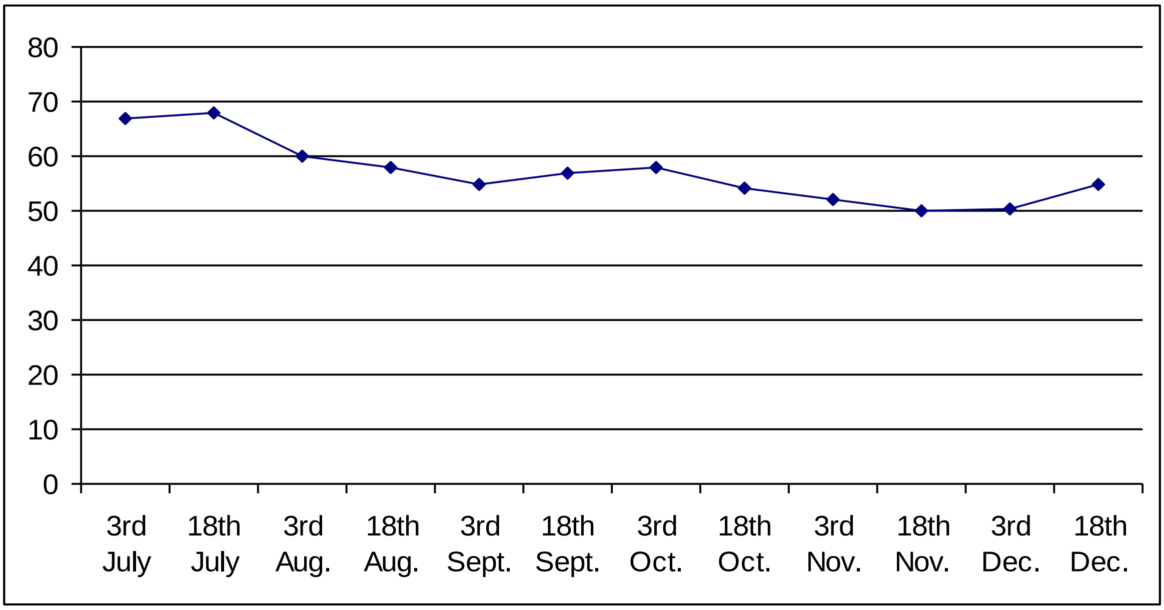


Fig. 2. Fortnightly variation of Transparency (From 3rd July 2002 to 18th Dec. 2002)

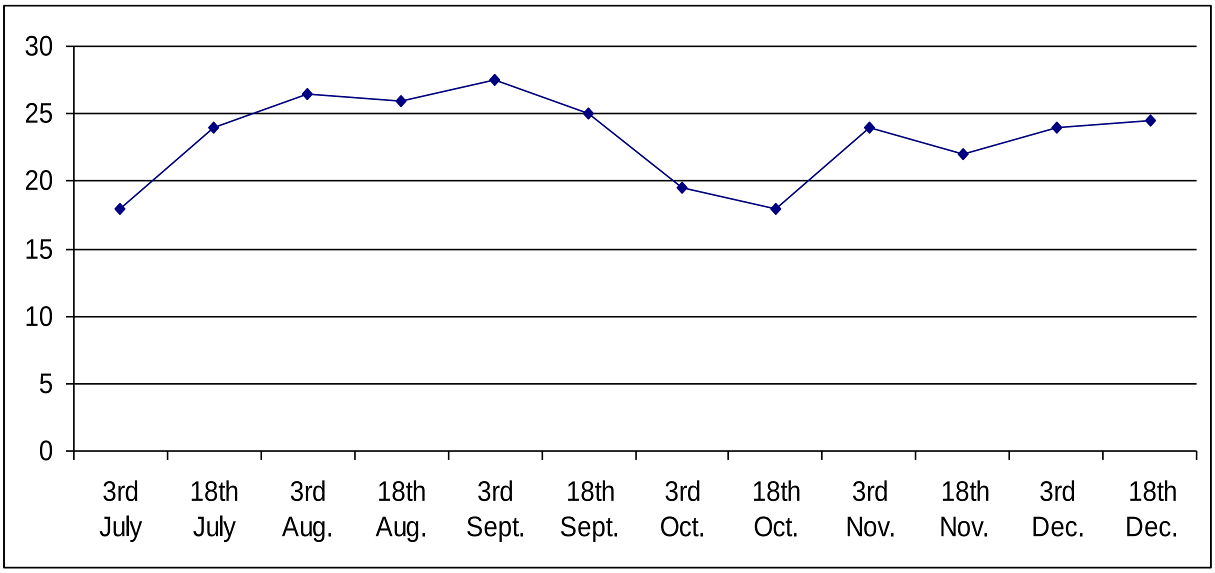


Fig. 3. Fortnightly variation of Air Temperature (From 3rd July 2002 to 18th Dec. 2002)

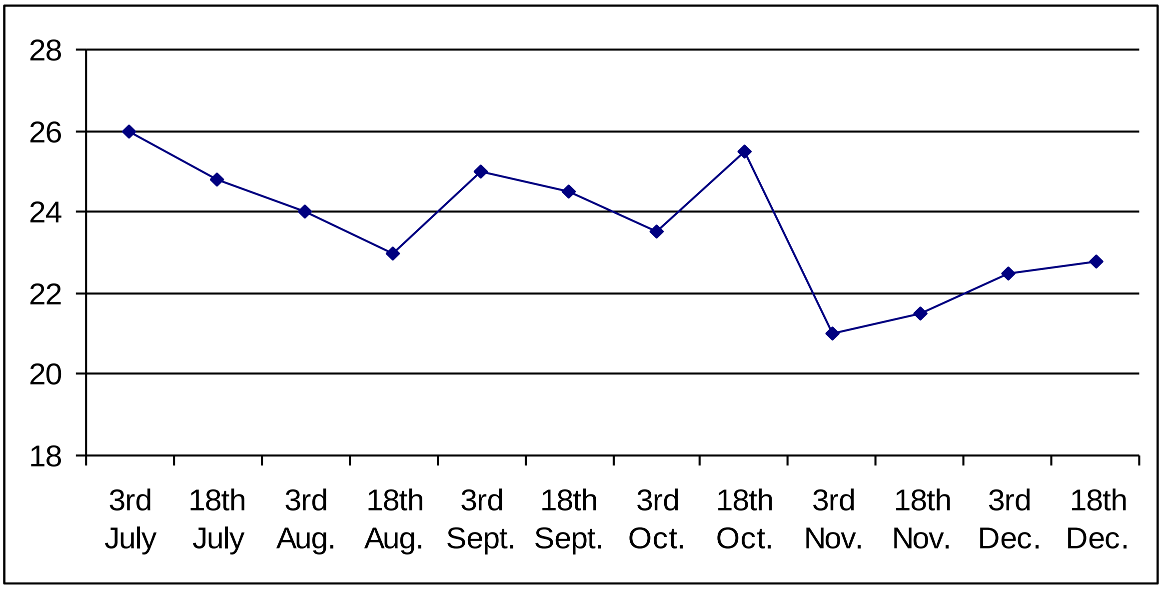


Fig. 4. Fortnightly variation of Water Temperature (From 3rd July 2002 to 18th Dec. 2002)

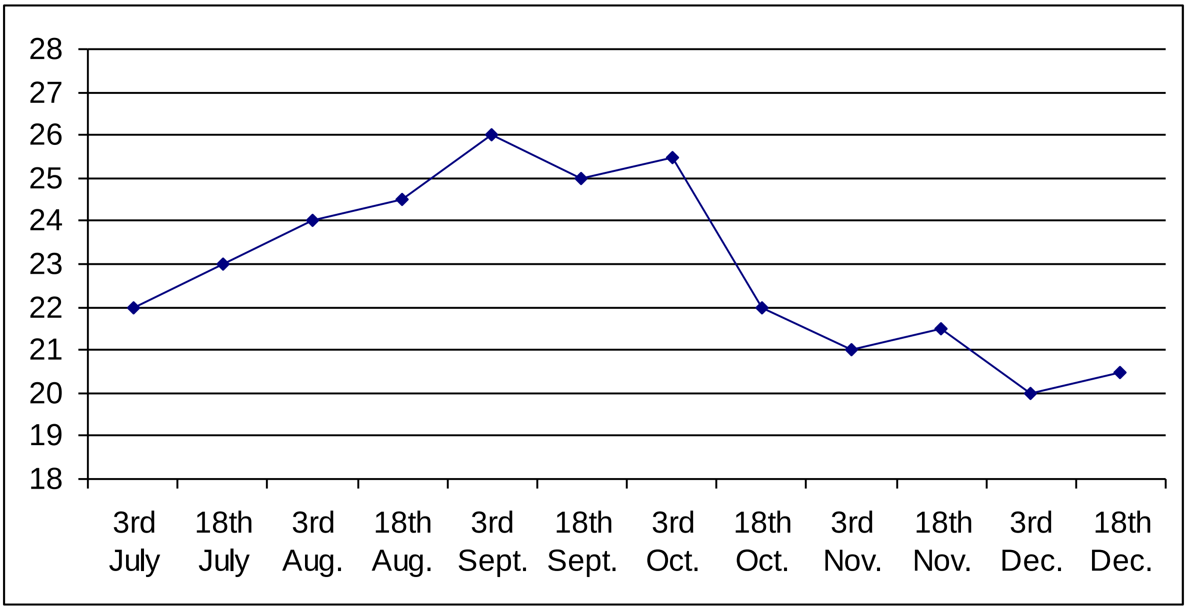


Fig. 5. Fortnightly variation of pH (From 3rd July 2002 to 18th Dec. 2002)

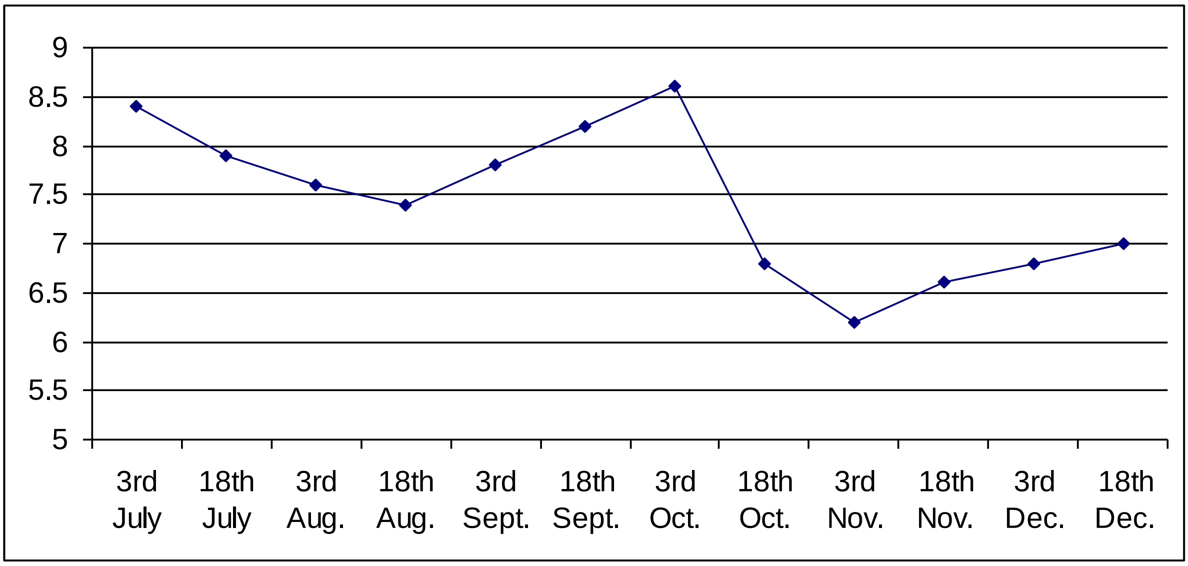


Fig. 6. Fortnightly variation of Dissolved Oxygen (DO) (From 3rd July 2002 to 18th Dec. 2002)

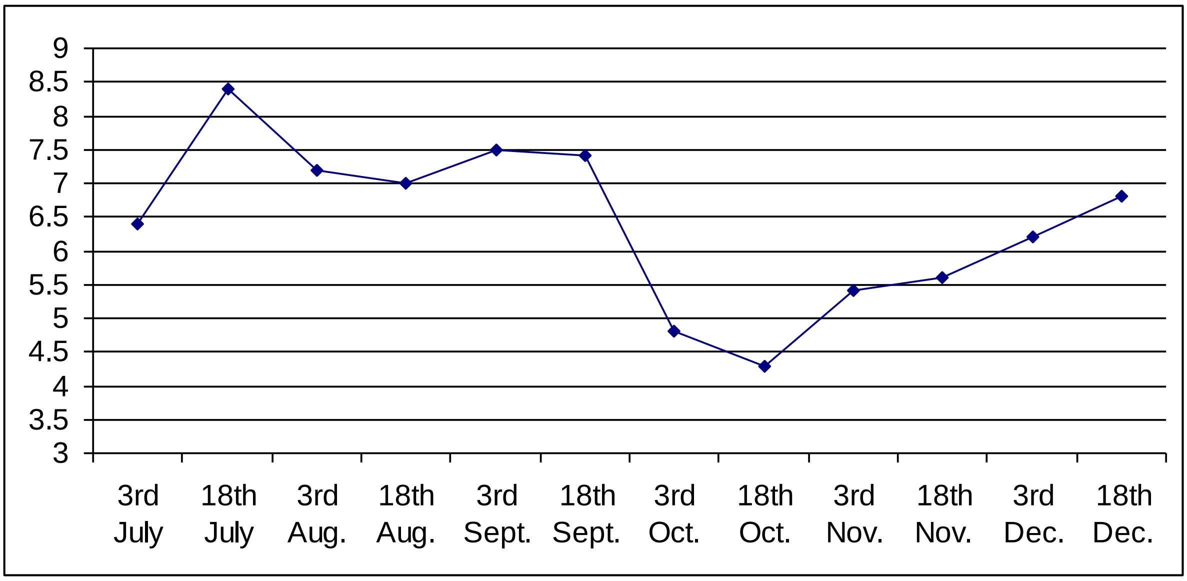


Fig. 7. Fortnightly variation of Free Carbon dioxide (CO_2) (From 3rd July 2002 to 18th Dec. 2002)

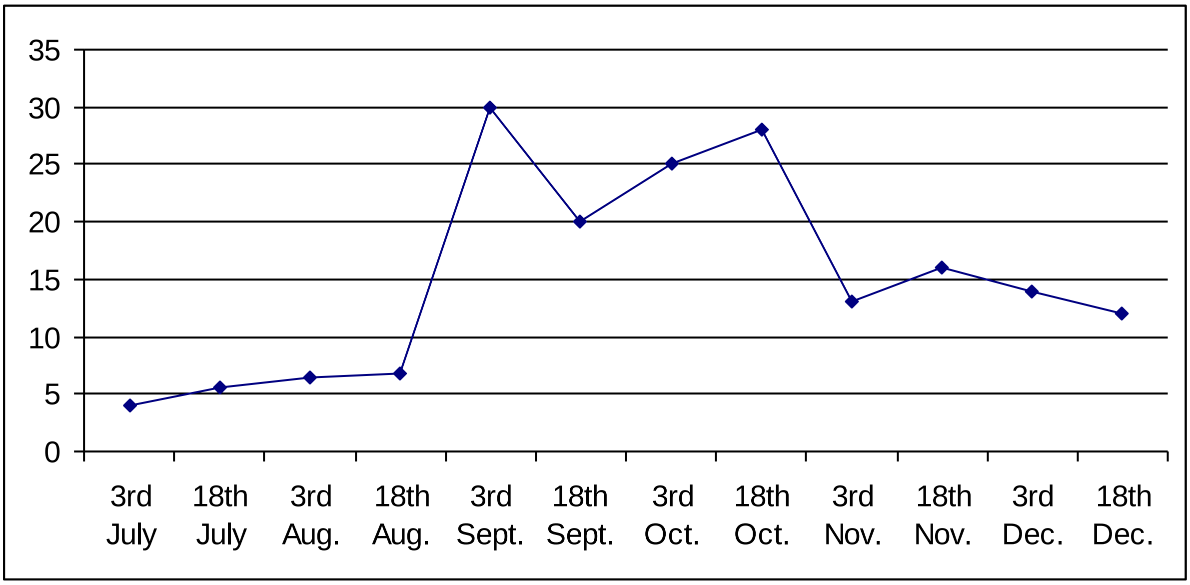


Fig. 8. Fortnightly variation of Total Alkalinity (From 3rd July 2002 to 18th Dec. 2002)

