CHAPTER - ONE

INTRODUCTION

1.1 General Background

Nepal, a noble gorgeous land, teeming with natural wealth, is a paradise for nature lover, a microcosm of world terrestrial bio-diversity, an unparallel potential for hydropower and a heritage of vast cultural diversity. Nepal is rich in its natural resources, still she is poor and underdeveloped in economic field.

Squeezed between the two big countries India and China, Nepal is a small landlocked country covering an area of 1,47,181 square kilometers. But it has large number of highest mountains of the world including the tallest Mt. Everest measuring 8848 meters of height. Nepal's climate, altitude and geography are extremely diverse, the variation of which has resulted in the occurrence of the all major climatic zones of the world. This has made Nepal a treasure-house of a rich biological and genetic diversity.

Geographically, Nepal can be divided into three regions: (i) low land (ii) mid land and (iii) high land. The Churia ridge or Siwalic hills up to 1500 m. separates Terai in the south from the large rivers valleys of the Churia ridge forms the bulk of inner Terai. The lower inner Terai and the main Terai of South constitute the low land. The lower Himalayas foot hills constitute the hill region. Lower hill area up to 2700 m. and upper hills are those between 2700 m. to 4000 m. and the greater Himalayas are located above 4600 m. (Shrestha, 1978). The great Himalayas of this region embrace eight of earth's tallest mountain peaks.

Rainfall is concentrated in the monsoon period and varies between 1000 to 2000 mm. Rainfall is adequate in the eastern part of the Terai which ranges 70 to 75 inches in a year (Shrestha 1990). The western portion of Nepal is little bit dry. The average annual rainfall in the country is estimated to be 16,000 mm (APROSC, 1978).

The main resources of Nepal are forest, agricultural land, minerals and water. Terai in the southern part of the country is very fertile and it is the main area of the crop land. About 90 percent of population is engaged in agriculture (National Census, 1993). Water in Nepal is the second major resources after agriculture. Water may be designated as white "gold". Fisheries of Nepal is great National assets. Fish as a protein rich diet is acceptable to every level of the population unlike other protein. Fishes of Nepal are very unique in adaptation, breeding habits and other features (Menon, 1954).

Among the total area occupied by water, the rivers and rivulets (6000 in numbers, 1000km in length) comprise more than 395,000 hectares; 5000 hectares by natural lakes; 5000 hectares by village ponds; 1500 hectares by reservoir and 12,500 hectares by marsh lands. The irrigated rice fields are estimated to be about 325,000 hectare (Shrestha, 1981). The area covered by these fresh water resources is 2.8% of the total area of Nepal.

There are manly four major river system in Nepal which drain out the country.

a) The Koshi River System

b) The Gandaki River System

c) The Karnali River System

d) The Mahakali River System

Besides these major river systems, there are some other rivers such as; Mechi, Kankai, Ratuwa, Kamala, Bagmati, Rapti, Trishuli, Narayani, Babai, Tinau Chamelia etc. There are also numerous small rivulets which completely dry up during the winter season.

Lakes are naturally formed bodies of water which constitute great potential of fishery resources. The most famous lake of Nepal are Phewa tal, Begans tal, and Rupa tal located in Pokhara valley. The other lakes are Gaduva, Tamor Ghila (Chitwan), Satyavati (Palpa), Khaptad (Doti), Rara (Mugu), Taudah (Kathmandu), Gosainkund, Dudhkund, Gopalkund, Tilicho, Tanju, and others dotting the Himalayan slopes. Few reservoirs of Nepal which are constructed for multipurpose use, such as, hydroelectric power generation, irrigation, flood control and water storage for public water supplies are Trishuli, Sunkoshi, Kulekhani, Marsyangdi, Sundarijal etc. These reservoirs and ponds are ample ground for the inland fisheries research.

Ponds are considered as small bodies of standing water, so shallow that rooted plants can grow over most of the bottom in abundance. Welch (1952), regarded all large bodies of standing water as lakes. Criminating in his definition, ponds according to him are very small bodies of quite standing water in which extensive occupancy by higher aquatic plants is a common characteristics. Holy and cultural ponds are numerous in Nepal. There are about 119 ponds in Kathmandu valley and about 1700 in Janakpur (Cited by Kumar, 1994) whose sculptor and incarvings on the stones laid in the pond depicts a clear historical picture of our arts and culture of medieval Nepal. According to the purpose of construction and location, ponds may be termed as village pond, temple pond, homestead pond, spill pond, fish pond, sewage pond, etc.

Pond water is a key natural resources supporting economic development in the Asian region, particularly to a poor country like Nepal, whose people are undernourished and the source of protenious food is extremely low. Still these water bodies are undervalued, inefficiently exploited and inadequately protected.

Besides rivers, reservoirs, lakes ponds and the wet lands such as marshes and swamps are also ecologically rich with interesting communities. National Fisheries Development Program (1992/93) estimated that Nepal possessed more than 12,500 hectare of marshland. Unfortunately these water bodies are least appreciated (Fishery section H.M.G., 2055 B.S.).

1.2 Scope and Limitation of the Study

For the present dissertation work, Kirtipur village pond was selected. The present investigation pond is one of the sacred pond of Hindu. It has historical and cultural significance to the people. According to some local people, the water from Dudha pokhari was captured in this pond in the past during it's formation.

But at present, the water in the pond is not clean but loaded with a mixture of animal excreta, domestic and municipal sewage. Thus, the present study on the water quality in relation to primary productivity was carried out to understand the existing ecological conditions of the pond and to generate data which may help in formulating various policies and plans as preventive and prophylactic measures.

Limitations

Some limitations of this study are as:

1. Because of the time limitation, observation was done for only six months.
2. The researcher could not cover up biological parameters such as zooplanktons and phytoplanktons.
3. Because of the financial problem and time limitations, researcher could not include maximum respondents to generate the detailed information about the pond.
4. Also, because of the time limitations, the information about the fish culture i.e., fish production and fish survival rate could not be investigated.

1.3 Objectives of the Study

The objectives of the study were as follows:

i. To investigate the physico-chemical parameters.
ii. To investigate the variation of physico-chemical parameters.
iii. To investigate the fluctuation of primary productivity with physico-chemical parameters.
iv. To know about possibility of fish culture practices.

1.4 Justification of the Study

Justification of the present study is as follows:-

i. In spite of greater water resources in Nepal, very little work has been done in the field of limnology.
ii. For successful fish culture, studies of physico-chemical parameters and productivity of pond water is very essential.
iii. Studies on seasonal change in the physico-chemical characteristics of water and green algae are very important for fish culture development in any water body.
iv. The knowledge of primary productivity of a pond is essential for fish culture practices.

CHAPTER - TWO

LITERATURE REVIEW

Like all phases of learning, the science of Limnology has had a gradual, and spasmodic development during recorded history. The word Limnology is derived from the Greek word "Limnos" meaning pool, marsh or swamp or lake. The first definition of Limnology was given by Forel (1892), a Swiss Professor, who has been called the father of Limnology. His definition was given in "The Oceanography of Lakes." So Limnology can be defined as a branch of science dealing with study of fresh water and can be divided into two groups: running water (Lotic environment) such as streams, rivers and standing water, (Lentic environment) such as lakes, swamps and ponds (Cole, 1975).

The most important goal of Limnology is to study the circulation of materials, especially the organic substances in a body of water.

Although Limnological observation have a long history, they only evolved into a distinct science during the last two centuries.

Limnology in the United States began in the middle of the last century when Agassiz (1850) published 'Lake Superior". Its physical character, vegetation and animals which was primarily concerned with the biota of lake superior, specially the fishes. At the turn of the century, American limnology was dominated by four investigators Kofoid, Needham, Birge and Juday (Goldman 1983).

In the early part of 20th century Welch (1935) wrote the first American text book on limnology. Admist of 20th century

Hutchinson began to compile "Treatise on limnology" (1975) which became standard reference work throughout the world. Two texts on streams appeared in 1970s. Hynes wrote "the ecology of running waters", (1970) and Whittons edited text on "River ecology" (1975). Other introductory texts were after Cole (1975) and Reid and Wood (1976).

By the time when limnology was beginning in the United States, the science was also well developed in the other part of the world. The Australian lakes were studied by Simony in 1950. Fritsch studied the Bohemian forest lakes around 1888. Similarly, physical limnology was studied in Switzerland and Scotland and study of microbial limnology was rooted in Russia (Goldman, 1983).

In 1949 Baldi, a prominent Italian Limnologist, set limnology apart from other disciplines by defining it as the science dealing with interrelation of processes and methods whereby matter and energy are transferred within a lake (Cole, 1975).

Hopkins (1971) studied the annual temperature regime of a small stream in Newzealand. Taylor and Mariam (1988) studied the size, structure and productivity of the plankton community of an Ethiopian rift valley lake. Woof and Jackson (1988) studied on some aspects of the water chemistry in the area around Malham Taru, North Yorkshire (UK). Lair and Ayadi (1989) studied on the seasonal succession of planktonic events in the lake Ayadat, France.