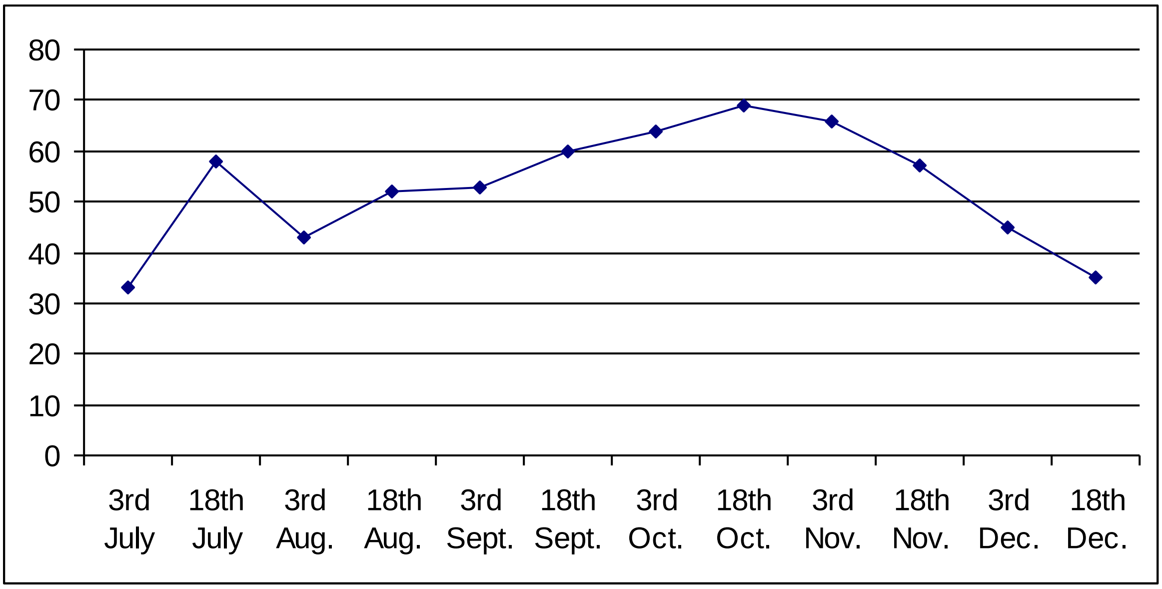


Fig. 9. Fortnightly variation of Total Hardness (From 3rd July 2002 to 18th Dec. 2002)

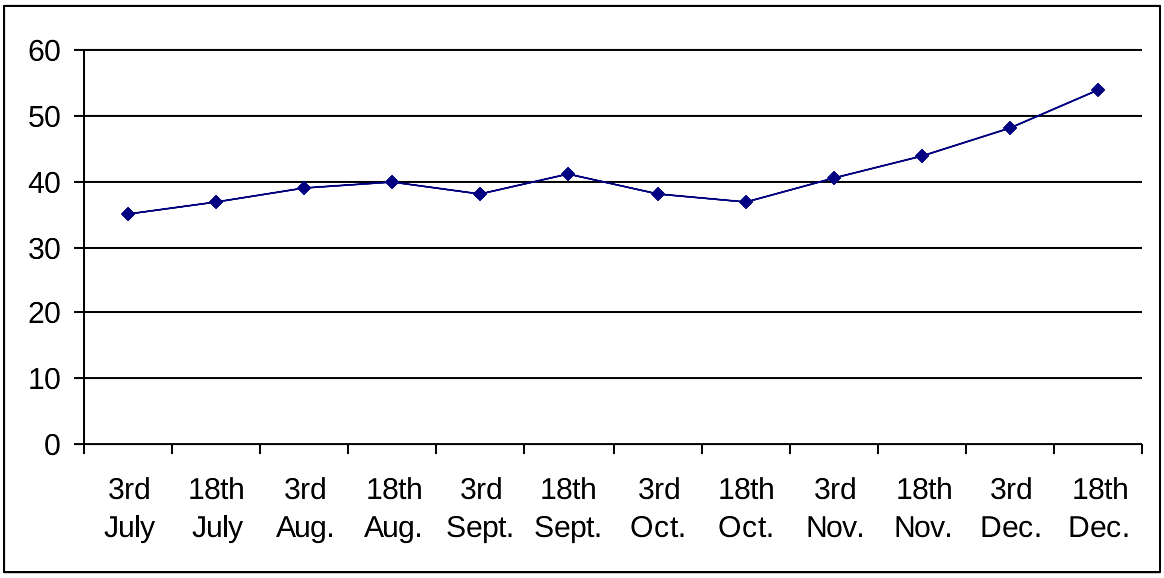


Fig 10. Fortnightly variation of Calcium (Ca) (From 3rd July 2002 to 18th Dec. 2002)

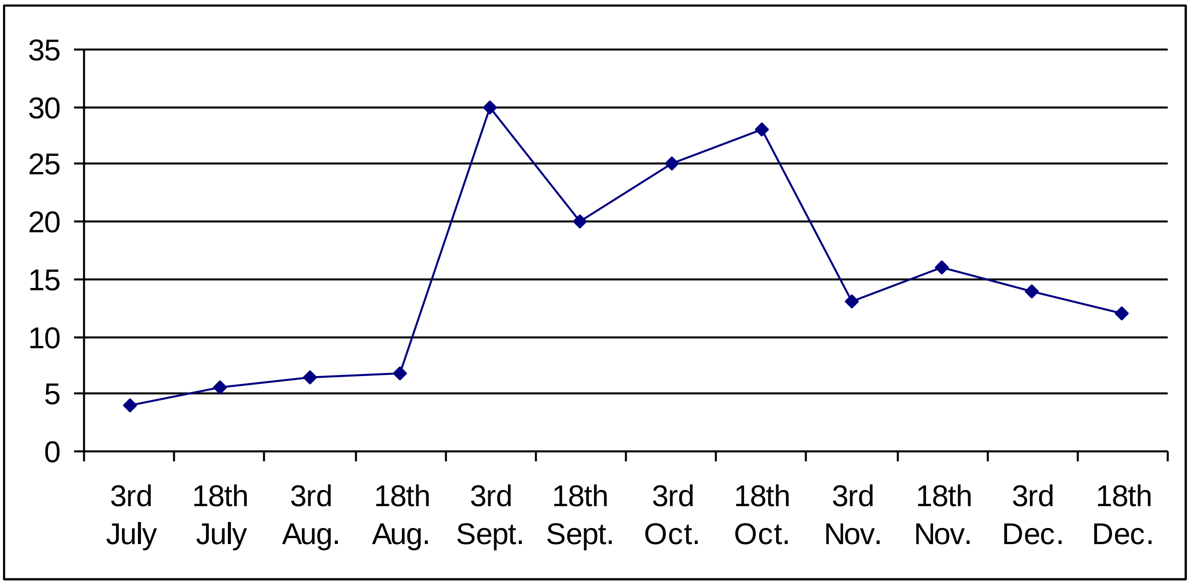


Fig. 11. Fortnightly variation of Chloride (Cl^-) (From 3rd July 2002 to 18th Dec. 2002)

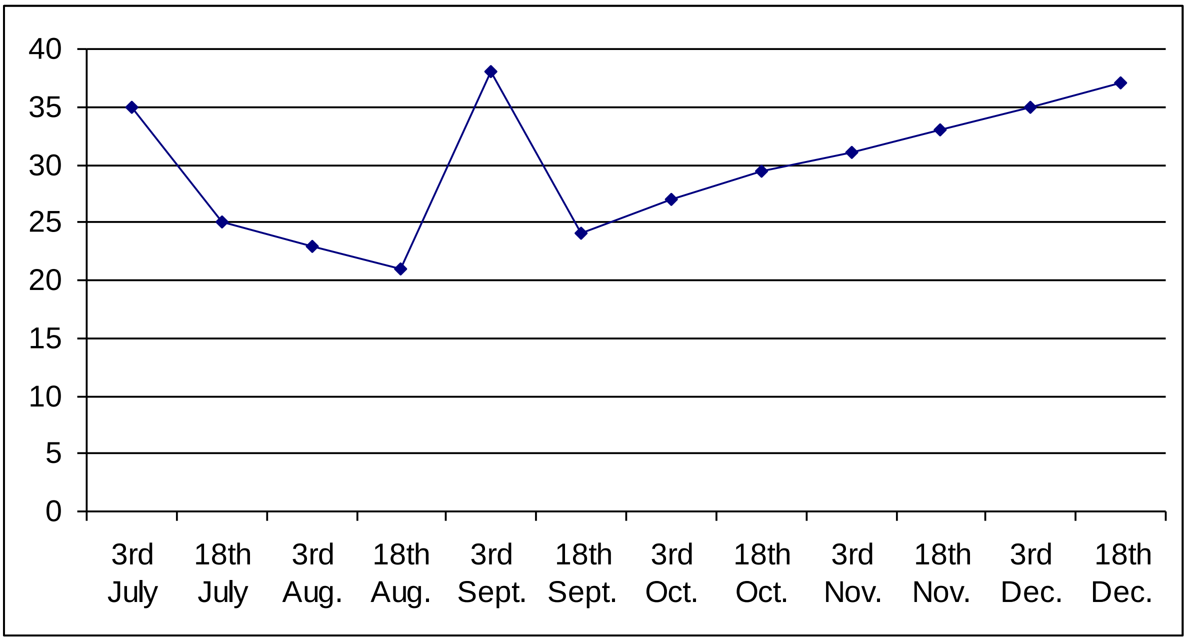


Fig. 12. Fortnightly variation of Protozoa (From 3rd July 2002 to 18th Dec. 2002)

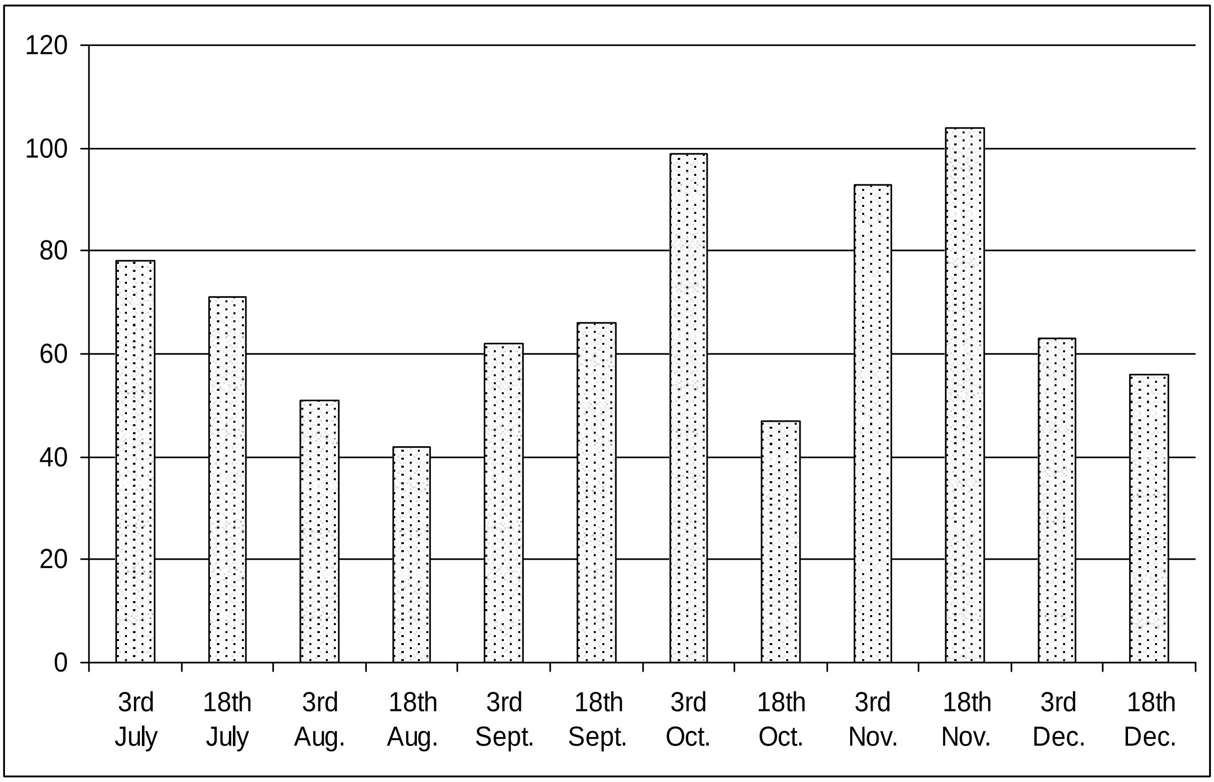


Fig. 13. Fortnightly variation of Rotifera (From 3rd July 2002 to 18th Dec. 2002)

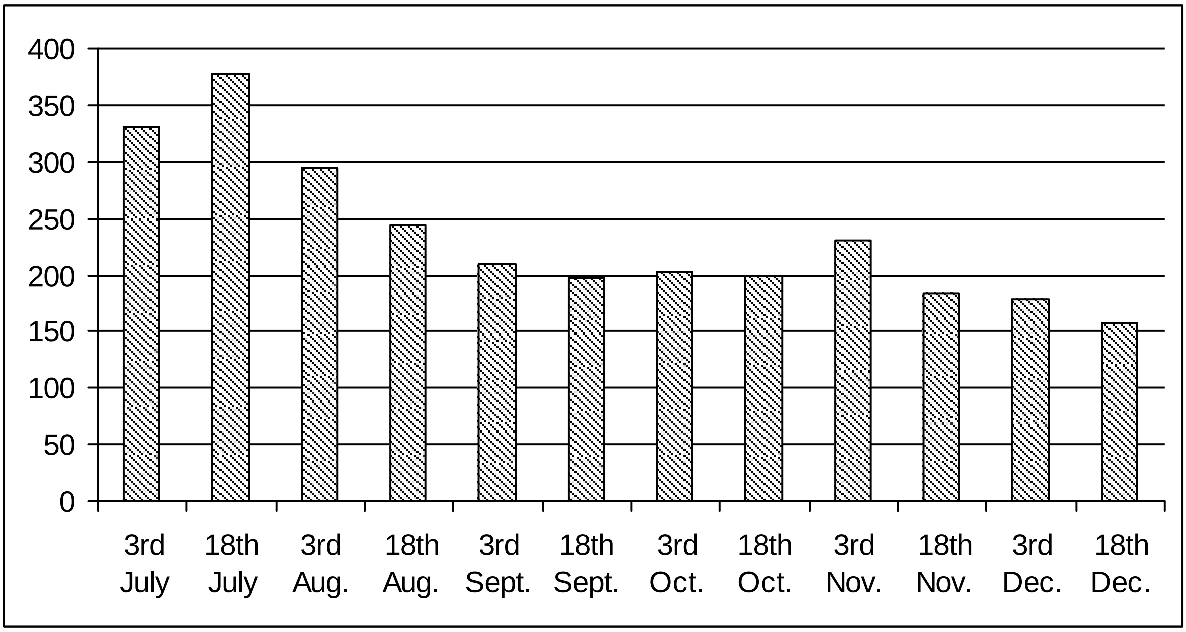


Fig. 14. Fortnightly variation of Cladocera (From 3rd July 2002 to 18th Dec. 2002)

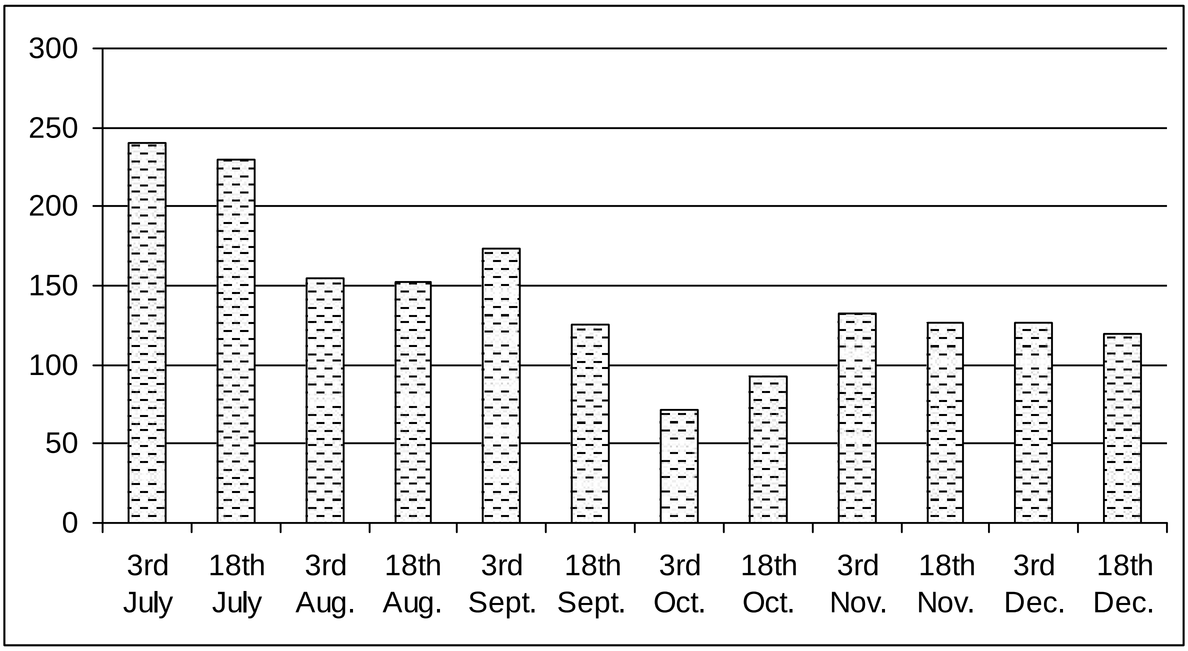


Fig. 15. Fortnightly variation of Ostracoda (From 3rd July 2002 to 18th Dec. 2002)