The limnological studied of Indian freshwater started by the 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 condition of the water in the tank in Indian Museum Compound. Phillipose (1940) studied ecology and succession in a permanent pool at Madras city. Ganapati (1941) made divergent limnological investigation 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 in limnological relations of Indian Inland waters with special reference to the algal blooms. In the same year, Das and Srivastava (1956) studied on plankton from freshwater ponds and tanks of Lucknow. Saha *et al.* (1958) did some works on physio-chemical qualities of Calcutta Sewage. Philipose (1959a) studied on freshwater phytoplankton of Inland fisheries.

George (1961) made ecological observation of the physico-chemical nature of water and zooplankton and Rotifers of certain shallow ponds of Delhi. Nayar (1965) studied ecology of rotifer population in two ponds of Pilani, Rajasthan. Hussain (1966) studied the productivity potential in Bihar lake. Banerjee (1967) studied water quality and soil condition of fish ponds in some state of India in relation to fish production. Similarly Chatterjee *et al.* (1967) made some observation on utilization of sewage for fish culture in Oxidation ponds.

Zutshi and Vass (1972) studied limnology of high altitude Kashmir lake. Kant and Kachroo (1975) recorded the diurnal changes in the temperature and pH of water movement of plankton in Dal Lake of Srinagar, India.

Sharma (1980) studied on plankton and productivity of Udaipur water in comparison to selected water bodies of Rajasthan. Singh (1986) studied on the fluctuations in the composition of zooplankton population in relation to Hydrobiological conditions of a reservoir. Karki (1988) worked on some limnological aspects of selected closed water ecosystem of Udaipur, India. Ayyappan *et al.* (1988) studied the diel variation in water quality, primary production and plankton of a Peninsular tank at Orissa. Anitha Kumari and Abdulaziz (1989) studied the limnology of a temple pond in Kerela.

Vass and Langer (1990) studied changes in primary production and tropic status of a Kashmir Oxbow lake. Rao *et al.* (1990) studied the morphometric, hydrological and sedimental characteristics of Gandhisagar lake. Mazhar *et al.* (1992) studied the limnology of Dorania river at Bareily. Pandey *et al.* (1992) studied the limnological status of an ancient temple pond of Deogarh, Bihar. Sen *et al.* (1992) studied the physico-chemistry, 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 the biology of the Sagar lake. Srivastava *et al.* (1995) did observation of algal flora in reflection to industrial pollution of Rapti river at Gorakhpur.

For a country not much bigger than a bread-box, Nepal has more than its share of natural wonder. Several water bodies and the flora and fauna of this country have attracted the interest of many biologist. Brehm (1953) was the first to study some aquatic fauna from Kalipokhari in eastern Nepal. Hiriono (1955) has published few papers concerning to the Nepalese algae. Later on, Foster (1965) had also published few papers on Nepalese algae.

Ueno (1966) analyzed a few zooplankton samples from Yangama, in north east Nepal, and recorded five sps. of cladocera and one sps. of Copepoda. Loffler (1969) studied on zooplankton taxonomy and limnology of 24 high altitude lakes in the Mt. Everest region.

Hickel (1973) made an extensive study on three lakes and two ponds in the valleys of Pokhara and Kathmandu and in the same year Dumont, University of Ghent, Belgium, collected many zooplankton samples from different places during his trip to Nepal and studied on the taxonomy of different groups.

Some limnological survey of lake Rara, a deep Himalayan lake, was conducted by the Integrated Fishery and Fish Culture Development Project, Pokhara, Nepal (Ferrow, 1978).

Swar and Fernando (1978) studied seasonal fecundity of Daphnia sps. of Phewa, Pokhara.

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

A preimpoundment survey of the Kulekhani reservoir was carried out in 1979 (Shrestha *et al.,* unpublished). Likewise, Pradhan (1982) carried out a preliminary study of Syarpu Daha (Rukum), a mid hill lake of Nepal.

Regarding the phytoplankton and zoobenthos of Nepalese water, very few information are available. Mehata (1980) worked on abundance and biomass of freshwater zoobenthos in the two ponds of Godavari fish farm. Mahaseth (1988) reported the Physio-chemical parameters of Tadi rivers in relation to fish production and management.

Apart from these, various limnological works for M.Sc. dissertation have done and submitted to the Central Department of Zoology, T.U., Kirtipur, Kathmandu by Mehata (1980); Rai (1983); Mahato (1988), Sharma (1988); Singh (1989); Sharma (1990); Dhakal (1991); Upadhya (1991); Kushawaha (1991); Chettri (1992); Mandal (1992); Kumar (1994); Mahato [1994]; Shrestha [1994]; Shah [1994]; Dango [1994]; Bhattarai [1996]; Khadka [1996]; Kushwaha [1996]; Shrestha [1997]; Shah [1998]; Shah [1999]; Prasad [2003]; Sharma [2004]; Shrestha [2004].

CHAPTER - 3

3.1 The Study Area

Kirtipur is a historical place. It is situated in Southwest of Kathmandu at a distance of about 6 km. The town is famous for temples, shrines, old traditional customs and university (T.U.).

There are about 8 ponds located in Kirtipur. These ponds are man made. The present study pond is named "Kirtipur Pukhu". It is an old pond and all four sides are bounded by stones. This pond is not so deep and was constructed for the purposes such as bathing, drinking water to livestock, cloth washing and for irrigation of crops and vegetable field. The name "Pukhu" is derived from some Newari language pukhu means pond. The shape of the pond is rectangular having the length of 20.30 meter and breath of about 12.10 meter with an area of 245.63 sq. meter. This pond has not been well maintained. The bottom, of the pond is made of clay and sands. The water of the pond is polluted due to the domestic sewage.

The study pond "Pukhu" was divided in to three station i.e. "A", "B" and "C". The maximum depth of the pond was about 78 cm. In rainy season the water becomes more or less clean, but in the summer and winter water becomes turbid due to algal mats. There are not clear out let and in let found in this pond so, it can be called semiclosed aquatic ecosystem.

3.2 Methodology

The present dissertation work entitled **"Study on Some Physico-Chemical Parameters in Relation to Primary Productivity of "Kirtipur Village Pond"** was conducted from 5th

July 2002 to 20th December 2002 for the regular sampling programme.

The pond was divided in to three station i.e. station 'A', 'B' and 'C'. The sample was collected from each station twice a month and the average data represent the fortnightly observation from 5th July to 20th December 2002.

Sampling forms the first and the most important part of any limnological investigation. The reading of temperature, depth, transparency water colour and analysis of pH, hardness, DO, CO_2, calcium, chloride, alkalinity were done at the field itself. For the measurement of primary productivity light and dark bottles techniques were used.

The present study was undertaken to assess the water quality and productivity of the water body of this pond. The standard method given by Welch (1948), Boyd (1979), Liken and Wetzel (1979), APHA (1981), Trivedy and Goel (1986) and others were followed.

3.3 Materials

The materials (equipment) and chemicals needed for the present study were as follows.

A. Glass Wares

1. Conical flasks
2. Pipettes
3. Beakers
4. Petridisc
5. Test tubes

6. BOD bottles
7. Measuring cylinders
8. Volumetric flasks
9. Burette
10. Dropper
11. Glass rods
12. Standard Mercury thermometer

B. Laboratory Instrument

1. pH meter
2. Weighing balance

C. Other Requirements

1. Burette stands
2. Sacchi's disc
3. Measuring tape etc.

3.3.1 Chemicals

The chemicals which were needed to prepare reagent solutions, standard solutions, indicator solutions and other solutions were weighed on electric weighing machine. These chemicals were dissolved in double distilled water to make different kinds of solutions, which were used for chemical analysis of water.

3.3.1.1 Preparation of reagent solutions:

a. Winkler 'A' Solution or $MnSo_4$ Solution

91 grams of $MnSo_4.H_2O$ was weighed and dissolved in double distilled water. The solution was poured in to 250 ml. volumetric flask: its volume was made 250 ml. by adding double distilled

water up to the mark on the flask. Then the flask was filtered through ordinary filter paper in glass funnel. The filtrate was kept in a reagent bottle. It was then labelled and stored for later use.

b. Winker 'B' Solution or Alkaline Iodine Solution

125 grams of Sodium Hydroxid (NaOH) and 31.75 grams of Sodium Iodide were weighed and dissolved in double distilled water. The solution was poured in to volumetric flask. Its volume was made to 250 ml. by adding double distilled water. The flask was shaken well in order to mix the solution properly. Then the solution was kept in the bottle, labelled and stored for late use.

3.3.1.2 Preparation of Standard Solutions

a. Sodium Thiosulphate Solution or Hypo Solution (0.015N)

6.3 grams of $Na_2S_2O_3.5H_2O$ was weighed and dissolved in freshly boiled and cooled double distilled water. The solutions was stirred with glass rod for uniform mixing. The solution was made to 1000 ml. by adding double distilled water. The solution was kept in the reagent bottle and labelled.

b. Standard Sodium Carbonate Solution (0.045N)

0.602 gram of an hydrous Na_2CO_3 was weighed and dissolved in double distilled water. The solution was made to the mark by adding double distilled water. The solution was kept in the bottle and labeled. The solution was freshly prepared one or two days before the sampling date.

c. Sulphuric Acid (0.02N) Solution

3 ml. of concentrated sulphuric acid was taken and mixed with double distilled water. The volume of this solution was made to 1000 m (0.1N). Then 200ml. of 0.1 N. H_2SO_4 was made to 1000 ml by adding double distilled water. The solution was kept in the reagent bottle and labelled.

d. E.D.T.A. Solution (0.01N)

3.723 grams of Di-sodium salt of E.D.T.A. was weighed and dissolved in double distilled water. The volume of the solution was made up to 1000 ml. by adding double distilled water. The solution was kept in the reagent bottle and labelled.

e. Sodium Hydroxide Solution (1N)

40 grams of sodium hydroxide (NaOH) was weighed and dissolved in double distilled water. The solution was stirred with glass rod for uniform mixing. The volume of the solution was made 1000 ml. by adding double distilled water. The solution was kept in the bottle and labelled.