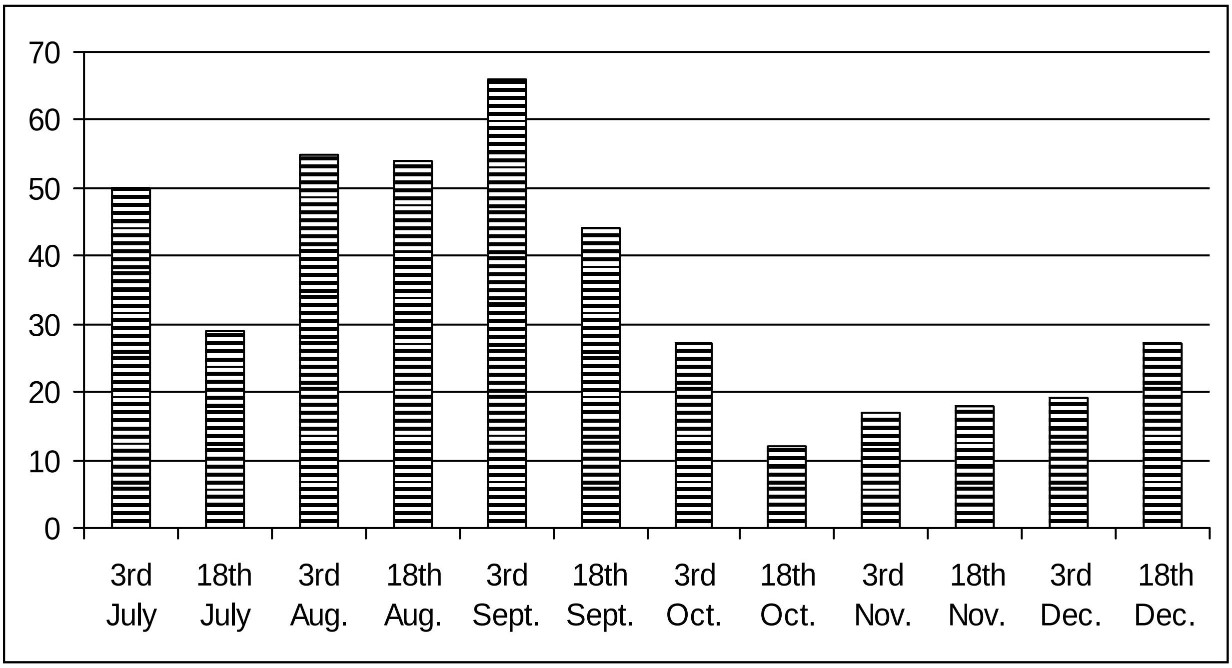


Fig. 16. Fortnightly variation of Copepoda (From 3rd July 2002 to 18th Dec. 2002)

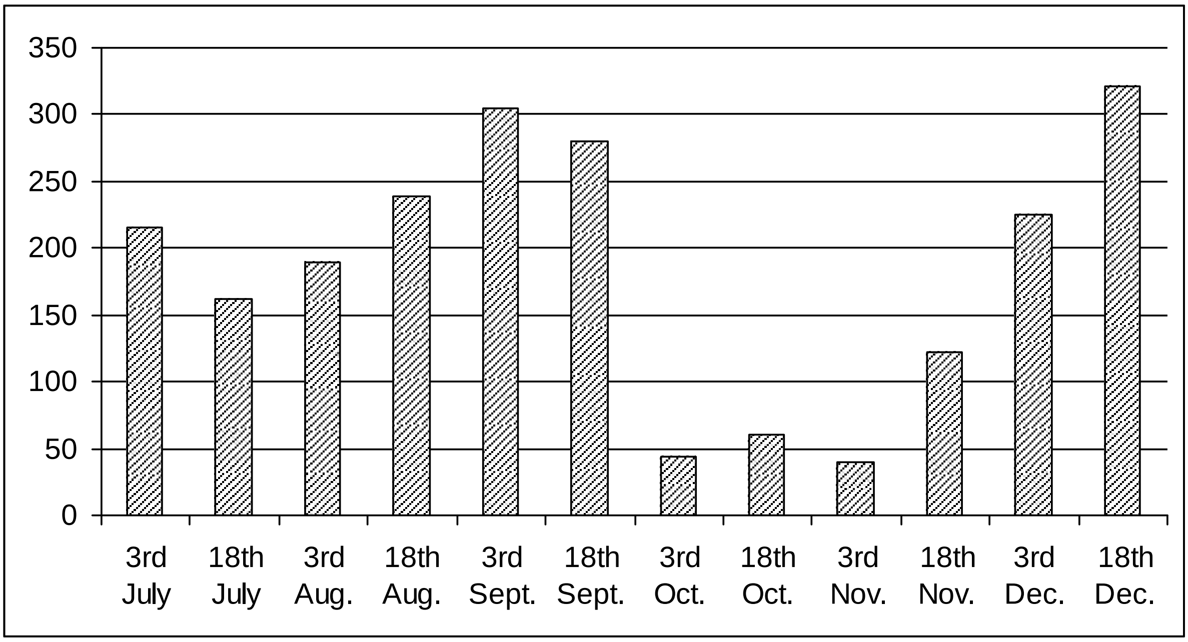


Fig. 17. Graphs showing the variation of zooplankton population density with depth (From 3rd July 2002 to 18th Dec. 2002)

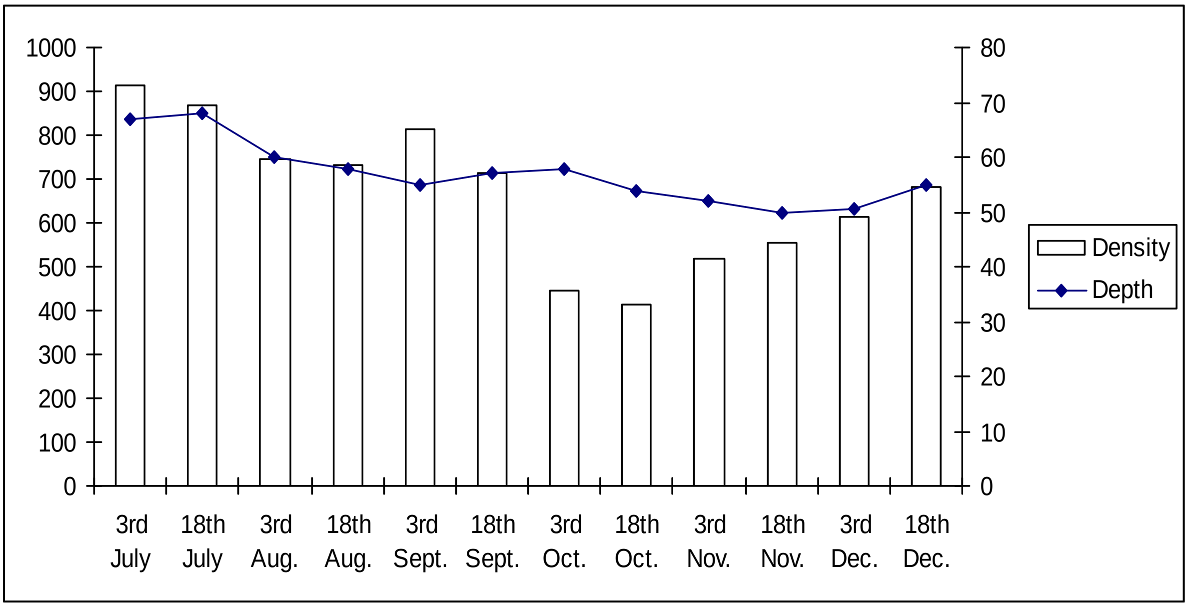


Fig. 18. Graphs showing the variation of zooplankton population density with air temperature (From 3rd July 2002 to 18th Dec. 2002)

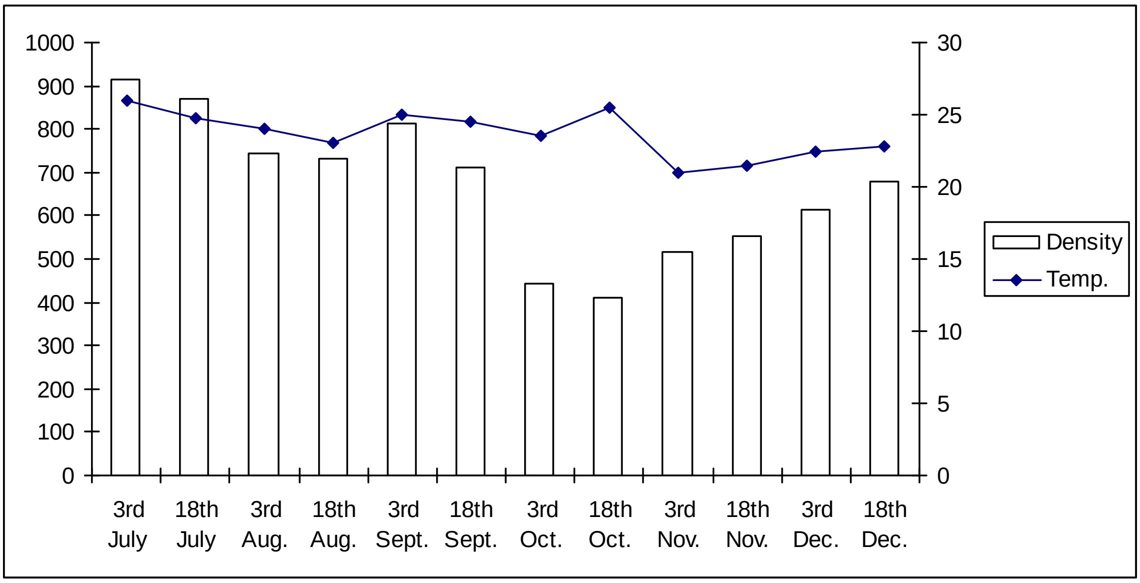


Fig. 19. Graphs showing the variation of zooplankton population density with water temperature (From 3rd July 2002 to 18th Dec. 2002)

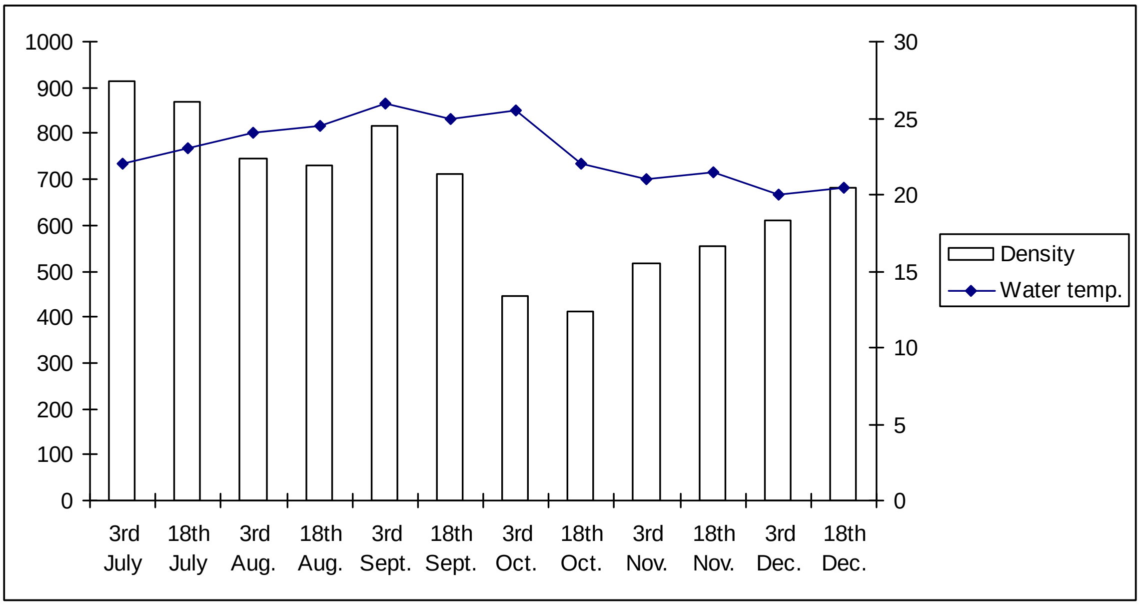


Fig. 20. Graphs showing the variation of zooplankton population density with transparency (From 3rd July 2002 to 18th Dec. 2002)

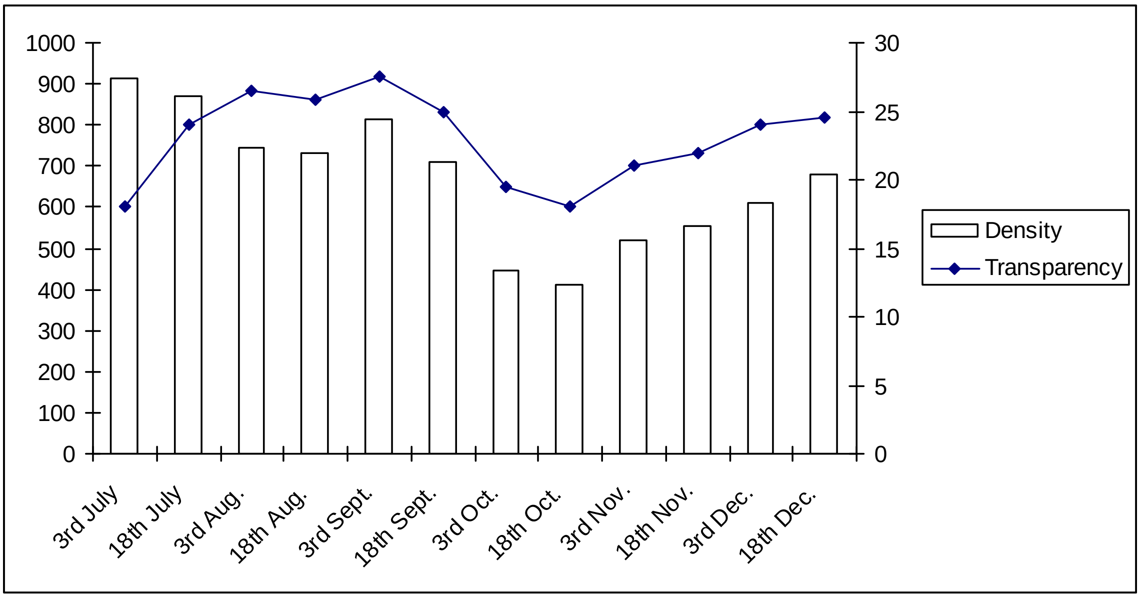


Fig. 21. Graphs showing the variation of zooplankton population density with pH (From 3rd July 2002 to 18th Dec. 2002)

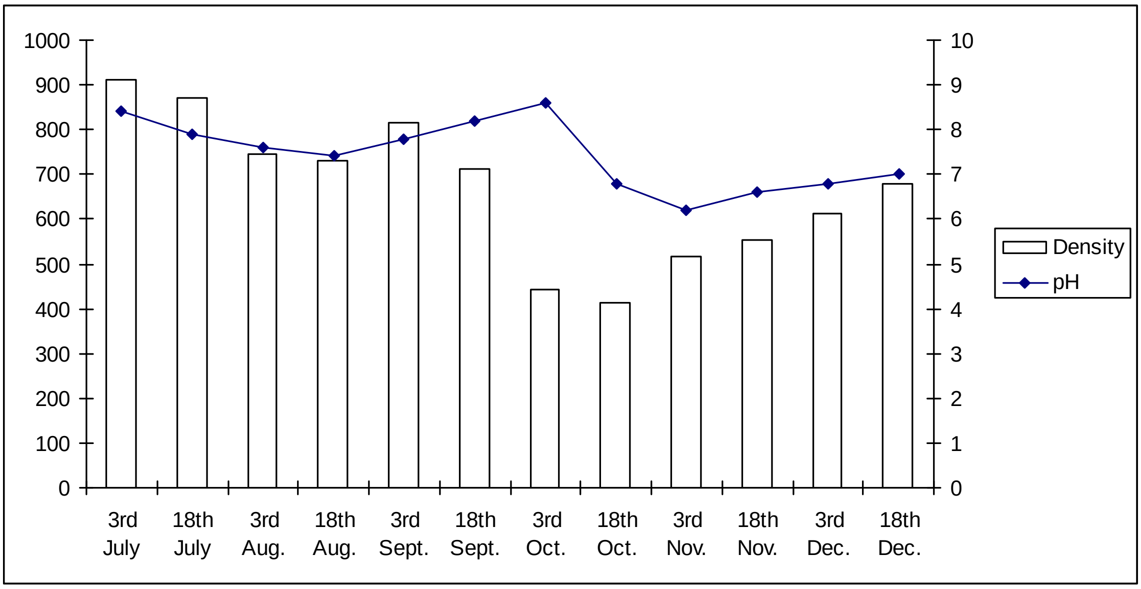


Fig. 22. Graphs showing the variation of zooplankton population density with Dissolved Oxygen (DO) (From 3rd July 2002 to 18th Dec. 2002)

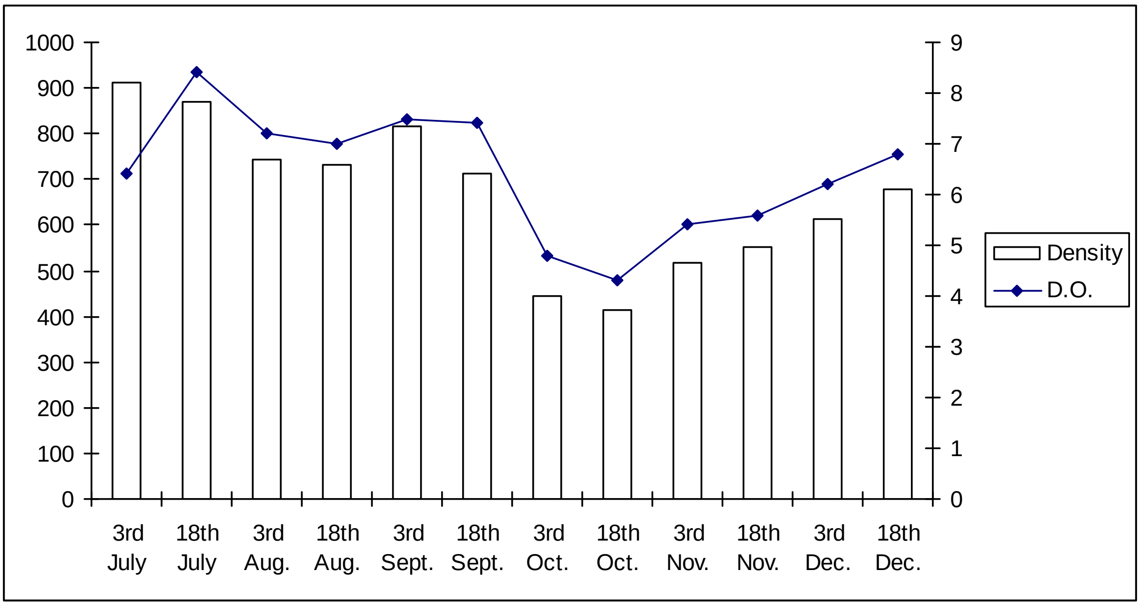


Fig. 23. Graphs showing the variation of zooplankton population density with Free CO_2 (From 3rd July 2002 to 18th Dec. 2002)

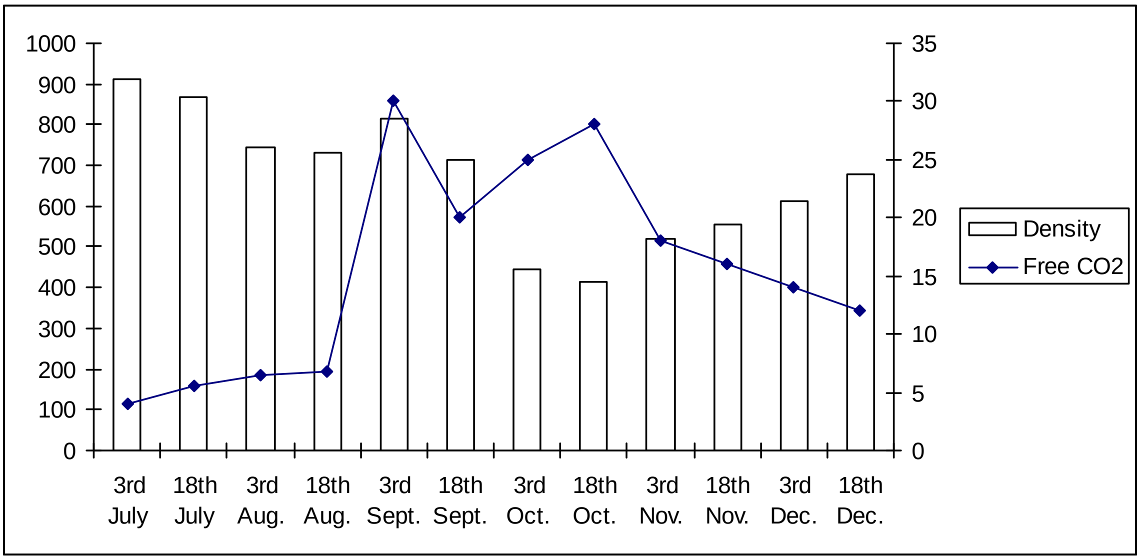


Fig. 24. Graphs showing the variation of zooplankton population density with Total Alkalinity (From 3rd July 2002 to 18th Dec. 2002)

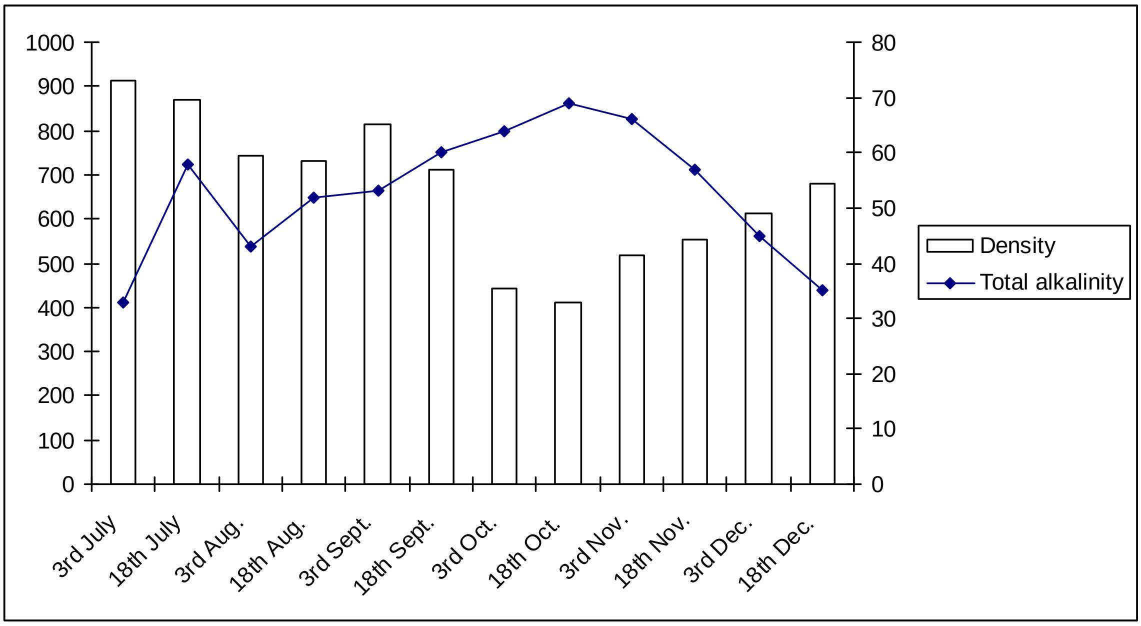


Fig. 25. Graphs showing the variation of zooplankton population density with Total Hardness (From 3rd July 2002 to 18th Dec. 2002)

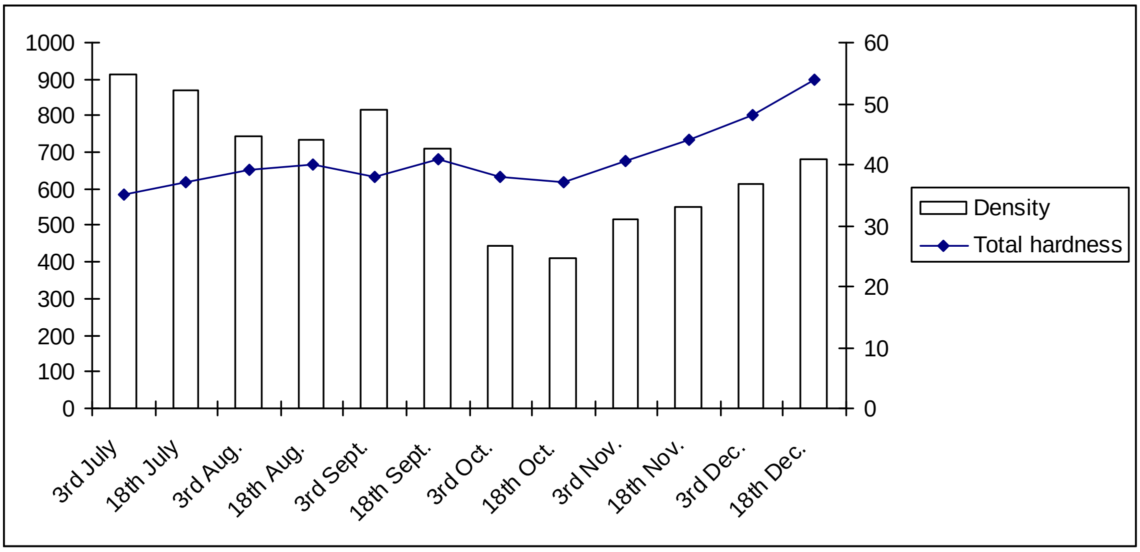


Fig. 26. Graphs showing the variation of zooplankton population density with Calcium (Ca) (From 3rd July 2002 to 18th Dec. 2002)

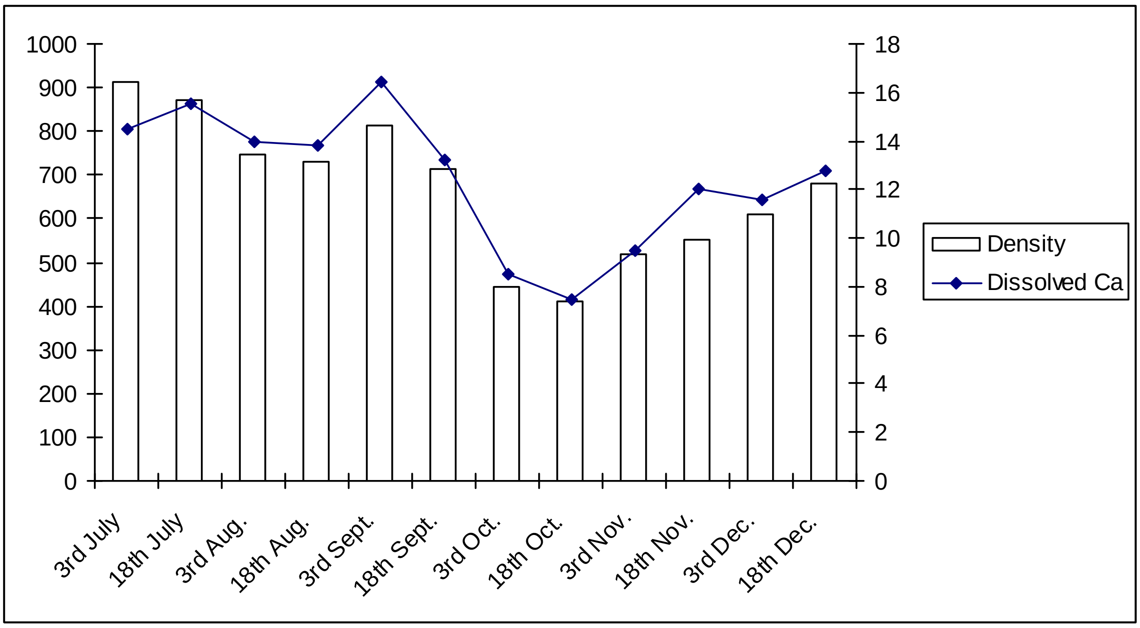


Fig. 27. Graphs showing the variation of zooplankton population density with Chloride (From 3rd July 2002 to 18th Dec. 2002)

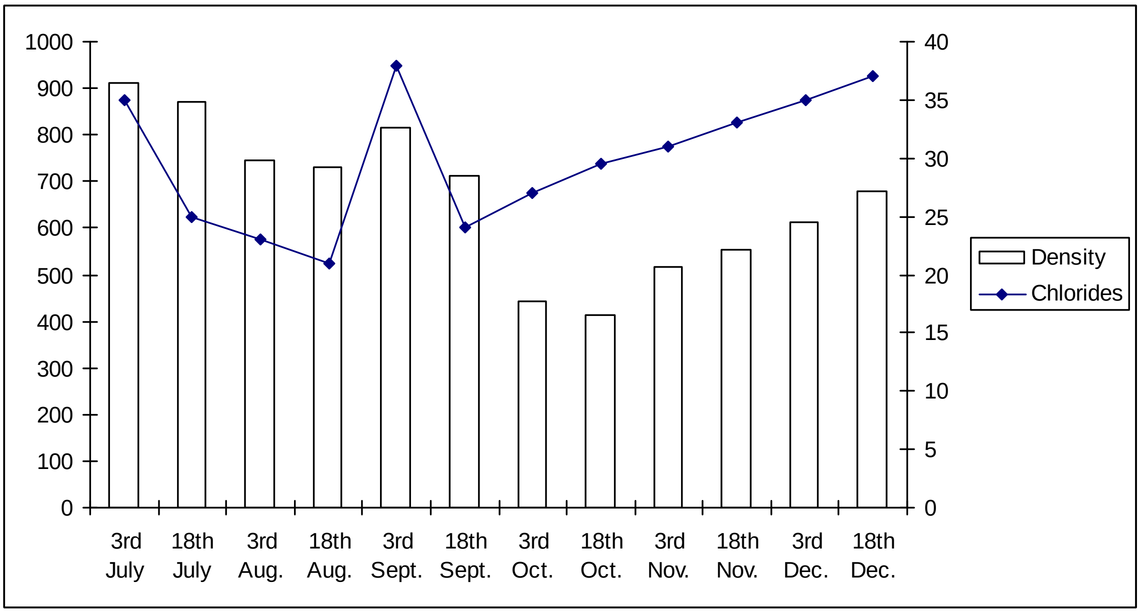


Fig. 12. Fortnightly variation of Protozoa (From 3rd July 2002 to 18th Dec. 2002)

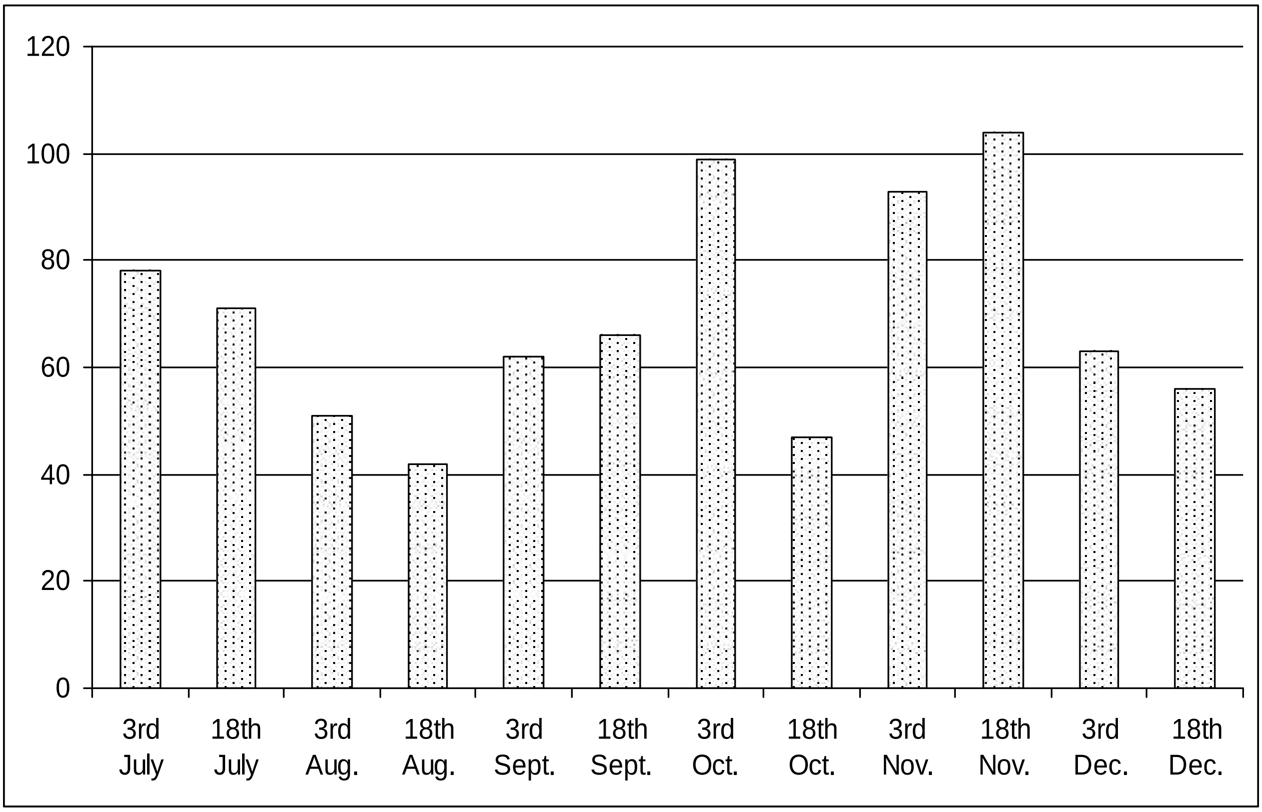


Fig. 13. Fortnightly variation of Rotifera (From 3rd July 2002 to 18th Dec. 2002)