3.3.1.3 Preparation of other solutions

(a) Ammonium buffer solution:

(I) 16.9 grams of ammonium chloride (NH_4Cl) was weighed and dissolved in 143 m of concentrated ammonium hydroxide (NH_4OH) solution.

(II) 1.179 grams of di-sodium salt of E.D.T.A. and 780 mg. of Mg $SO_4.7H_2O$ was weighed and dissolved in double distilled water.

The solution was stirred with a glass rod for better mixing.

Then the solution (I) and (II) were mixed and poured in the 250 ml. volumetric flask. The volume of the solution was made to 250 ml. by adding double distilled water up to the mark on the flask. The flask was shaken well for uniform mixing of the solution. The solution was kept in the bottle and labeled.

b. Silver Nitrate Solution

3.4 grams of silver nitrate was weighed and dissolved in double distilled water. The solution was stirred with glass rod for better mixing. The volume of the solution was made to 1000 ml. by adding doubles distilled water. The solution kept in dark bottle and labeled.

3.3.1.4 Preparation of indicator solution

a. Starch Indicator

6 grams of starch powder was weighed and dissolved in small amount of distilled water. The volume was made to 1000ml. The solution was boiled for few minutes and was allowed to settle down overnight. It was preserved by adding 1.25 grams of salicylic acid. It was kept in the bottle and labeled.

b. Phenolpthalein Indicator

0.5 gram of phenolpthalein powder was weighed and dissolved in 50 ml. of ethyl alcohol. 50 ml of double distilled water was added. Then 0.5 gram of free sodium hydroxide solution was added till the solution turned faint pink.

c. Methyl Orange Indicator

0.5 gram of Methyl orange powder was weighed and dissolved in double distilled water. The mixture was stirred with glass rod. The volume was made to 100ml. by adding double distilled water. The solution was kept in the bottle and labelled.

d. Potassim Chromate Indicator

5 grams of potassium chromate (K_2CrO_4) was weighed and dissolved in a double distilled water. The mixture was made to 1000ml by adding double distilled water. The solution was kept in a bottle and labelled.

3.3.1.5 Preparation of Other Indicators

a. Eriochrome Black-T indicator

0.40 grams of Eriochrome black-T and 100grams of sodium chloride (Nacl) were weighed and mixed. The mixture was grind in a mortar. It was then kept in a dry neat and clean bottle. The bottle was then labelled.

b. Mureoxide Indicator

0.2 gram of ammonium perpurate and 100 grams of sodium chloride (Nacl) were weighed and mixed. The mixture was grind in a mortar. It was then kept in a dry neat and clean bottle and labelled.

3.4 Sampling for Physico-chemical Parameters:

3.4.1 Physical parameter

The physical parameter observed during the field investigation period were nature of day, colour of water, depth, transparency and temperature.

a. Nature of day

The nature of the day was recorded at the field during working hour by looking around cosmos with naked vision.

b. Colour of water

To know the colour of water a little amount of pond water was taken in a clean petridish and kept over the white paper, then the colour of water was observed by naked eyes.

c. Depth

To know the depth of pond a good quality long nylon rope tied with an appropriate weight was used. First of all the rope was lowered in the water body till it reached the bottom and the length of rope under water was measured with the help of the measuring tape. The depth of three stations was recorded and the mean depth was noted.

d. Transparency

The Secchi's disc was used to calculate the transparency of the water. The Secehi's disc is a metallic plate painted with four alternate black and white quadrants on the upper surface bodies was devised by an Italian scientist Secchi (1965)

The transparency was measured by lowering the Secchi's disc in water and depth was recorded at which it just disappeared, and just reappeared when pulling up. Then the average value of two readings of the Secchi's disc was noted as transpareney and expressed in centimeter.

$$\text{Transparency (in cm)} = \frac{\text{Just disappeared} + \text{Just reappeared}}{2}$$

The transparency co-efficient was calculated with the help of following standard formula.

$$K = \frac{1.7}{D}$$

Where,

D = Secchi's disc reading

K = Transparency co-efficient and

1.7 = Constant factor

e. Temperature

The temperature of water and air was recorded with the help of a standard mercury thermometer. The surface temperature of water was taken by dipping the thermometer bulb into the water body. The air temperature reading was taken under a shady side, avoiding direct exposure of the mercury bulb to sunlight.

3.4.2 Chemical Parameters

The chemical parameters measured during the study were pH, DO, CO_2, Hardness, Alkalinity, Calcium and chloride.

a) pH (Hydrogen ion concentration)

A portable pH meter was used to measure the pH of the water. The pH of water at different sampling station was taken and mean value was noted down in a field record sheet.

b) DO (Dissolved Oxygen)

Dissolved oxygen of the water of study site was determined by using Winkler's modified method. This method was first developed in 1888 by Winkler and method enables the shortage of samples and has high degree of precision. Hence, the procedure is time consuming and the Winkler's reagents WA and WB help in removing the interference due to the high organic matter and chloride. The principal method is as follows.

$MnSo4+2KOH \longrightarrow Mn\ (OH)_2 + K_2So_4$

$2Mn\ (OH)_2 + O_2 \longrightarrow 2Mno(OH)_2$

$MnO(OH)_2+2H_2So4 + 2KI \longrightarrow MnSo_4 +3H_2O + I_2\downarrow$

In practicing this method it is very important to minimize contact between sample and the atmospheric air. For this the water sample was collected in B.O.D. bottle (250ml.) having conical stoppers to prevent the entrapment of air bubles. After the sample was allowed to overflow the bottle, it was then quickly stopped, taking care not to trap any air bubbles.

To fix the dissolved oxygen in the B.O.D. bottle 2 ml. each of WA and WB solution were added at an interval of 2 minutes with the help of pipettes. The bottle was shaken upside down 6 times and the precipitate was allowed to settle down. Then 2 ml. of concentrated sulphuric acid (H_2So_4) was added which dissolved the precipitate. The bottle was again shaken for 6 times upside down. The oxygen was thus fixed in the B.O.D. bottle.

For the estimation of dissolved oxygen. 50 ml. of fixed sample was taken in a conical flask and starch solution was added as an indicators with constant shaking of the flask till the colour changed to blue. Then this solution was titrated against 0.025 N sodium thiosulphate solution with shaking of a flask till the blue colour disappeared. The burette reading was noted down in the field record sheet.

The calculation for dissolved oxygen was made by following formula.

$$\text{mg. of O2/liter} = \frac{\text{used vol. of titrant} \times 1000 \times 0.2}{\text{vol. of sample}} = \text{ppm}$$

Where,

0.2 represent 1 ml. of 0,025 N sodium thiosulphate solution which is equivalent to 0.2 mg. of O_2.

c. Free Carbon-dioxide (CO_2)

For the estimation of free carbon-dioxide, 50 ml of phenolpthalein indicator was added in it and shaken well.

If the water sample remain colourless, it indicates the presence of CO_2. The water sample containing CO_2 was titrated against 0.45 N sodium carbonate (Na_2CO_3) solution till a faint pink coloured end point was observed. The reading noticed in the burette was noted in the field record sheet. The calculation for CO_2 was made by following formula:

$$\text{mg. of } CO_2/\text{litre} = \frac{\text{Used vol. of titrant} \times 1000}{\text{Vol. of sample}} = \text{ppm}$$

d. Total Alkalinity

Generally, two alkalinity values are measured, one is the alkalinity to pH 8.3, which is called phenolphthalein alkalinity, the another is alkalinity to PH 4.3, which is called total alkalinity. In this methyl orange is used as an indicator (Masuda and Pradhan, 1988).

To determine the alkalinity, 50 ml. of water sample was taken in a conical flask and four drops of phenolphthalein solution was added as an indicator. The flask was shaken well and the appearance of pink colour indicates the presence of carbonate in the sample water. This sample was titrated against 0.02 N sulphuric acid (H_2SO_4) till the pink colour disappeared. The burrette reading was noted down.

Then four drops of methyl orange was added in to this solution as an indicator and the flask was shaken well. Then the titration was continued with constant shaking of the flask till the colour changes from yellow to brick red. The burette reading was noted down for the total volume of titrant used in both titrations.

The calculation for carbonate or phenolphthalein alkalinity and total alkalinity was made by using following formuals:

$$\text{Total alkalinity} = \frac{\text{Total vol. of titrant} \times 1000}{\text{Vol. of sample}} = \text{ppm}$$

e. Total Hardness

Hardness of water is due to soluble salts of divalent cations, mainly calcium and magnesium. Temporary hardness is due to calcium and magnesium bicarbonates. This is called temporary hardness because on boiling, the bicarbonates change to carbonates and part of calcium and magnesium are precipitated.

$$Ca\,(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$$

Permanent hardness is principally due to Ca and Mg carbonates and salts of inorganic acids (e.g. $CaSO_4$).