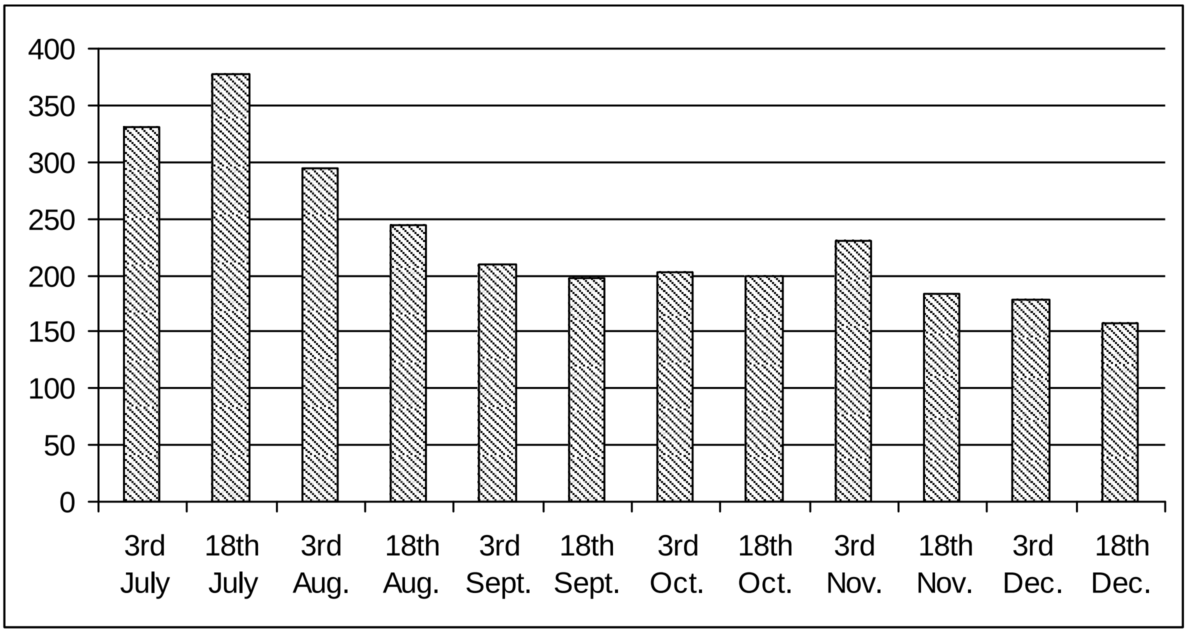


Fig. 14. Fortnightly variation of Cladocera (From 3rd July 2002 to 18th Dec. 2002)

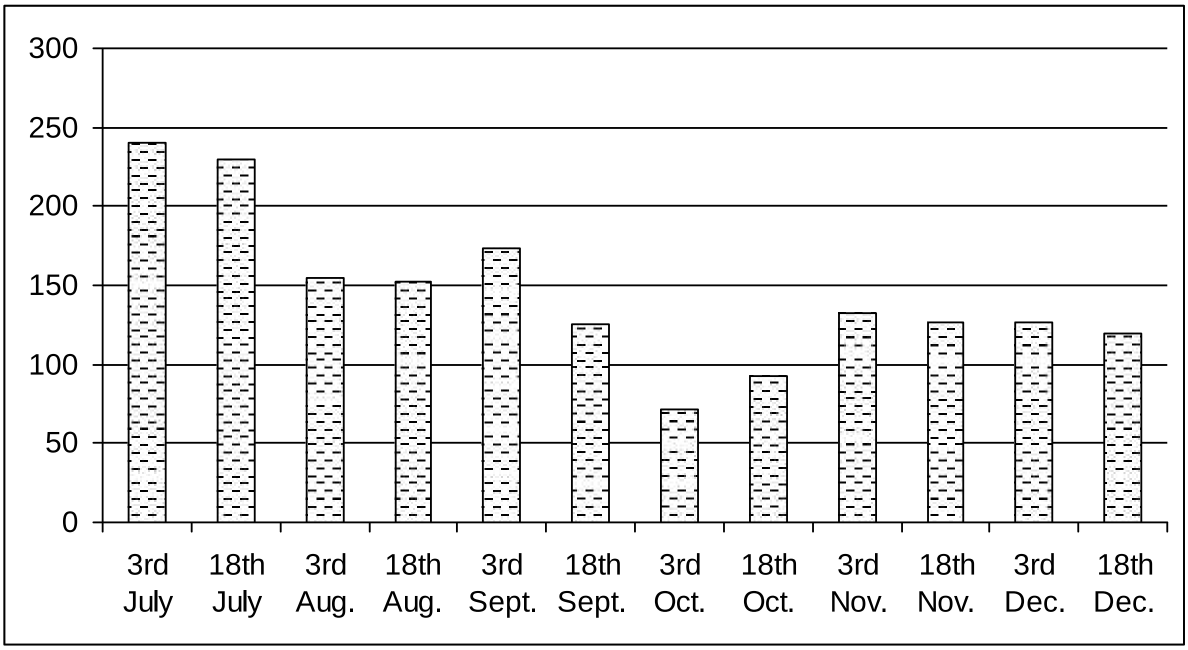


Fig. 15. Fortnightly variation of Ostracoda (From 3rd July 2002 to 18th Dec. 2002)

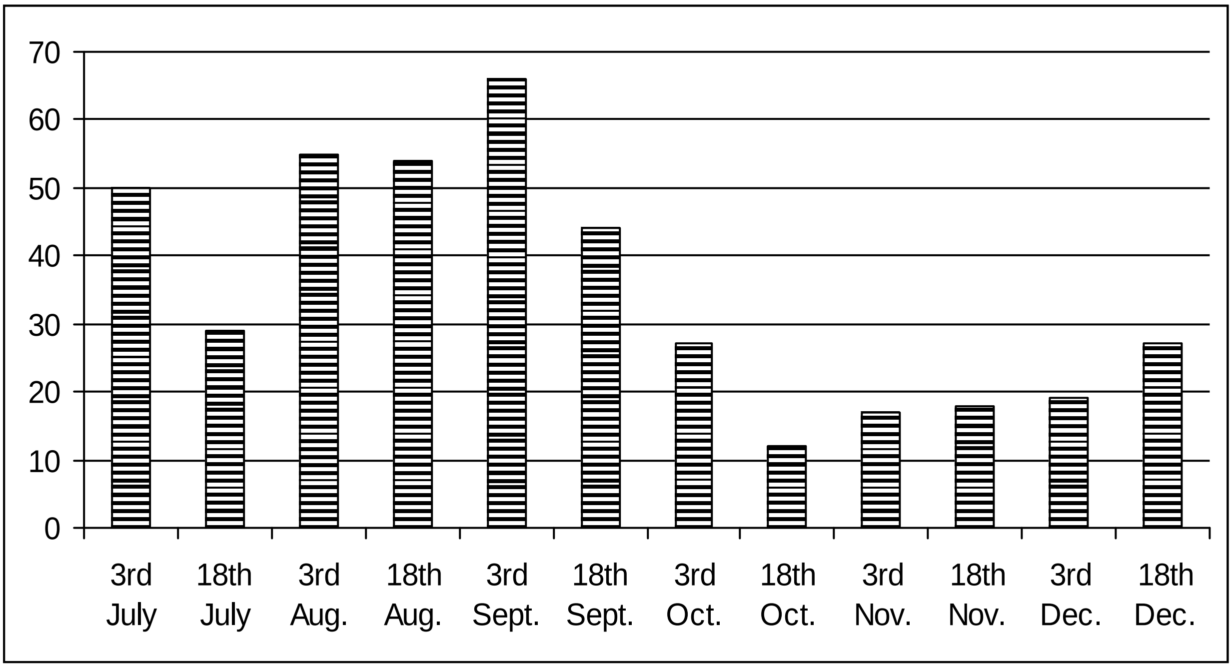
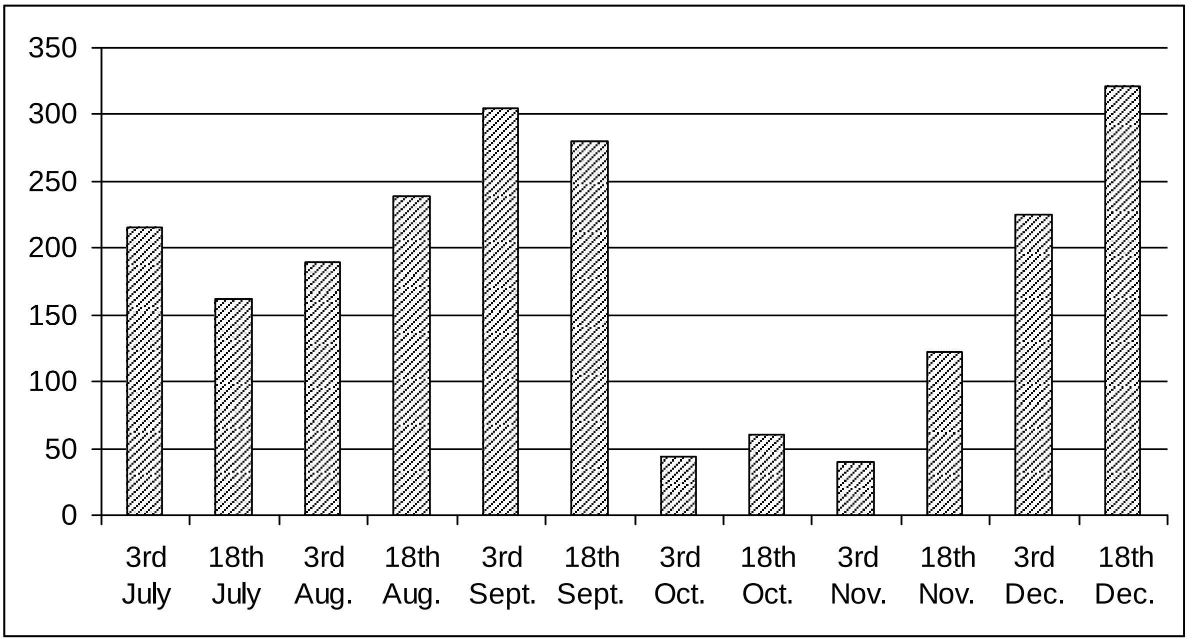


Fig. 16. Fortnightly variation of Copepoda (From 3rd July 2002 to 18th Dec. 2002)



Chapter Six

Discussion

Physico-chemical and Biological parameters determine quality of a water body. The physico-chemical parameters affect the Biological parameters in various ways which inturn affect the productivity of water body and is directly related to fish production. In an aquatic ecosystem the zooplanktons, the biological parameter constitute secondary trophic level upon which fishes and their larvae feed, depend largely upon the physico-chemical parameters for their growth and survival. The interactions between the physical and chemical parameters create circumstances for the growth and development of any particular biota. According to Ruttner (1953) each physiological activity of biota is affected by the conditions of environment i.e. temperature, light, oxygen content and other physico-chemical properties of water.

On the basis of observation carried out during the study period, the fluctuations in various Physico-Chemical parameters and their effects upon abundance and distribution of zooplanktons of pond "Dauna" Kirtipur, Panga are disscussed below.

In the present study water colour was found changing from brownish green to light green and finally to green. This may be because of the suspended particles of silt and clay during monsoon season, removal of algae from the pond and presence of algae blooms and mats. With changing water colour the zooplankton population directly fluctuated from low to high and finally to higher.

Depth

Depth of the pond water is an important factor, affecting the physico-chemical and biological parameters. In the present study maximum depth was recorded during rainy season and minimum during winter season. This is because of the heavy rainfall and inflow of water from surrounding high lands during rainy season and evaporation of water during winter which is a natural phenomenon. The increase and decrease in depth resulted in the increase and decrease in the population density of zooplankton during study period. The population density of zooplankton fluctuated from higher density in summer to lower density during winter. The coefficient of correlation (r) calculated between depth and zooplankton population density was also positive (i.e. $r = 0.69$) and significant suggesting that, there exists a positive relationship between depth and zooplankton density.

Transparency

Transparency is an important physical parameter influencing the pond productivity and thus affecting population density of zooplankton in water body. Transparency is inversely proportional to the turbidity which is caused due to silting, micro-organism and poor penetration of sunlight into it, reduce photosynthetic activity of aquatic autotrophs, and thus limit pond productivity.

In the present study transparency was found minimum on 3rd July this may probably due to the entry of silt laden rain water into the pond from surrounding high lands. Banerjee and Ray Chaudhary (1961) studied the Physico-Chemical features of Chilka lake and reported the low transparency during monsoon due to siltation. The maximum value of transparency recorded on 3rd September is probably due to the settling down of the mud as well as other suspended particles to the bottom and also because of the calm atmosphere. The fluctuation in transparency have affected the population density of zooplanktons. During the present study period, the density of zooplankton was found high when transparency was high and low when temperature was low. The coefficient of correlation (r) calculated between transparency and zooplankton density was also positive (i.e. r = 0.45) suggested that increase and decrease in transparency value was positively related to increase and decrease in zooplankton density which is not clearly known yet.

The finding of present study is supported by the findings of Sharma (1990), Jha (1994) and Khadka (1996) but the finding of Upadhya (1991), Mandal (1992), Chhetri (1993) are contrary to the present findings.

Temperature

Temperature is an important limiting factor of an aquatic ecosystem. The temperature of surface water layer depends on the air temperature. The temperature influences the metabolic and physiological activities of life processes such as feeding, reproduction, growth, movement and distribution of aquatic organisms. It also influences other Physico-Chemical parameters of water as at high temperature the capacity of water to keep oxygen in solution decreases and biological oxygen demand increases. (Holdren and Armstrong)

In the present study both the air and the water temperature were recorded and the rise or fall in both air and the water temperature may be due to the weather conditions. The variation in the temperature affected the population density of zooplanktons. The population density of zooplankton was found increasing and decreasing with the rise and fall of temperature respectively. The coefficient of correlation calculated between both the air and water temperature with zooplankton was also positive suggested that zooplankton population density increase with increasing temperature. The findings of Sharma (1990), Upadhya (1991), Rijal (1994) and Khadka (1996) are in support of present findings.

pH (Hydrogen ion concentration)

pH is an important chemical parameter of water influencing species composition and metabolism of all living organisms. Neutral water has pH value 7 and the waters having pH value below 7 are acidic and above 7 upto 14 are alkaline in nature.

In the present study the pH value ranged from 6.2 to 8.6 with an average value of 7.4.

Swingle (1967) reported that pond water having pH value between 6.5 to 9.0 is most suitable for fish culture and the water having pH value below 5 and above 9.5 are not suitable. Which supports the present result. Ellis (1937) reported that pH range between 6.7 to 8.4 is suitable for aquatic life. Hussain (1966) reported the pH range of 7.6 to 8.6 in Bihar lake. In the present study also the pH value was found to be nearly in the same range as mentioned by opcit workers.

The highest pH value (8.6) in the present study was in summer. This may be due to the high photosynthetic activities of aquatic autotrophs. The relation between pH and photosynthetic activity was studied by Elwakoel and Wahby (1970), Juday et. al. (1924 and 1934) Khanna and Bob (1980) and Sreenivason (1970 and 1976). The photosynthetic activity removes carbondioxide which results in the precipitation of $CaCo_3$ by plankton (algae) results in the increase of pH of water. Karki (1988) worked in Delhigate tank and Mahasati temple tank and reported the highest pH value below 9.1 and 8.1 respectively. The lowest pH value reported in the present study was 6.2 in winter, probably due to the poor penetration of light and poor photosynthetic activity.

The population density of zooplankton was found to be varied with fluctuating pH during the study period. The zooplankton population was found to be high and low with high and low pH values. The coefficient of correlation calculated between pH and zooplankton density was positive(i.e r=0.461) suggested the high and low population densities of zooplanktons was related to high and low pH values of pond water respectively.

Sharma (2004) worked on a village pond "Kamalpokhari", Kamal vinayak and reported the similar relation between zooplankton density and pH of water.

Dissolved oxygen (DO)

The dissolved oxygen of aquatic ecosystem is one of the most important parameter, which to a great extent can reveal the nature of whole aquatic ecosystem even when information on other chemical, physical and biological parameters are not available. It is the most critical factor in an aquatic ecosystem because all living organism except anaerobic forms require oxygen for respiration.

The Dissolved oxygen is available in water by direct diffusion from the atmospheric air and mainly though the photosynthetic activities of aquatic autotrophs. The photosynthetic activities depend on the presence of sunlight, it's effective penetration into the water and the depth of water body to which plant life exists. The animal communities residing in the water body utilize the dissolved oxygen for respiration and release carbon dioxide as a catabolic product during day and night. Some of dissolved oxygen is also utilized in the putrefaction of organic matters. The Oxygen producing and oxygen consuming processes must be balanced so as to keep the dissolved oxygen concentration within a range congenial to all organisms.

In the present study dissolved oxygen was found to range from 4.3ppm to 8.4ppm with an average value of 6.35ppm during the study period. According to Masuda and Pradhan (1988), dissolved oxygen more than 5 mg./lt. is good for pond productivity.

The maximum value of dissolved oxygen in the present study was 8.4ppm recorded in summer. This is probably due to the high temperature which accelerated the process of photosynthesis (saunder et. al. 1975) and the minimum value was recorded as 4.3ppm on 18th October is probably due to the accumulation of organic matters in the pond. The main source of organic matter in the pond is the litter fall from riparian vegetation. The dissolved oxygen present in the water was rapidly used up during the process of mineralization and bacterial decomposition.

In the present study, the zooplankton population density was found fluctuated with varying dissolved oxygen content throughout the study period. The density of zooplankton population was high and low when D.O. was high and low respectively. The coefficient of correlation(r) calculated between density of zooplankton population and dissolved oxygen was found to be positive (i.e. $r = 0.86$) suggesting the increase or decrease in population density of zooplankton was in accordance with the increase or decrease in dissolved oxygen content. Same pattern of variation of zooplankton population density with dissolved oxygen was found by Dhakal (1991), chhetri (1992), Rajil (1994), Khadka (1996) and Sharma (2004).

Free Carbon Dioxide (CO_2)

Free carbon dioxide is essential for the photosynthetic activity of chlorophyll bearing aquatic autotrophs. It provides the source of carbon, which is necessary for the growth of all green plants and indirectly for all other organisms. Hence, it plays a significant role in the food cycle of an aquatic ecosystem.

In the present study, the high value of CO_2 was recorded on 3rd September is probably due to the organic matter decomposition and respiratory activities of aquatic plants and animals (Ansari (1986)), Mandal (1992) and also because of poor photosynthesis and the minimum value of CO_2 recorded on 3rd July was probably due to the high dissolved oxygen content of water produced by photosynthesis in which CO_2 was used up in this process. The dissolved oxygen content and free - CO_2 in the present study was found inversely correlated which is natural.

The density of zooplankton population was affected by the free CO_2 present in water in the study period as population density of zooplankton went on increasing when free CO_2 was decreasing and vice-versa. The coefficient of correlation calculated between free CO_2 and density of zooplankton was found negative (i.e. r = - 59) suggesting that increase and decrease of free CO_2 content of water cause the corresponding decrease and increase in density of zooplankton population. Similar findings were also reported by Singhal et. al. (1986), Mahato (op cit), Mandal (op cit), Khadka (1996) and Sharma (2004) etc.

Total Alkalinity

In the present study, the total alkalinity was found due to the bicarbonates. According to Jhingran (1975) carbonates remain absent and biocarbonates may be present when pH value lies between 8.3 to 4.5. The present results were found to be in accordance to above result as the average pH value was 7.3. More or less similar behaviour of total alkalinity was laso reported by Kuslan and Hunt (1979) in an alligator pond and Karki (1988) in two temple tanks of Udaipur, India.

In the present study, the total alkalinity ranged from 33 to 69 ppm with an average value of 51ppm. Bennett (1970) reported that pond waters with total alkalinity fluctuating between 41 to 90ppm has medium to high productivity. Cole (1975) reported that, the total alkalinity ranging between 51 to 67ppm is good for pond productivity. In the present study, the total alkalinity range was found more or less similar to the above ranges.

The density of zooplankton population was found to be fluctuated with the varying total alkalinity values. The density of zooplankton population was higher when total alkalinity was lower and vice versa. The coefficient of correlation (r) calculated between these two variables was found to be negative (i.e. $r = -0.62$) suggesting that the increase and decrease in total alkalinity values was responsible for the corresponding decrease and increase in density of zooplankton population. Singhal et. al. (1986) also reported same pattern of fluctuation of density of zooplankton with total alkalinity.

Total Hardness

Total hardness is an important chemical parameter affecting the density of zooplankton population in a water body. In the present study total hardness ranged from 35ppm to 54ppm with an average value of 44.5ppm. The maximum value of total hardness was reported in winter and minimum in summer. Similar results were also reported by Shrestha (1994). According to Swingle (1967), pond water having total hardness of 15 ppm or above may be considered suitable for the growth of the fish. Total hardness influences other Chemical parameters and density of zooplankton population. In present study the population density of zooplankton was found to be high when total hardness was low and vice versa. The coefficient of correlation calculated between density of zooplankton and total hardness was found to be negative (i.e. r = - 0.18), which suggested that the higher values of total hardness were unfavourable for growth and production of zooplankton. Similar results were also pointed out by Chetri (1992), Rijal (1994), Khadka (1996) where as Rajbansi (2002), and Sharma (2004) found the positive relationship between these two variables.

Calcium

Dissolved calcium is essential for all living organism. It is the important constituent of cell wall and regulates various vital physiological functions in organisms. Soft waters may contain less than 1mg/lit of dissolved calcium where as hard waters may contain upto 100 mg/lit (Krebs, 1972). Calcium fluctuations in water are directly related to hardness (Ruttner, 1953). Jewell (1939) reported that the calcium bicarbonate content of water is a critical factor, restricting population density of aquatic organisms. In the present study, the dissolved calcium was found in the range of 7.5 to 16.4 ppm with an average value of 11.5 ppm. Jhingran and Mehrotra (1986) worked in Gulariya reservoir and reported the dissolved calcium range between 12 - 26 ppm.

Turnpenny (et. al. (1987) reported the calcium range of 0.80 to 27 ppm. The dissolved calcium range found in present investigation is more or less similar to these dissolved calcium ranges. With higher values of dissolved calcium, the values of DO, pH and dissolved chlorides were also found to be higher during the study period. Chhetri (1992), Rajbansi (2002), Sharma (2004) also reported the same results. The coefficient of correlation calculated between dissolved calcium and density of zooplankton was positive (i.e. r = 0.21)suggested that increased value of dissolved calcium favoured the zooplankton production.

Chlorides (Cl^-)

Chlorine is in the form of chloride (Cl^-) is one of the major inorganic anion in water and waste water. The salty taste produced by chloride concentration is variable and dependent on the chemical composition of water. Typically salty taste may be absent in waters, those containing as much as 1000 mg/lit of dissolved chlorides when the predominant cations are calcium and magnesium. The chloride concentration is higher in waters because NaCl is the common article of diet and pass unchanged through the digestive tract. High concentration of chloride harms the growing plants and aquatic animals. Chlorides are usually present in low concentration in natural waters. Low concentration of chlorides play metabolically active role in photolysis of water and phosphorylation reaction in autotrophs. Higher chloride values in water indicates the pollution of animal origin which is always present in ponds like the present village pond called “Dauna”

In the present study chlorides value ranged from 21 to 38 ppm. with an average value of 29.5. More or less similar chloride range was also reported by Mahato (1994), Shah (1994) and Sharma (2004). The population density of zooplankton was found to be fluctuated with varying values of chlorides. In the higher values of chlorides population density of zooplankton was found higher and lower with lower value of chlorides. The coefficient of correlation calculated between these two variables was positive suggested that there existed a positive relation between zooplankton population density and chlorides.

Zooplankton

Zooplankton, the free swimming planktons of animal nature feed on phytoplanktons are in turn consumed by the tertiary consumers in an aquatic ecosystem. The zooplanktonic oscillations, thus influence the population structure and distribution of organism at primary and tertiary levels. Together with phytoplanknons, they provide a varieties of indicator species. Zooplanktons are represented by a wide array of taxonomic groups of which the members of protozoa, rotifera, cladocera , copepoda, and ostracoda are most common and often dominate the entire consumer community.

The abundance and species diversity of zooplankton is related to the alkaline nature of water (Goldman and Horne, 1983). In the present study, though the average pH of water during study period was 7.4, the abundance and species diversity of zooplankton was not found to be much profound. In present study, the total abundance of zooplankton was 8006 no/lt with an average value of 667.16 and total of 10 genera belonging to five taxonomic groups as protozoa, rotifera, cladocera, ostracoda and copepoda were recorded. Goldman and Horne (1983) reported that diversity of zooplanktonic population is related to alkaline nature of water body. Very low pH is known to reduce species diversity and abundance. Agrawal et.al. (1995) worked in Sagar lake and Millitary engineering lake of India and reported the more or lees similar species diversity of zooplankton. Khair (1988) also reported more or less similar species diversity from Tandah lake.

In the present study the population densities of protozoa, Rotifera, Cladocera, Otracoda, and Copepoda were 832 no/lit 2083 no/lit, 1728 no/lit, 418 no/lit, and 2225 no/lit respectively. Similar observation was reported by Karki (1988) in two temple tanks in Udaipur, India.

In the present study, maximum zooplankton abundance was 913 no/lit recorded on 3rd July followed by 870 no/lit recorded on 18th July. This is probably due to the optimum physico-chemical parameters such as water temperature 22^{o}C, depth 67 cm, dissolved oxygen 6.4 ppm and CO_2 4ppm on 3rd July and water temperature 23^{o}C, depth 68 cm dissolved oxygen 8.4 ppm and CO_2 5.5 ppm on 18th July. Sah et. al. (1971) worked in a fish pond at cuttack and reported four peaks of zooplanktons in which one peak was reported in summer. Khadka (1996), and Sharma (2004) also reported the zooplankton peak in summer. The minimum zooplankton abundance was recorded as 412 no/lit on 18th October. This is probably due to the low dissolved oxygen 4.3 ppm and high free CO_2 content (28 ppm) of the water.

In the present study two genera of protozoa i.e. Paramecium sps. and Vorticella sps., two of rotifera i.e. Keretella sps. and Brachionus sps., one of Ostracoda i.e. Cypris sps., three genera of Copepoda i.e. Diaptomus sps., Cyclopus sps. and Nauplius sps., and two of Cladocera i.e. Daphnia sps. and Moina sps. were recorded. Khair (1988) and Rajbanshi (2002) also reported the similar genera from Taudah lake and Sharma (2004) from a village pond "Kamal Pokhari".

In the present study, the group protozoa constituted 10.39% of total zooplanktonic population, in which the genus Paramecium constituted 7.99% and vorticalla 2.39% of the total population. Maximum density of protozoan population was 104 no./lit on 18th November and minimum 42 no./lt recorded on 18th August.

Rotifera constituted 35.01 present of total zooplanktonic population of which the genus Keretella constituted 25.5 percent and Brachionus constituted 9.50 percent of total population of zooplankton. The population density of Rotifera was highest on 3rd July as 378 no./lit and minimum on 18th December as 157 no/lit. This is probably because of the high dissolved oxygen content (i.e. 8.4), water temperature (23^oC) and low value of free CO_2 on 18th December. In the present study zooplanktonic population was found to be dominated by Rotifers. Mallin (1989) reported that in planktonic community of sutlon reservoir (U.S.A), rotifers were found high in number and under which Keretella was higher than the other groups. Sharma (2004) also found the zooplanktonic population dominated by the group Rotifera from a village pond "Kamal Pokhari".

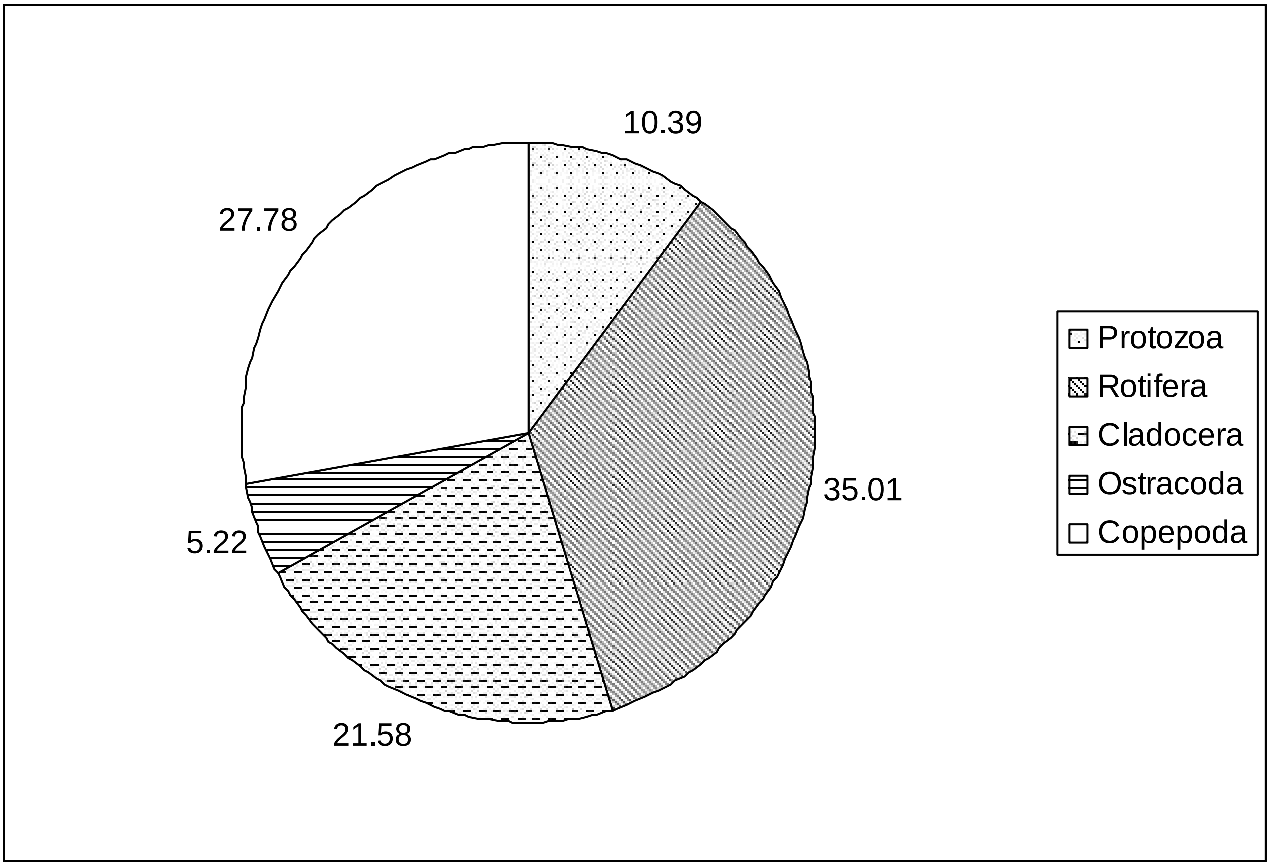
The group Cladocera contituted 21.58% of total zooplanktonic population. Among Cladocera the two genera namely Daphnia and Moina constituted 15.20% and 6.38% of total zooplanktonic population respectively. Maximum density of Daphnia was 175 no./lit recorded on 3rd July. This may be due to the appropriate Physico-Chemical parameters. (water temperature 22^oC, transparency, 18 cm dissolved oxygen, 6.4 ppm and free CO_2 4 ppm). The minimum density was 40 no/lit. on 3rd October. This is probably due to the low value of dissolved oxygen (4.8 ppm). The highest count of Moina was 85 no/lit recorded on 18th July and lowest count was 24 no/lit on 18th Dec. This high and low density of Moina is probably due to the appropriate Physico-Chemical factors i.e. water temperature 23^oC, dissolved oxygen 8.4 ppm, pH 7.9 on 18th July and low value of pH i.e. 7.0, water temperature 20.5^oC on 18th December respectively.

The one genus i.e. Cypris belonging to the group Ostracoda constituting 5.22% of total zooplanktonic population. The Cypris population density was found maximum 66 no/lt. on 3rd September and minimum 12 no/lit on 18th October. This is probably due to the high value of pH i.e. 7.8 which favoured the growth on 3rd September and low value of pH 6.8 which declined the population density on 18^{th} October respectively.

The group Copepoda constituting 27.78% of total zooplankton population density. Among this group, three genera recorded namely Diaptomus, Cyclopus and Nauplius constituted 1.78%, 15.65% and 10.35% of total zooplanktonic population respectively. Maximum density of Diaptomus population was recorded on 3rd July as 25 no./lit and minimum density was recorded on 3rd November as 3 no./lit. This is probably due to high pH 8.4, high dissolved oxygen 6.4 ppm on 3rd July and high free CO2 content of water 18 ppm and low dissolved oxygen content 5.4 ppm on 3rd November. The population density of Copepods was found maximum (321 no./lit.) on 18th December and minimum (40no./lit.) on 3rd November. This high and low density of Copepods is probably due to the high (7.0) and low (6.2) value of pH of pond water respectively. De Smet et. al. (1989) reported the higher number of copepods from the alkaline and moderately eutrophic surface water of Belgium.

The present study observed that in some genera, the amplitude of rise and fall in population density was not so large while in others the change was so great. The periods of population increase and decrease of single genus of zooplankton do not coincide with the seasonal maxima and minima of the total zooplanktonic population.

Fig. 28. Pie Chart showing zooplanktonic composition of the pond.



Chapter Seven

Conclusion and Recommendations

7.1 Summary and Conclusion

The present study entitled "A Study on the effects of some Physico-chemical parameters on the abundance and distribution of zooplanktons of a village pond "Dauna" Kirtipur Panga" was carried out fortnightly for a period of six months from 3rd July 2002 to 18th December 2002. The main purpose of the present study was to know about how physicochemical and biological parameters especially zooplanktons of this pond are interrelated to each other and to investigate the suitability or unsuitability of pond water for productivity so that on the basis of which fish culture practice in this pond would be suggested.