Hence,

Total hardness = Permanent + temporary hardness

For the determination of total hardness, 50 ml. of sample was taken in a clean conical flask in which 1 ml. of Ammonium buffer solution was added and stirred for mixing. Then, 100-200 mg. or a pinch of Erichrome black - T indicator was added and shaken well. Then the sample was titrated against standard E.D.T.A. solution of 0.01 N till a blue coloured end point was reached. The burette reading was noted down. The total hardness of water was calculated by using the following formula:

$$CaCO_3 \text{ mg/litre} = \frac{\text{Vol. of titrant used} \times 1000 \times A}{\text{Vol. of sample}} = \text{ppm}$$

f. Dissolved Calcium (Ca)

E.D.T.A. hardness titration described in total hardness measures the sum of the calcium and magnesium ions. Only calcium can be measured in the similar E.D.T.A. titration after making magnesium ions inert chemically or precipitated as an insolube hydroxyl salt.

For this 50ml. of water sample was taken in a conical flask and 1 ml. of 1 N sodium hydroxide solution and a pinch of Mureoxide indicator was added to it. The flask was shaken well and the colour of the water sample turned to salmon pink. It was then titrated against 0.01 N of E.D.T.A. solution with constant shaking of the flask till the purple colored end point was reached. The burette reading was noted down in the field. The calculation for the dissolved calcium was made by using following formula:

Dissolved calcium mg/litre =

$$\frac{\text{Volume of titrant used} \times 1000 \times \text{A}}{\text{Volume of sample}} = \text{ppm}$$

Where,

A = 0.4008 mg. of Ca equivalent to 1 ml. of titrant.

g. Chloride (cl$^-$)

Chloride in the form of chloride ion (Cl^-) is one of the major organic anions in water and wastewater. The salty taste prodcued by chloride concentrations is variable and dependent on the chemical composition of water.

Chloride are usually present in low concentration in natural waters. The chloride concentration is higher in wastewater because NaCl is common article of diet and passes uncharged through the digestive system. It is also high in seacoast because of leakage of salt water in to the sewage system.

For chloride determination, 50 ml. of the sample was taken in a clean concial flask and 4 drops of potassium chromate (K_2CrO_4) solution was added to it. This solution was titrated against Silvernitrate solution (0.01 N of $AgNO_3$) until a persistent red tinge colour appeared.

The volume of silver nitrate of three reading at each station was taken as mean volume which was converted later on to mg/lit. by using following equation:

$$\text{Chloride (mg/lit.)} = \frac{\text{Used vol. of titrant} \times N \times 1000 \times A}{\text{Vol. of sample}} = \text{ppm}$$

Where,

A = 35.45 and N = 0.02

3.5 Primary Productivity

Primary production is the most important biological phenomenon in nature on which the entire diverse array of life depends, either directly or, indirectly. Where the productivity is defined as the rate at, which inorganic carbon is converted to an organic form. Chlorophyll bearing plants serve as primary producers in the aquatic food chain.

Primary productivity can be defined by measuring the change in oxygen and CO_2 concentration. There are two methods of measuring the rate of carbon uptake and net photosynthesis in situ are the "oxygen method" and the "carbon method". In both method clear and darkened bottles are filled with water samples and suspended at regular depth interval for an incubation period of several hours.

$$CO_2 + H_2O \xrightarrow[\text{sunlight}]{\text{green plant}} (CH_2O)_2 + O_2 \downarrow$$

Light and dark bottle technique was first employed by "Gaardner" and "Garn" (1927), measurement of dissolved oxygen can be done using Winkler's method. This measurement was finished in two steps. In initial steps 250 ml. of water was taken in a oxygen bottle without bubbling and collected from known depth and stopper tightly for measurement of dissolved oxygen and were added 2 ml. of Winkler 'A' and 'B' solution at the interval of a few minutes. The oxygen was fixed with 2 ml. of conc. H_2SO_4 followed by through shaking. 50 ml. of this dissolved oxygen sample was titrated against 0.025 N sodium thiosulphatte solution using starch indicator till a colourless end point was reached. The calculation was made by following formula:

$$\text{mg. of } O_2/\text{litre} = \frac{\text{Used volume of titrant} \times 1000 \times 0.2}{\text{Volume of sample}} = \text{ppm}$$

Where, 0.2 represent 1 ml. of 0.025 N sodium thiosulphate solution which is equivalent to 0.2 mg. of O_2.

After finishing the first step of calculation of dissolved oxygen, the second step was started. For this both black and white bottle were filled up by water and tightened the mouth of both bottle by stopper.

Both bottle were hanged into water horizontally at each depth about 30 cm. below the surface with the help of thread and bamboo bar. After three hours, of incubation in water both bottles were taken out from, the water and dissolved oxygen was estimated. The differences of initial and final step of dissolved oxygen in both bottle were found out and calculated by following formula.

Total photosynthesis is called gross primary production.

Gross productivity = $\frac{LB-DB}{T(hrs)} \times \frac{.375}{1.2} \times 1000\,gm/c/m^3/hr.$

Net productivity = $\frac{LB-IB}{T(hrs)} \times \frac{.375}{1.2} \times 1000\,gm/c/m^3/hr.$

The energy left after photosynthesis and stored as organic matter is net primary production.

Primary productivity = Gross productivity - Net productivity = (GP-NP)

Where,

LB = Light bottle reading after incubation.

DB = Dark bottle reading after incubation.

IB = Initial bottle reading of oxygen.

0.375 = Factors for conversion of oxygen to carbon.

1.2 = Respiratory quotient.

T (hrs) = Time in hour.

$gm/c/m^3/hr$ = Gram carbon per meter cu. per hour.

3.6 Statistical Analysis

The statistical analysis to determine the coefficient of correlation between different physico-chemical parameters and primary productivity has been worked out by using the method adopted by "Karl Pearson" and the significance of the co-efficient of correlation was tested.

The formula adopted for this statistical analysis is as follows:

a) Correlation coefficient = $\dfrac{N\sum XY-\sum X.\sum Y}{\sqrt{N.\sum X^2-(\sum X)^2}\times\sqrt{N.\sum Y^2-(\sum Y)^2}}$

b) Probability Error (P.Er) = $0.6745\times\dfrac{1-r^2}{\sqrt{N}}$

A. Correlation between water temperature and Primary Productivity

X	Y	XY	X^2	Y^2
27	25	675	729	625
25.5	15.4	392.7	650.25	237.16
24.0	30	720	576	900
23.5	34	799	552.25	1156
28	40	1120	784	1600
23	45	1035	529	2025
24.5	34	833	600.25	1156
25.5	28	714	650.25	784
27	24	648	729	576
22	27	594	484	729
18	23	414	324	529
18.5	34	629	342.25	1156
ΣX=286.5	ΣY=359.4	ΣXY=8573.7	ΣX^2=6950.25	ΣY^2=11473.16

Where,

N=12

ΣX = 286.5 ΣY²=11473.16

ΣY=359.4

ΣXY=8573.7

ΣX²=6950.25

a)

Correlation Co-efficient (r) = $\frac{N\sum XY-\sum X.\sum Y}{\sqrt{N.\sum X^2-(\sum X)^2}\times\sqrt{N.\sum Y^2-(\sum Y)^2}}$

= $\frac{12\times 8573.7-286.4\times 359.4}{\sqrt{12\times 6950.25-(268.5)^2}\times\sqrt{12\times 11473.16-(359.4)^2}}$

= $\frac{102884.4-102968.1}{\sqrt{83403-82082.25}\times\sqrt{137677.92-129168.36}}$

= $\frac{-83.7}{\sqrt{1320.75}\sqrt{8509.56}}$

= $\frac{-83.7}{\sqrt{11239001}}$

= $\frac{-83.7}{3352.4619}$

r =-0.02496

b. Probability Error (P. Er) $= 0.6745 \times \frac{1 - r^2}{\sqrt{N}}$

$$= \frac{0.6745 \times 1 - (-0.02496)^2}{\sqrt{12}}$$

$$= \frac{0.6745 \times 0.9993}{3.4641}$$

$$= \frac{0.6740}{3.4641}$$

P.Er. = 0.1945

CHAPTER - FOUR

RESULTS

The hydrological factor in addition to morphometry is the paramount factor, directly governing the micro climate of a particular habitat. In a closed aquasystem, the regional difference in light, temperature, moisture and wind velocity are of great environmental significance which not only affect the physico-chemical properties of water, but also regulate the behaviour and activity of flora and fauna, so much so that they often limit the biological productivity. The effects of physical forces are solely responsible for the phenomenon like thermal stratification, chemical stratification, diurnal and seasonal variations and distribution of micro and macro-organisms. The chemical factors like the dissolved gases play a vital role in the biogeochemical cycle of any organisms. Non-nutrient chemical parameters are having characteristics of inherent properties of any natural water derived from minerals, soils and the sorrounding terrains through run-off and leaching processes. The balance of these governing factors in the ecosystem is equally important from both the ecological and biological point of view.