The present study has been summarized into seven chapters. The first chapter deals with general introduction, the second chapter deals with the review of literature. The third chapter discusses the study area, materials and methods. Observation has been included in chapter four. The statistical analysis in chapter five and discussion has been dealt in chapter six. Chapter seven includes conclusion and recommendations.

The different physico-chemical parameters observed in the present study were nature of the day, water colour,temperature , depth, transparency ,pH,dissolved oxygen, free carbon dioxide , total alkalinity, total hardness and ,dissolved calcium and chlorides .

The colour of water varied according to the season indicating the swarms of planktons. Temperature varied due to seasonal change and weather conditions. High and low population density of Zooplankton was observed with high and low temperature respectively.

Transparency fluctuated from 18 to 27.5 cm with an average value of 22.75 cm. Depth ranged from 50 to 68 cm in which minimum (50 cm) was noted in winter and maximum (68 cm) was in monsoon. Population density of Zooplankton was found to be directly proportional to the depth.

The pH of the pond water varied from 6.2 to 8.6,the average being 7.4. The dissolved oxygen varied from 4.3 to 8.4 ppm. It was minimum on 18th October and maximum on 18th july. The free carbon dioxide fluctuated from 4 to 30 ppm. The total alkalinity ranged from 33 to 69 ppm and total hardness from 35 to 54 ppm. The dissolved calcium ranged from 7.5 to 16.4 ppm. where as dissolved chlorides from 21 to 38 ppm.

Five major groups namely protozoa,rotifera,cladocera,ostracoda and copepoda contributed the zooplanktonic assemblage of this pond called "Dauna" . The zooplanktonic population density was dominated by rotifers (35.01%) , followed by copepoda (27.78%), cladocera (21.58%), protozoa (10.39%) and ostracoda (5.22%).

The density of zooplankton population was minimum (412no/lit) on 18th October and maximum (913no/lit) was found on 3rd july 2002.It was observed that the maximum peak of the zooplankton population was during monsoon while troughs in the winter months of the year.

It was found from the statistical analysis that, there was positive correlation between the population density of zooplankton and different parameters like depth, temperature , transparency, dissolved oxygen, pH, dissolved calcium and chlorides where as negative correlation was between zooplankton density and free carbon dioxide , total alkalinity and total hardness.

Through the actual depth of this pond is 1.5 meter, during study period, depth of pond water was found in an average of 59 cm. This low depth of pond water was due to the evaporation of water and also because of the inadequate water source to the pond, as the major source of water for the pond is the rain water and surface runoff water from the surrounding lands and a limited water is supplied from a tap located far distance from the pond. Therefore, it can be concluded that, if additional water source can be made available, the depth of the pond is appropriate for pond productivity and fish culture practice can be suggested. The important chemical parameters such as PH, dissolved oxygen, dissolved calcium and chlorides which favoured the growth of zooplankton population were also found in an appropriate range. The optimacy of these above parameters for pond productivity in the present range was also revealed by various workers who worked in the field of Limnology. Also, the chemical parameters free carbon dioxide , total alkanity and hardness with which density of zooplankton population was found decreasing were found in an appropriate range. Therefore, it can be concluded that as in the present study the important physico-chemical parameters were found suitable for zooplanktonic production essential for pond productivity, fish culture in this pond can be suggested.

Through, the density of zooplankton population in the present study was not found to be so high (i.e. total 8006 no/lt), the species diversity of zooplankton was found to be good. The density of zooplankton population can be improved, if physical conditions of the pond are improved. Thus, in the present study, the various physicochemical and biological parameters were found in support of good productivity of the pond.

7.2 Recommendation

For the improvement and better utilization of the pond following suggestions are recommended.

1. Though, an ideal environmental condition furnished by a healthy atmosphere around the pond enhancing it's recreational and aesthetic value is appropriate, but because of lack of adequate water source, water level goes on decreasing during dry season, affecting pond creatures, therefore, additional sources of water should be arranged.
2. The washing of pesticide containers by the farmers should be strictly avoided because pesticides are detrimental to both fishes and fish food organisms.
3. The pond should be maintained by the responsible local VDCs.
4. Unwanted vegetations, planktons and algal booms should be removed regularly by ecological methods.
5. Biological monitoring programme should be launched for better knowledge of pond and to know the function of ecosystem.
6. The local people should be made aware regarding the water pollution. So that they come forward to protect the pond by restricting the throwing of organic solid wastes and grabages from the surrounding areas.
7. In the present study, the most part of the pond was found to be covered by the floating water plants having large flat leaves, which block the sunlight from entering into the pond water affecting the photosynthetic activity and thus reducing pond productivity. Therefore, for good productivity of pond for fish culture, these floating plants should be regularly removed.

Table No. 1. Fortnightly Variation of Physico-Chemical parameters of village pond "Dauna" Kirtipur, Panga-11

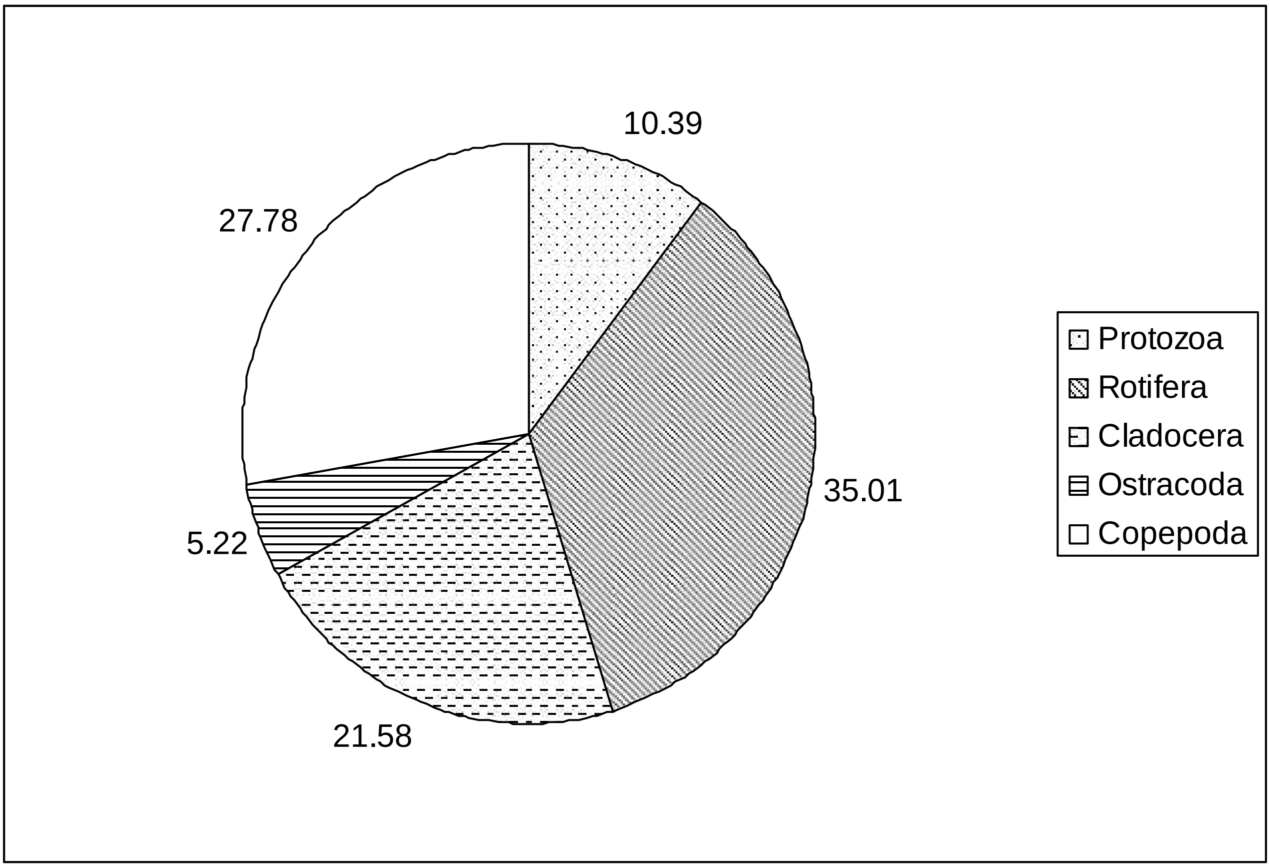
(From 3rd July 2002 to 18th December 2002)

Parameters	3rd July	18th July	3rd Aug.	18th Aug.	3rd Sept.	18th Sept.	3rd Oct.	18th Oct.	3rd Nov.	18th Nov.	3rd Dec.	18th Dec.	Mi
Depth (cm)	67	68	60	58	55	57	58	54	52	50	50.5	55	
Transparency (cm)	18	24	26.5	25.9	27.5	25	19.5	18	21	22	24	24.5	
Air temp. (^{o}C)	26	24.8	24	23	25	24.5	23.5	25.5	21	21.5	22.5	22.8	
Water temp. (^{o}C)	22	23	24	24.5	26	25	25.5	22	21	21.5	20	20.5	
pH.	8.4	7.9	7.6	7.4	7.8	8.2	8.6	6.8	6.2	6.6	6.8	7.0	
DO (ppm)	6.4	8.4	7.2	7.0	7.5	7.4	4.8	4.3	5.4	5.6	6.2	6.8	
CO_2 (ppm)	4	5.5	6.5	6.8	30	20	25	28	18	16	14	12	
Total alkalinity	33	58	43	52	53	60	64	69	66	57	45	35	
Total hardness	35	37	39	40	38	41	38	37	40.5	44	48	54	
Calcium (ppm)	14.5	15.5	14.0	13.8	16.4	13.2	8.5	7.5	9.5	12	11.6	12.8	
Cl (ppm)	35	25	23	21	38	24	27	29.5	31.0	33	35	37	

Table No. 2. Fortnightly Variation of Zooplanktons (no./lit.) of Village Pond "Dauna" Kirtipur, Panga - 11 (From 3rd July 2002 to 18th December 2002)

Months	**3rd July**	**18th July**	**3rd Aug.**	**18th Aug.**	**3rd Sept.**	**18th Sept.**	**3rd Oct.**	**18th Oct.**	**3rd Nov.**	**18th Nov.**	**3rd Dec.**	**18th Dec.**	**Total**	**Minimum**	**Max.**	**Average**	**Percent (%)**
Zooplankton **A) Protozoa** a) Paramecium b) Vorticella	54 24	55 16	43 08	42 -	62 -	41 25	75 24	47 -	73 20	83 21	35 28	30 26	640 192	30 8	83 28	53.33 16.0	7.99 2.39
Total	78	71	51	42	62	66	99	47	93	104	63	56	832	42	104	69.33	10.39
B) Rotifera a) Keretella b) Brachionus	245 85	210 168	219 75	180 65	150 59	140 57	160 42	155 45	159 71	145 38	142 36	137 20	2042 761	137 20	245 168	170.16 63.41	25.50 9.50
Total	330	378	294	245	209	197	202	200	230	183	178	157	2803	157	378	233.58	35.01
C) Cladocera a) Daphnia b) Moina	175 65	145 85	120 35	110 42	125 48	80 45	40 32	45 47	85 48	95 31	102 25	95 24	1217 511	40 24	175 85	101.41 42.58	15.20 6.38
Total	240	230	155	152	173	125	72	92	133	126	127	119	1728	72	240	144	21.58
D) Ostracoda a) Czpris	50	29	55	54	66	44	27	12	17	18	19	27	418	12	66	34.83	5.22
Total	50	29	55	54	66	44	27	12	17	18	19	27	418	12	66	34.83	5.22
E) Copepoda a) Diaptomus b) Cyclopus c) Nauplius	25 125 65	22 75 65	15 105 70	9 140 90	- 150 155	- 145 135	4 40 -	5 50 6	3 - 37	19 53 50	20 195 10	16 175 130	143 1253 829	3 40 6	25 195 155	11.91 104.41 69.08	1.78 15.65 10.35
Total	215	162	190	239	305	280	44	61	40	122	225	321	2225	40	321	143.75	27.78
G. Total	913	870	745	732	315	712	444	412	518	553	612	680	8006	412	913	667.16	100%

Fig. 28. Pie Chart showing zooplanktonic composition of the pond.



REFERENCES

ADB/HMGN (1982) Nepal Ag. Sec. Strategy study vol-II ADB Monila, HMG/Nepal.

Adoni, A.D. (1985). "Work book on Limnjology", Parathibha Publisher, Sagar, India.

Agrawal, N.C., Bais, V.S. and Sukla, S.N. (1995) Contrast effect of temperature and redox potential on the biology of the Sagar lake. Ecol. Env. & Conv. 1(1-4):31-32.

Aizaki, Tarashima, M., Nakahara, A., Nisho, T. & Ishida, Y. (1987). Trophic Status of Tilicho (Nepal) a high altitude Himalayan lake, Hydrobiology.

American Public Health Association (APHA) (1978). "Satandard Methods for the examination of Water Waste Water Including Bottom Sediment and Sludge" 4th Edition New York. pp. 874.

APROSC (1985) Perspective Ag. Plan. Agriculture project service centre, Kathmandu.

Augusthy, K. T. (1979). "Fish Farming in Nepal". Archana Prints and Publishers, pp. 13-18.

Ayyapan, S., Sakuntala, K., Parmeshwaran, S., Sukumaran, P.K. and Raghavan, S.L. (1988) Diel variation in water quality, primary production and plankton of a peninsular tank. J. Inland Fish. SOC India, 20 (1):13-25.

Banerjee, A. C., Roy & Chaudhary, N. C. (1961). Chemical Features of Chilka Lake, India. J. of Fisheries, Vol. XIII, pp. 48-82.

Banerjee, S.M. (1967) Water quality and soil condition of fish ponds in some stations of India in relation to fish production. Ind. J. Fish 14 (1 and 2):115-144 p.

Barbato, S. (1983) Water quality I warm water fish ponds, Auburn University. Agr. Expt. Frossion, italy.

Bhattarai, B.K. (1996) Fortnightly study on hydrological characteristics and primary productivity of Kamal Pokhari, Bhaktapur., M.Sc. Dissertation. (Degree in Zoology), T.U. (Unpublished)

Boyd, C. E. (1979). "Water Quality in Warm Water Fish Pond", Auburn University, Agricultural Experiment Station.

Brehm (1953). Some aquatic fauna from Kalipokhari. Eastern Nepal. (Unpublished).

Campos J.K. (1988) Fresh water quality fauna and flora of Caurgue lake, Chile Hydrobiology, 53(1):55-65.

Campos, H., Steffen, W. Oscar, P., Patricio, D. & Gloria, A. (1988) Limnological studies in Lake Caburgua (Chile). Institute de Zoologia, Universidad Austral de Chile. GAYANA BOT 44 (1-4): pp. 61-84.

Chacko, P. I. & Krishnamurithy, J. B. (1954) "Study on the Plankton of Three freshwater Fish Ponds in Madras City, India". Symp. Mar. Freshwater Plank.Indo - pacific Fish Count. (UNESCO), pp. 103-170.

Chhetri, K. (1998) Study on the abundance and distribution of Zooplankton of a Village Pond (Bhim Pokhari), Kirtipur. M.Sc. Dissertation, (Degree in Zoology), T.U., Kathmandu (Unpublished).

Chidobem, I. J. & Chiweyite, E. (1987) Seasonal Periodicity of Planktons in The Sehen Reservoir (Jos. Pleatue, Nigeria), (Univ. Jos. Dept. Zool. Jos, Nigeria). Cata Hydro Bio! 29 (2). pp: 193-202.

Cole, G. A. (1975) "Text Book of Limnology" Dept. of Zoology, Arizona State University, Temple, Arizona. pp: 1-120.

Dahal, Badri Prasad (1991) Study on physico-chemical parameters of Godavari fish pond no. 20 in relation to fish production. M.Sc. Dissertation. (Degree in Zoology). T.U., Kathmandu (Unpublished).

Das and Gupta, R. (1996) The Trophic Structure and Physical Characteristic of Some lenitic habitats in Darjeeling Himalaya. J. of Bengal Natural History Society, New series 14 (1). pp: 11-40.

De Leo, G. A. and I. Ferrai. (1993) Distribution and diversity in a river Zooplankton Community. Coenoses 8 (2). pp: 121-129.

De-Smet, W. H. Das, A., (1989) Hydrobiological Studies of Van-Rompu. E.A. & Surface Water in Antwerpe Greef-De, J.A [Belgium]. (Lab. Voor Algemene Biol. Univ. Antwerpen, Ruca Campus, Groeneborge Loan 171, 2020 Antwerpen) Natnur wet TIJ DSCHR 69 (4-6). pp: 156-213.

Dangol, G.S. (1994) Study on some effect of physico-chemical parameters in relation to zooplankton production Labha Pukhu, Kirtipur.

Ferrow, W. K. & Swar, B. D. (1978) Bathymatric Maps from Lakes in Pokhara Valley. J. Institute of Science, T.U. Kathmandu, Nepal. (1). pp: 177-188.

Forel, F. A. (1892, 1895, 1904) "Le Leman", Monographic Liminologique - F. Rouge. Lausanne, Vol. 3.

Foster, R.F. (1965) The lake as a microcosm. Bulletin science. Academy. Preoria.