4.1 Physical Factors

a. Nature of day:

During the time of water analysis and data collection, the nature of the day, was observed sunny, cloudy, rainy, foggy, calm, clear etc.

In the study period, there was rain on 20th July and 5th August, 5th December and 20th December were little foggy days.

b. Water colour:

The colour of water was muddy on 5th July and 20th July, brownish on September and October and greenish white on the remaining days.

c. Depth:

Depth is the minimum vertical distance between the surface and the underlined bottom of the pond at any point. The maximum depth measured in the pond was found to be 78 cm. on 20th July and minimum depth was found to be 45 cm. on 20th December.

d. Transparency:

Transparency is a most important physical parameter which determines the productivity of any water body. It directly or indirectly creates turbidity and blocks the penetration of light. The transparency of water depends upon the amounts of suspended particles and the seasonal periodicity of plankton.

The lowest transparency (12 cm) was recorded on 5th July and highest (38 cm) was on 5th September.

e. Temperature:

The temperature of an aquatic body has great bearing on the physiological activities of all aquatic organisms. Temperature also affects the fundamental stratification and so is responsible for the zonation of the water body (Odum 1971).

During the study period, the maximum surface water temperature (28^0C) was on 5th September and lowest (18^0C) on 5th December.

4.2 Chemical Factor

a. pH (Hydrogen ion concentration):

pH indicates the acidity or alkalinity of solution. This is related to the concentration of hydrogen ion in a solution. It is one of the indicator commonly used to know the level of pollution. The variations of pH with other factors are linked with the species composition, life processes of animal and plant communities inhabiting therein.

In the present study, the pH showed a variation from 7.2 to 9.0 with an average value of 8.25. This clearly indicated that the pH remained alkaline throughout the study period.

b. Dissolved Oxygen (D.O.):

Dissolved oxygen exhibits a direct relation with temperature that accelerates the rate of photosynthetic activity in aquatic flora leading to profuse accumulation of oxygen in water which is used by aquatic organisms. A low quantity of oxygen indicates organic pollution. This gas was found to be quite fluctuating during the study period ranging between 3.2 to 7 ppm with an average of 4.90.

The maximum value of D.O. (7 ppm) was recorded on 20th July and minimum (3.2 ppm) was on 20th September.

c. Free Carbondioxide (CO_2):

Large amount of CO_2 was available in the water bodies through community respiration. It is also derived from atmosphere as well as by decomposition of organic matter. Presence of CO_2 is very essential for photosynthesis while on the other hand excess of this gas is harmful. Free CO_2 showed a variation from 11 to 28 ppm with an average 19.16 ppm. It was less in the summer months.

d. Total Alkalinity:

The total alkalinity is the sum of carbonates and bicarbonates which are bound and half bound derivatives of CO_2. The total alkalinity recorded was found to be in the range of 65 to 210 ppm with an average value of 100.58 ppm. It was minimum (65 ppm) on 20^{th} November and maximum (210 ppm) on 20^{th} September.

e. Total Hardness:

Calcium and magnesium are the salts which are mainly responsible for the hardness of water. Apart from this other metals like Zn, Al, Fe etc. can also contribute to some extent.

The value of total hardness recorded during the study period ranged from 70-105 ppm with an average value of 84.08 ppm. It was minimum (70 ppm) on 5^{th} December and maximum (105 ppm) 5^{th} September.

f. Dissolved Calcium (Ca):

Water in it's natural form contains some amount of calcium. The amount of dissolved calcium in the presently studied pond ranged from 32 to 160 ppm with an average of 99.75 ppm. The maximum value (160 ppm) on 20th August and minimum (32 ppm) on 5th July.

g. Dissolved Chloride (Cl^-):

The concentration of dissolved solids in a water body is a useful paratmeter in describing the chemical density as a fitness factor and as a general measure of edaphic relationship that contribute to the productivity of the water. The important sources of Cl^- in the water body are from the discharge of domestic sewage, human excreta, night soil etc.

Chloride values showed fluctuation from 30.5 to 45 ppm with an average value of 36.37 ppm. The minimum value of chloride (30.5 ppm) was recorded on 20th December and maximum (45 ppm) on 5th July.

Table 1: Limnological Profile of Village Pond, Kirtipur

Parameter	Unit	Average value	Maximum value	When recorded	Minimum value	When recorded
Air (Temp.)	^0C	25.04	30	5th Sept.	19.5	20th Dec.
Water (temp.)	^0C	23.87	28	5th Sept.	18	5th Dec.
Depth	cm.	59.58	78	20th July	45	20th Dec.
Transparency	cm.	22.41	38	5th Sept.	12	5th July
pH	ppm	8.25	9.0	20th Sept.	7.2	5th Oct.
DO	ppm	4.90	7	20th July	3.2	20th Sept.
CO_2	ppm	19.16	28	20th Dec.	11	20th July.
Total alkalinity	ppm	100.58	210	20th Sept.	65	20th Nov.
Total hardness	ppm	84.08	105	5th Sept.	70	5th Dec.
Dissolved Ca	ppm	99.75	160	20th Aug.	32	5th July
Dissolved Cl	ppm	36.37	45	5th July	30.5	20th Dec.

Table 2: Fortnightly variation of Physico-chemical parameters of village pond, Kirtipur

(From 5th July 2002 to 20th Dec. 2002)

Parameters	5th July	20th July	5th Aug.	20th Aug.	5th Sept.	20th Sept.	5th Oct.	20th Oct.	5th Nov.	20th Nov.	5th Dec.	20th Dec.	Max.	Mini.	Average
Air temp. (°C)	28	26	24.5	24	30	23.5	25.5	26	27.5	24	22	19.5	30	19.5	25.04
Water temp. (°C)	27	25.5	24	23.5	28	23	24.5	25.5	27	22	18	18.5	28	18	23.87
Depth (cm.)	75	78	65	60	55	50	52	54	58	62	61	45	78	45	59.58
Transparency (cm.)	12	20	25	34	38	25	22	21	20	19	17	16	38	12	22.41
pH	7.9	8.3	8.1	7.9	7.6	9.0	7.2	8.7	8.9	8.8	8.5	8.2	9.0	7.2	8.25
Dissolved oxygen (ppm.)	6.8	7	5.8	6	4	3.2	3.7	4.7	5.1	4.7	3.9	4	7	3.2	4.90
Free CO_2 (ppm)	16	11	18	17	19	21	20	14	13	26	27	28	28	11	19.16
Total alkalinity (ppm)	80	75	85	78	92	210	180	81	78	65	95	88	210	65	100.58
Total hardness (ppm)	75	78	80	95	105	100	92	85	78	76	70	75	105	70	84.08
Dissolved ca (ppm)	32	68	110	160	120	115	110	95	112	110	120	45	160	32	99.75
Dissolved Cl (ppm)	45	40.5	41	42	35	31.5	32	33	33.5	36	36.5	30.5	45	30.5	36.37

Table 3: Fortnightly variation of primary productivity of village pond, Kirtipur

Parameters	5th July	20th July	5th Aug.	20th Aug.	5th Sep.	20th Sep.	5th Oct.	20th Oct.	5th Nov.	20th Nov.	5th Dec.	20th Dec.	Max.	Mini.	Average
Gross Primary Productivity (gm/c/m^3/hr)	36	55	65	75	80	95	65	68	55	52	49	48	95	36	61.91
Net Primary Productivity (gm/c/m^3/hr)	11	40	35	41	40	45	31	40	31	25	26	14	45	11	31.58
Primary Productivity (gm/c/m^3/hr)	25.0	15.4	30	34	40	45	34	28	24	27	23	34	45	15.4	29.95

Fortnightly variation of physico-chemical parameters of Kirtipur village pond in terms of air temperature (^0C)

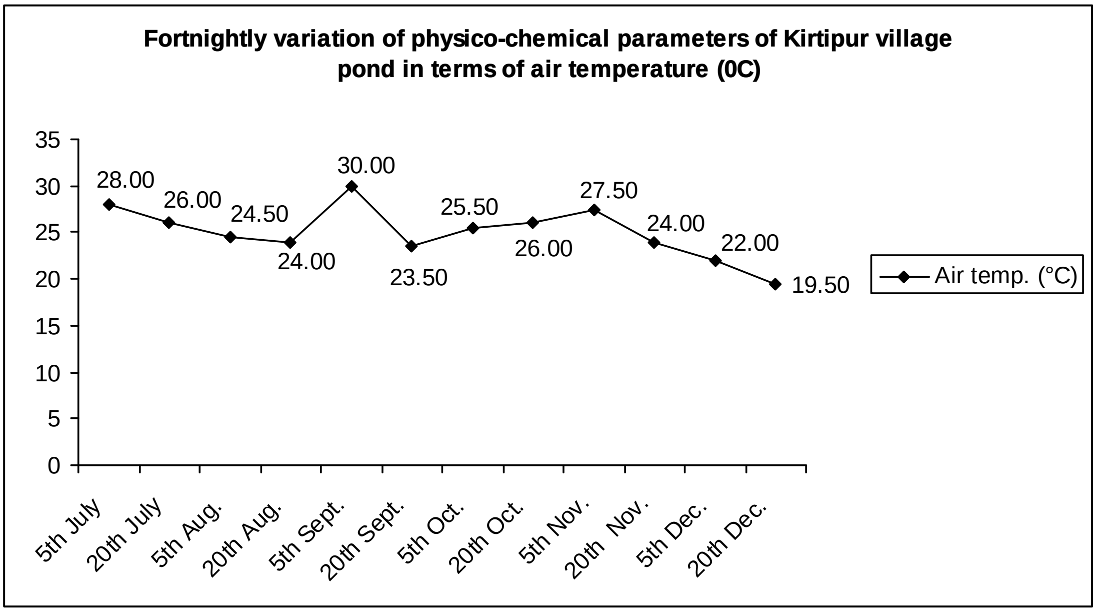

Figure 1: Fortnightly variation of air temperature

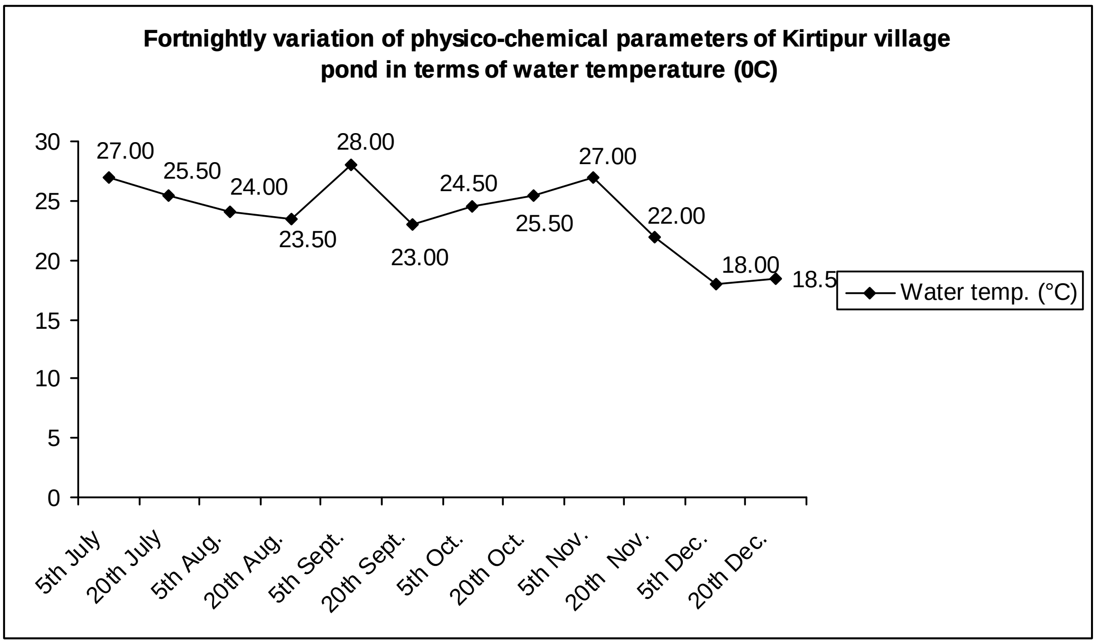

Figure 2: Fortnightly variation of water temperature

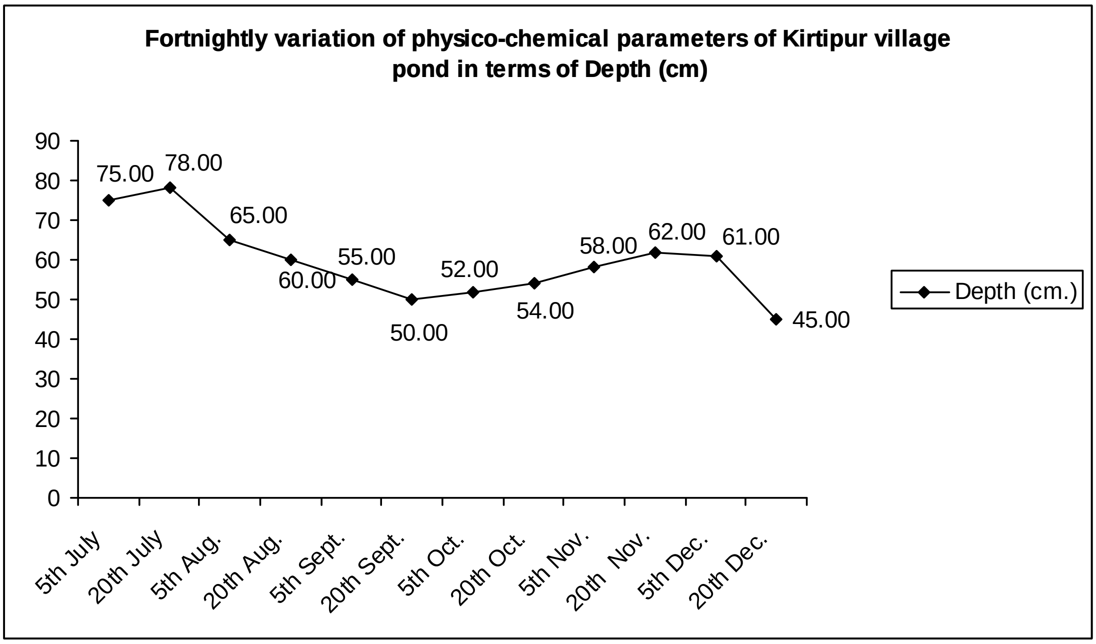

Figure 3: Fortnightly variation of depth

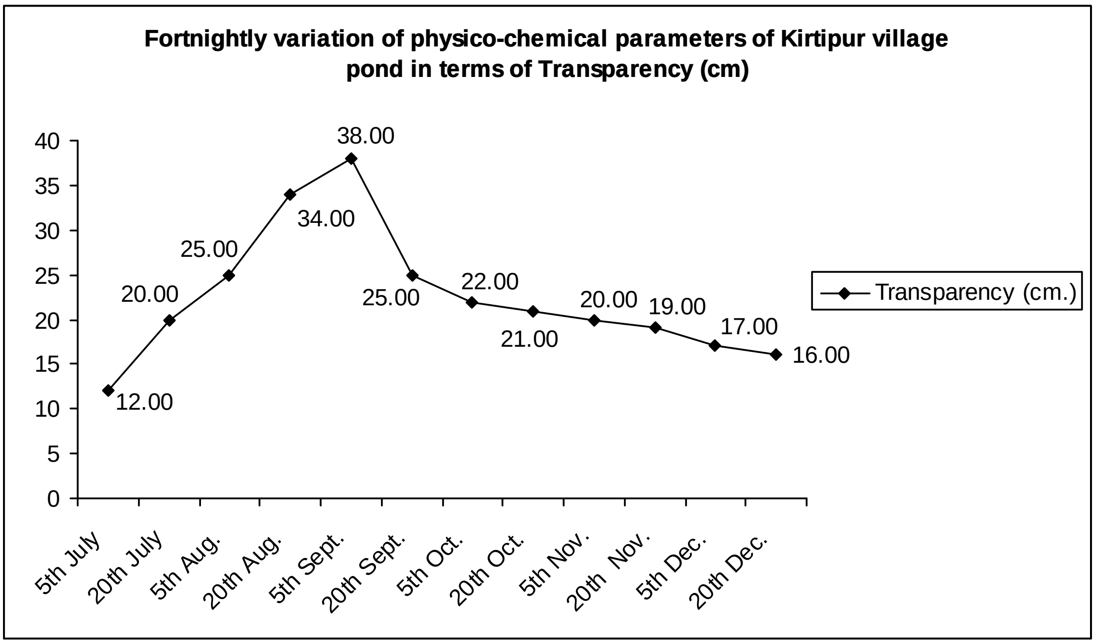

Figure 4: Fortnightly variation of transparency

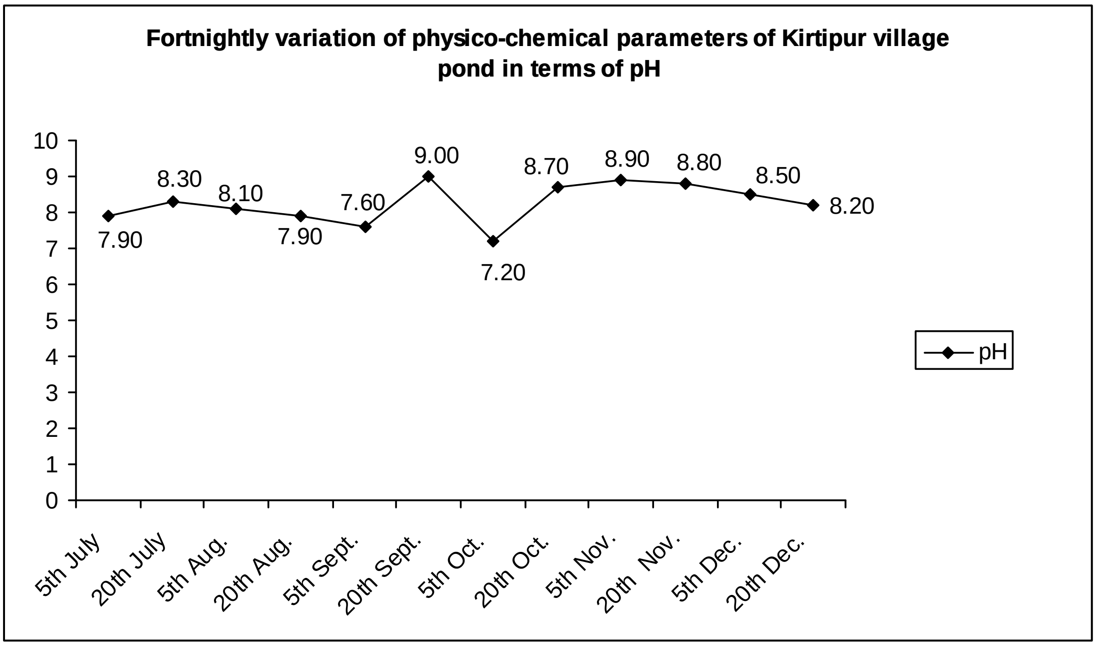

Figure 5: Fortnightly variation of pH

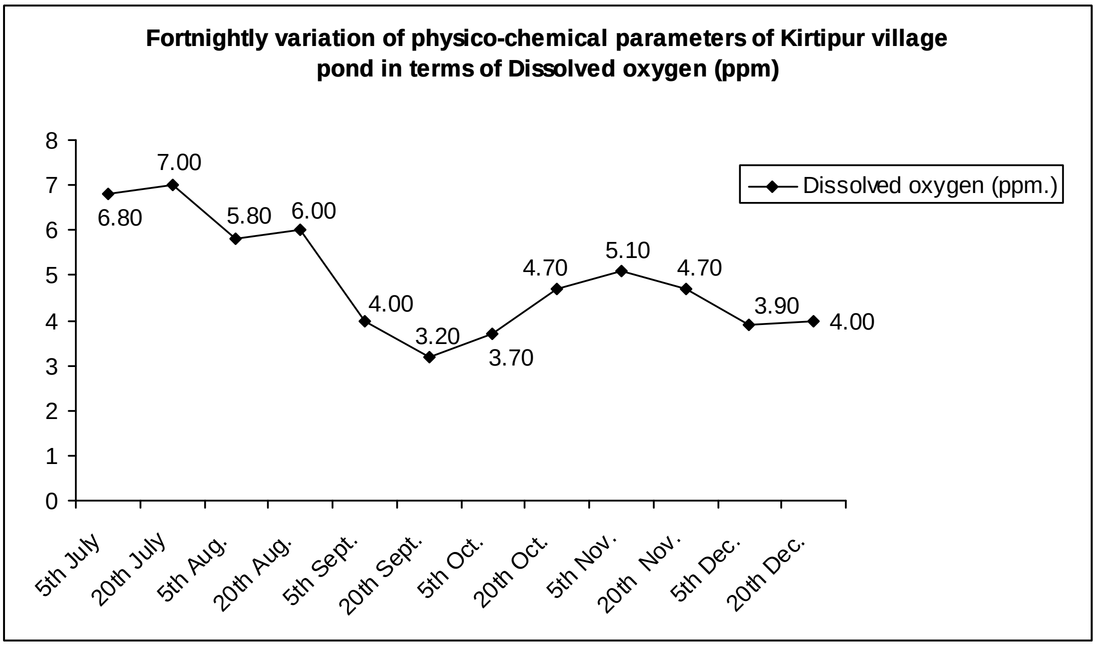

Figure 6: Fortnightly variation of DO