Ganapati, S. V. (1941) "Seasonal Change in Physical and Chemical Conditions of a Garden Pond Containing abundant Aquatic Vegetation". J. Mad. Univ. 13. pp: 55-69.

Ganapati, S. V. (1953) Hydrobiological Condition of Gangadhareswor Temple Tank. J. Asiatic. Soc. Sci. 19 (2). pp: 149-159.

George, M. G. (1961) Diurnal Variation in the Shallow Ponds in Delhi, India. Hydrobiology, 18. pp: 265-273.

Goldman, C. R. & Horne, A. J. (1983) "Limnology", Mc.Graw - Hill & Horne, A. J. International Book Company, Toronto.

Hall, Davis and Votenta, S.V.(1963) Preliminary works on the physico-chemical analysis of Zambenzi Mozambique lake, Holland, Hydrobiology 36(8-4):443-469.

Hickel, B. (1973) Limnological Investigation in Lakes of Pokhara Valley. Int. Rev. Ges Hydrobiol. 58 (5). pp: 654-672.

Hiriono, M. (1955) "Freshwater Algae in Fauna & Flora of Nepal Himal". Scientific Result of Japanese Expedition, Nepal, Himalaya, Kyoto, Vol. 1.

Hoenel and Johnson, P.V. (1972) Limnology of great Bear lake U.S.A. New. J. Zool. 21 :227-261.

Holman (1975) Hemial and biological characteristic of water column in lake Tohawe.

Hopkins, C.L. (1971) The annual temperature regime of a small stream in New Zealand. Hydrobiology. 37:397-408.

Hunt Singer, S.P. and Moslim P. (1972) Comparative limnological characteristics of the basins of Eagle lake, California U.S.A.

Hutchinson, G. E. (1957) "A Treatise On Limnology", Vol. 1 Geography, Physics and Chemistry, John Wiley and Sons. Inc., Printed in USA, N.Y. pp: 1015.

Hutchinson, G.E. (1932) Limnological studies in Kashmir lakes Int. Rew. Hydrobiology.

Hutchinson, G.E.(1967) "A Treatise On Limnology", Vol. II Introduction to lake Biology and the Limnoplankton, John Wiley and sons, Inc.,n.y.pp:1115.

Hynes, (1970) Ecology of running water. University of Toronto press. Toronto.

Iwakuma, K.H. (1989) Studies on primary production of phytoplankton and secondary production of Daphnia and Chaobid in Eutrophic pond of Japan. 74:92-105.

Iwakuma, T., Shibata,K. and Hanazato.T.(1989) "Production ecology of Phytoplankton and Zooplankton in a eutrophic pond". Environmental biol.Div.Nati.1st Env. studies, Tsukuba ibaraki 305 Jpn.Ecol. Res 4.(1) pp:31-54.

Joshi,C.L(1979) "Biological and Physico-chemical Features of ponds at kirtipur" M.sc. Dissertation.(Degree in Zoology). T.U Kathmandu (Unpublished)

Kant and Kachro (1975) The diurnal changes in the temperature and pH of water and movement of planktons in Dal lake, Srinagar, India.

Karki, S.B. (1988) Studies on some limnological Aspects of Selected Closed Water Ecosystem of Udaipur, India. A Ph.D. Thesis Sukhadia University. Udaipur, India.

Karna.R.(2002) "physico-Chemical parameters of the village pond (Jaleshor Nath) in relation to Zooplankton production". M.sc. Dissertation.(Degree in Zoology). T.U Kathmandu (Unpublished)

Khair, A.G (1988) Study kon some Limnological parameters of Taudah Lake with reference to Zooplakton. M.sc. Dissertation.(Degree in Zoology).T.U Kathmandu (Unpublished)

Khakda, Geeta (1996) Study on some limnological parameters of a historical pond Naghdaha, Dhapakhel, Lalitpur. M.Sc. Dissertation (Degree in Zoology). T.U., Kathmandu (Unpublished).

Kohl, M.P.S., Thakur, N.K and Munnet, S.K. (1986) Seasonal Changes in Plankton Population of Some Freshwater Pond at Patna Bihar, India. [Air breathing Fish Culture Unit, Central Fisheries, Natun Sarania, Gauhati 3], J. Inl. Fish Soc. India. 14 (1). pp: 69 - 79.

Kumar, S. (1994) Study on the diurnal variation of zooplankton in a village pond of Kirtipur, Kathmandu, Nepal. M.Sc. Dissertation (Degree in Zoology), T.U., Kathmandu.

Kumari, L.R., and Abdulazizi, P.K. (1989) Limnology of a temple tank in Triruranathapuram, Kerala. J. Inland. Fish. Soc. India, 21(2) :31-36.

Kushlan, J.A. & Hunt, B.P. (1979) "Limnology of an Alligator Pond in South Florida". Florida Scientiat. 42 (2). pp: 65 - 85.

Kushwaha, P.K. (1991) Study on primary productivity and phytoplankton in relation to some physico-chemical parameters of kirtipur village pond. M.Sc. Dissertation (Degree in Zoology), T.U., Kathmandu

Lair, N. and Ayadi, H. (1989) The seasonal succession of planktonic events in lake Ayadat, Franch. Arch Hydrobiology. 115(4):589-602.

Lerman, A. and Wevner, S. (1989) "Carbon dioxide storage and Alkalinity Trends in Lake" [Dept. Geological Sci. North Western Univ. Evanston, III 66208 USA]. Water Res. 23 (2). pp: 39 - 146.

Loffler, H. (1969) High altitude lakes in Mt. Everest region. Vern. Internal Verein Limnol. 17. pp: 373 - 385.

Mahaseth, V.K. (1988) Study on Physico-chemical parameters of Tadi river in relation to Fish Production and Management. Dissertation, (Degree in Zoology), T.U., Kathmandu, (Unpublished).

Mahato, D.D. (1988) "Studies on Some Physico-chemical parameters of Temple Tank (Kirtipur) in relation to Zooplankton production". M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Mallin, M.A. (1989) "Pelagic and Near Shore Plankton Communities of North Carolina (USA) Costal Plain Reservor" [Dept. Environ. Sci. Eng., Univ. N.C. Chapel Hill 27514] Brimleyana (5). pp: 87 - 101.

Mandal, B.K. (1992) Limnological studies in relation to Zooplankton productivity of “Bhi Pukhu” Pond Kirtipur, M.Sc. Dissertation (Degree in Zoolgoy). T.U., Kathmandu.

Mangalo, H.H. & Manal, M.A. (1986) "Seasonal Variation in Population Density of Zooplankton in he Lower Reaches of Diyala river Bhagdad, Iraq". J. Biol, Sci. Res. 17 (3). pp: 99 - 114.

Mazhar, M.D. and Kapur, C.P. (1992) Limnological studies on Dorania river at Bareilly. Inland J. Fish Soc.

Millbank, D.J. (1981) "manual for the Chemical and Microbiological Analysis of Water and sewage in Nepal".

Munawar, M. (1970) "Limnological Studies of Freshwater Ponds of Hydrabad, India", Hydrobiology, (15). pp: 127 - 162.

N.C.S. Nepal : Quarterly newsletter of National Conservation Strategy implemented by NPC/IUCN (1996) No. 1-2.

Nasar, S.A.K. & Munshi, J.D. (1977) "Seasonal Variation in the Physico-Chemical and Biological Properties of a Tropical Shallow Pond". Jap. J. Ecol. 24. pp: 255 - 259.

Nayar, C.K.G. (1965) Cyclomorphosis of Brachionus, Calcylorus, Passas, Hydrobiology. 25:538-544. P.

Pandey, L.H. (2004) Study on Fish and Fishing resources of Kaligandaki River with particular reference to impact of Dam.

Pandey, R.S and Verma, P.K. (1992) Limnological status of an ancient temple pond, Shivaganga of Deoghar, Bihar. J. Fresh water biology 4(3):163-174.

Philipose, M.t. (1940) The ecology and seasonal succession in a permanent pool at Madras. Unpublished M.Sc. Thesis, Madras University Madras.

Pradhan, B. (1982) Preliminary study of Syapru Daha a mid-hill Lake in Rukum district, Nepal. Press Company, New York.

Prasad, D. (2003) Effects of Limnological Parameters in the Primary Productivity of Taudaha Lake. M.Sc. Dissertation, (Degree in Zoology), T.U., Kathmantu, (Unpublished).

Pruthi, H.S. (1933) "Studies on the Bionomics of Freshwater of India, seasonal changes in the Physical and Chemical Condition of the Water Tank in India Museum Compound". Int. RevHydrobiol. pp: 2646 - 67.

Rai, A.K. (2000) Limnological characteristics of sub-tropical lakes Phewa, Begnas and Rupa in Pokhara Valley, Nepal Limnology. 1. pp: 1 - 13.

Rai, A.K., Mulmi, R.M. & Dhakal, R.P. (1996) Production Assessment of Planktivorous Fish Species in Relation to Seasonal Changes in Plankton Population in lakes of Pokhara Valley. J. NHM, Vol. 15, Nos. 1 - 4. pp: 49 - 54.

Rajbanshi, J. (2002) Some Limnological study of the Natural Lake "Taudaha", in relation to the Zooplankton production. M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Ramakrishnaiah, M. & Sarkar, S.K. (1986). Plankton productivity in Relation to Certain Hydrological Factors in Konar Reservoir, Bihar, India. J. INL.Fish Soc. India 14 (1). pp: 58 - 68.

Rao, K.S. and Srivastava, S. (1989) Studies on biological monitoring on water quality in Chambal and Khan rivers of Central India GEORIOS (Jodhapur) 16(273):78-82p.

Ravichandran, S. & Ramanibal, P.S. (1988) The Physical and Chemical Limnology of Buckingham Canal [Madras, India]. Ocean Data, Cent. Water Resource, Coll. Engineering Anna. Univ. Madras, India] ARCH Hydrobiol. 114 (1). pp 79 - 116.

Rijal, N. (1994) Study on the abundance and fluctuation of Zooplankton of a Fish Pond of Balaju, Kathmandu, Nepal. M.Sc. Dissertation, (degree in Zoology), T.U. (Unpublished).

Rutner, F. (1953) Fundamentals of limnology. University of Toronto Press Canada: 1-18 p.

Saha, K.C., Sen, D.P., Mukharjee, P.C. & Chakravarty, S.K. (1958). Physico-chemical Qualities of Calcutta Sewage from the View point of Pisciculture and the Danger of Feeding Raw Sewage of Confined Fisheries. Inida - J. Fish 5 (1). pp: 144 - 149.

Sanders, R.W., Porter, K.G., Bennet, S.J. & Andrienne, E.D. (1989) "Seasonal patterns of Bacterivory and Flagellates, ciliates, Rotifers Cladocerans in a Fresh Water Planktonic Community" [Philadelphia Academy Net Sc, Div.Environ. Res., Philadelphia, Pa19103] Limnol. Oceanogr. 34 (4). pp: 637 - 687.

Sarkar, H.C. & Rai. (1960). Limnology of Surajkund, Physico-chemical Condition and Planktons.

Sen, N.S, Hora, P. and Mishra (1992) Physico-chemistry, nutrient budget and the factors influencing primary production in a tropical lake. J. Freshwater biology. 4(2). 141-153.

Shah S.N.P. (1979) "Abundance ad Distribution of Bottom Fauna in Lagankhel Rajdal Pond, Kathmandu" M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Shah, G.M., Sengal, K.L., Vamitra, E. & Nandy, A.C. (1971) "Studies on the Seasonal and Diurnal Variations in Physico-chemical and Biological Conditions of Perennial Freshwater Pond". J. INL. Fish Soc. India, Vol. III. pp: 79102.

Shah, N.K. (1999) Study on the variations of zooplankton Productivity of A village Pond, Kirtipur, Kathmandu, Nepal. M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Shah, S.K. (1994) Study on Primary Productivity ad physico-chemical parameters of Kirtipur Village Pond, Kathmandu, Nepal. M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Shah, S.K. (1998) Study on some limnological characters of a village pond, Kirtipur, Kathmandu, Nepal. M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Sharma, L.L. (1980) "Some Limnological Aspects of Udaipur Water in Comparison to Select Waters of Rajasthan". Ph.D. Thesis, Sukhadia Univ., Udaipur, India.

Sharma, M.S. & Druve, V.S. (1985) "Trophic Status and Fishery Potential of Rajasthan Waters". Proc. Nat. Symp. Evalu. Environ. (Supl. Vol.) Geobios, pp: 180 - 186.

Sharma, P. (1990) Study on factors affecting the spatial distribution of zooplankton of a Sewage pond, Dhobighat. M.Sc. Dissertation (Degree in Zoology). T.U., Kathmandu.

Sharma, Yowa Raj (2004) Study of some limnological parameters of a village pond “Kamal Pokhari” in relation to Zooplankton Production. M.Sc. Dissertation (Degree in Zoology). T.U., Kathmandu (Unpublished).

Shrestha, J. (1981) "Fishes of Nepal", Curriculum Development Center, T.U., Kathmandu, Nepal. pp: 283 - 293.

Shrestha, S.B., Shrestha, T.K. and Pradhan B.R. (1974) “Report on the study of Aquatic ecology and the potential of fisheries development in Bagmati River” project GTZ. Bagmati mul. Pro. Kathmandu.

Shrestha, S.H. (1998) Economic Geography of Nepal, Education Enterprise, Pvt. Ltd. pp: 32 - 42.

Shrestha, S.R. (1994) Studies on the physico-chemical parameters and primary productivity of Taudaha lake. M.Sc. Dissertation (Degree in Zoology). T.U. Kathmandu.

Shrestha, T.K. (1979) "Studies on the resource Biology and Ecology of Freshwater of Kathmandu Valley with particular Reference of fish production, Management, Marketing and Conservation". Research Project, Research Division, T.U. Kathamndu, Nepal. pp: 267 - 278.

Shrestha, T.K. (1982) "Wildlife of Nepal", Curriculum Development Center, T.U. Kathmandu, Nepal. pp: 460 - 461.

Singh, R.N. (1956) Limnological relations of inland water with special reference to algal blooms. Proc. Internal. Assoc. Theor. Appl. Limn. 12 H.B.N.

Singh, S.C. (1978) "Studies on Some Limnological Aspects of Ranipokhari with Special Reference to Fish Production". M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Singhal, R.N., Swaranjeet & Davies, R.W. (1986) "The Physico-chemical Environment and the Plankton of Manage Pond in Haryana, India". Proc. Indian. Acad. Sc. Anim. Sci. 95 (3). pp: 353 - 364. Sons, Inc. N.Y., P. 1115.

Sreenivasan, A.R., Soundara, R. & Franklin, T. (1974) "Diurnal and Seasonal Changes in a Productive Shallow Tropical Pond". Ph. V kos. pp: 86 - 103.

Swar, B.D. (1979) Present Status of Limnological Studies and research in Nepal.

Swarup, K. & Singh, S.K. (1979) "Limnological Studies of Shara Lake (Ballia) Variations in Water Quality, J. Inland. Fish. Soc., India. (1). pp: 22 - 33.

Swingle, H.S. (1967) "Standardization of Chemical Analysis of Water and Pond Muds". pp: 397 - 421.

Taylor, W.D., and Mariam, Z.g. (1988) Size, structure and productivity of the plankton community of an Ethiopian rift valley lake. Fresh water ecology.

Thienemann, A. (1925) Die binnenge Wasse Mittleuropas: Eine limnologosche Einfuhrung. Die Binnenge Wasse 1:1-225p.

Trivedy, R.C. & Goel, P.K. (1986) "Chemical and Biological Methods for Water Pollution Studies", Environmental Publication, Karad, India.

Upadhyay, S.K. (1991) Study on Some Physico-Chemical parameters affecting the Zooplanktonic abundance of Sewage Stabilization Pond. Dhobighat. Lalitpur. M.Sc. Dissertation, (Degree in Zoology), T.U. (Unpublished).

Vass, K.K. and Langler, R.K. (1990) change in primary production and trophic status of a Kashmir Oxbow lake, consequent to man made modification in the environment. J. Inland. Fish. Soc. India, 22(122):43-51

Welch, P.S. (1935) "Limnology" Copyright by The Mc. Graw-Hill Book Company, Inc. Printed in the United States of America Nepal Press Company, New York.

Welch, P.S. (1952) "Limnology" 2nd Mc Graw-Hill Book company New York, Toronto London.

Welch, S. (1948) "Limnological Methods", balkisten Co., Philadelphia. pp: 381.

Wetzel, R.Z. (1975) "Limnology" Philadelphia, Toronto, W.B. Saunders Company., pp: 743.

Wetzel, Robert, G., Likens & Gene, E. (1979) "Limnological Analysis" 2nd Edition.

Winberg, C.G. (1963) "The Primary Production of Bodies of Water", U.S. Atomic Energy Commission Transl.

Yadav, S.R. (1993) Study on the fluctuation of some of the limnological Characteristics of Sewage Stabilization Pond., M.Sc. Dissertation. (Degree in Zoology), T.U. (Unpublished)

Zutshi, K and Vass K.F. (1972) Limnology of high altitude Kashmir lake Verch internal. Verein limnology. 18:599-604 p.