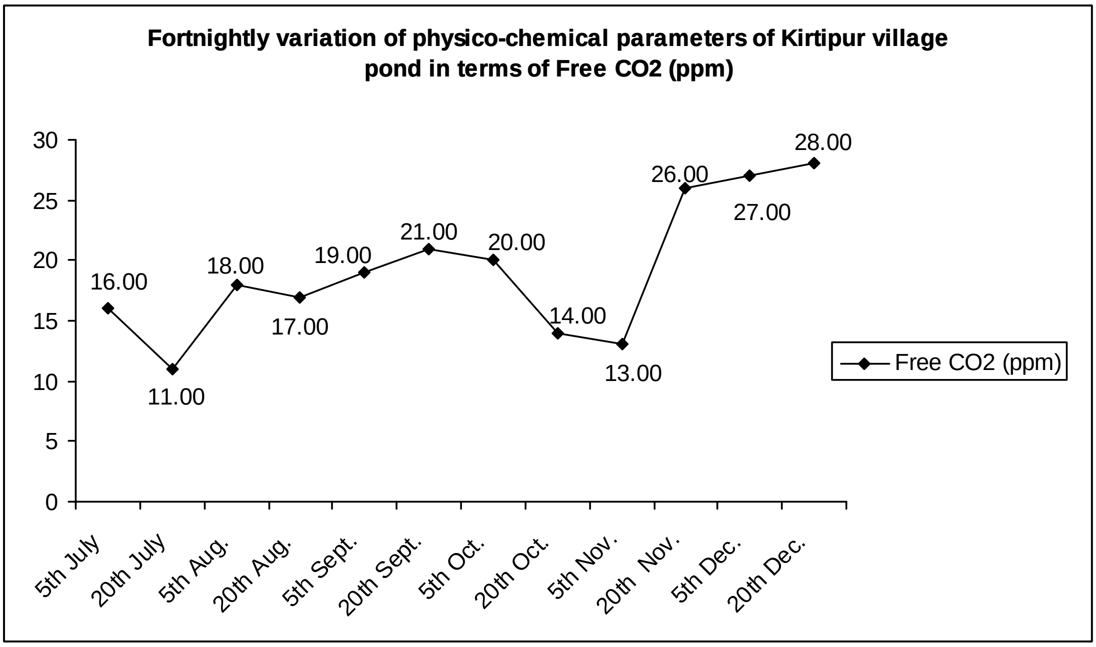

Figure 7: Fortnightly variation of CO_2

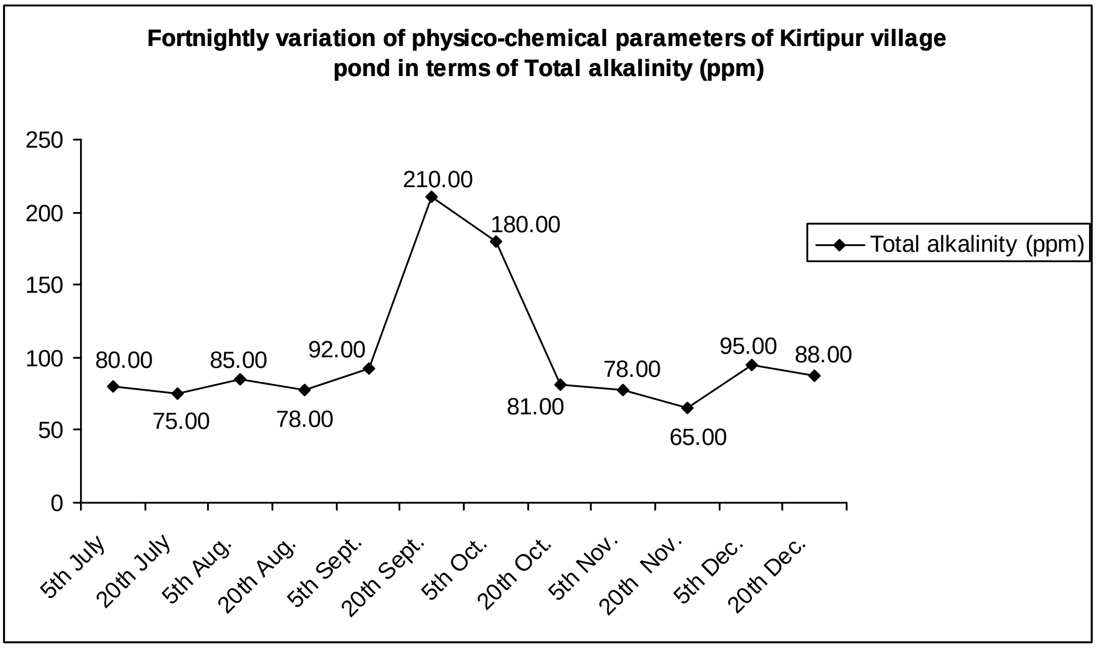

Figure 8: Fortnightly variation of alkalinity

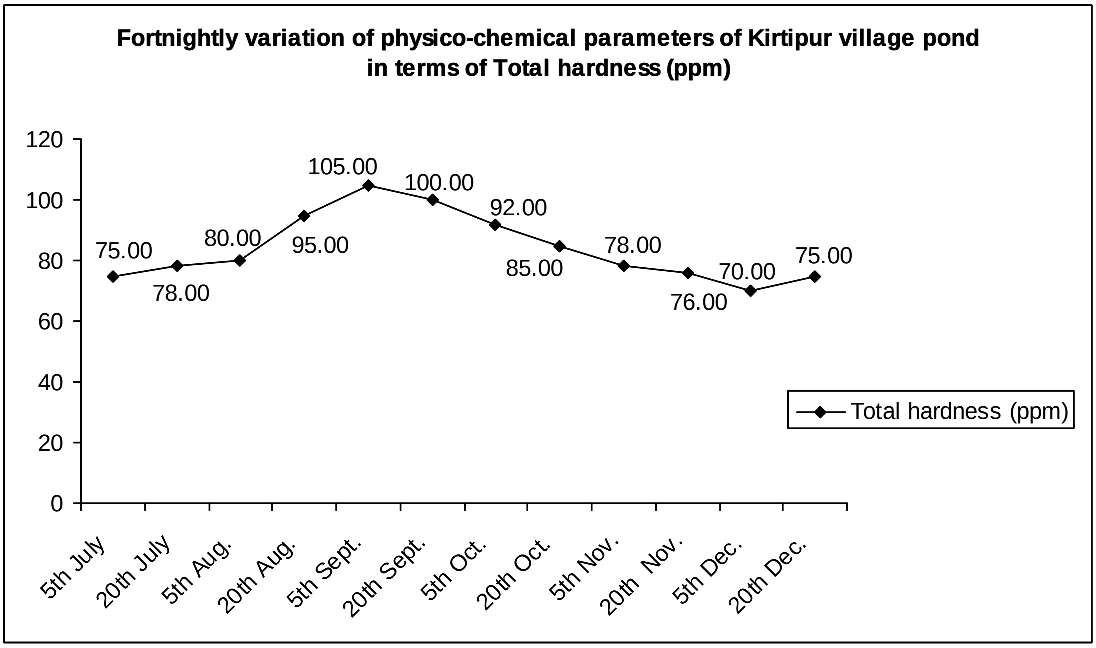

Figure 9: Fortnightly variation of hardness

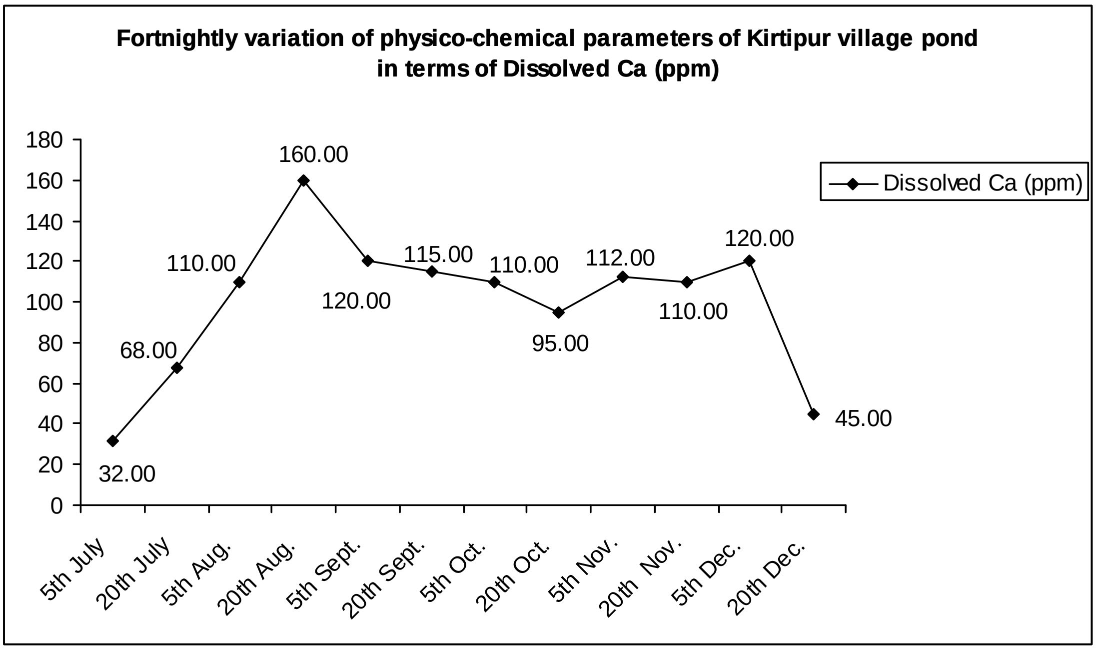

Figure 10: Fortnightly variation of Calcium

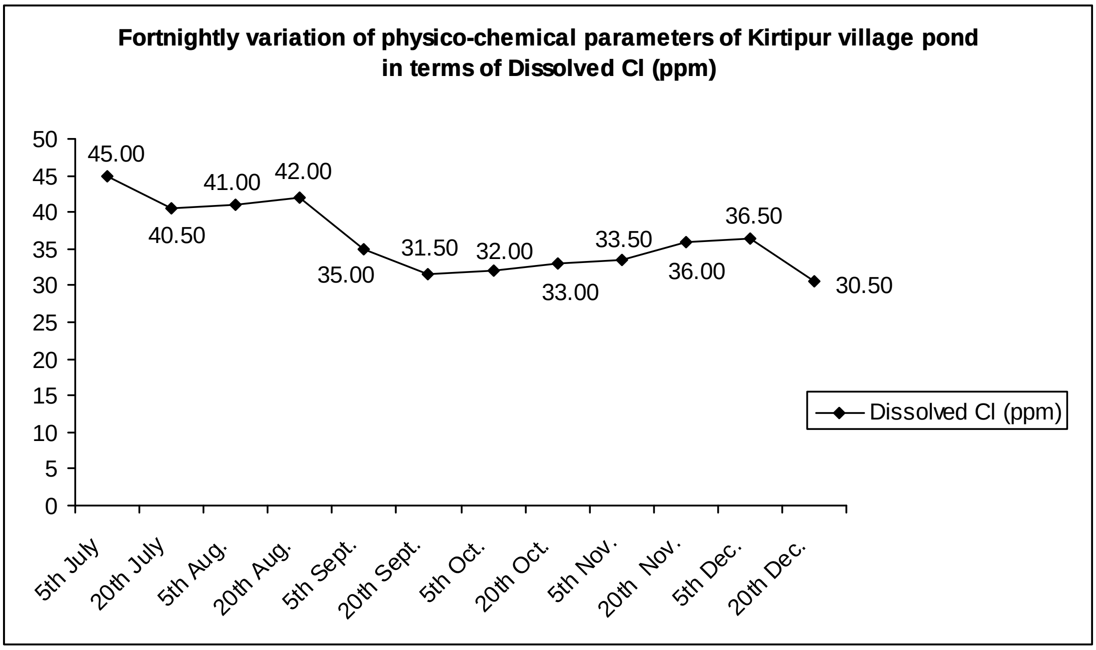

Figure 11: Fortnightly variation of Chloride

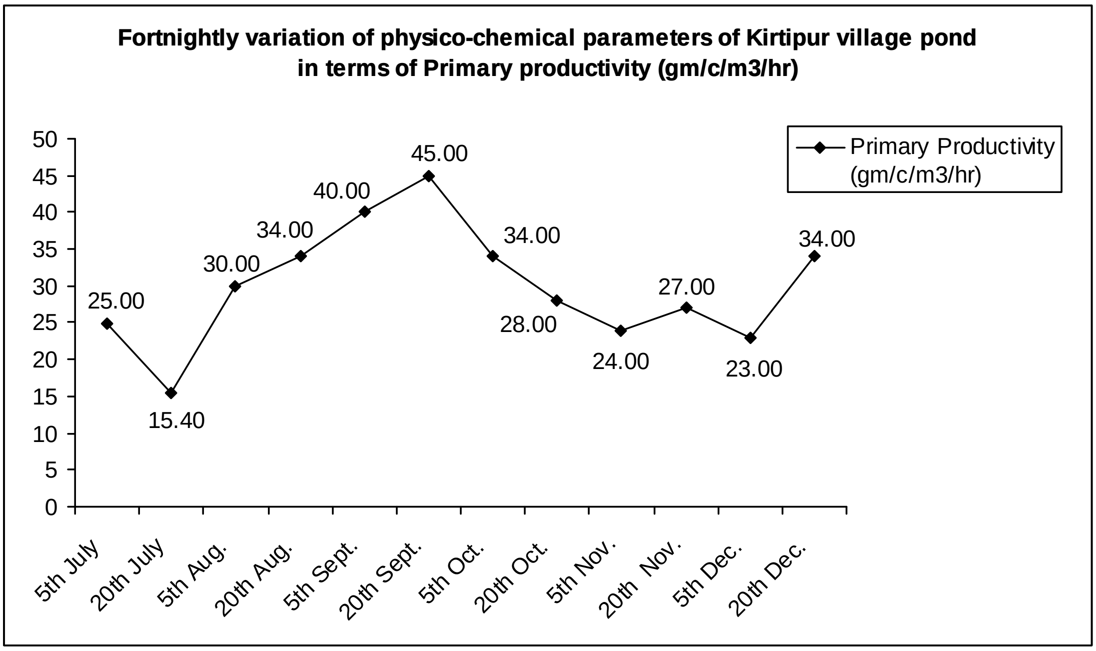

Figure 12: Fortnightly variation of primary productivity

4.3 Relation between Physico-Chemical Parameters and Primary Productivity

The relation between physico-chemical parameters and primary productivity are shown by statistical analysis and also given in graphs (1-12)

The value of correlation co-efficient (r) between depth and primary productivity was calculated to be negative as,

$r = -0.72$

$P.Er = 0.09$

$\because r < P.Er$

From the statistical analysis. It has been found out that there was positive correlation between transparency and primary productivity.

$r = 0.5641$

$P.Er. = 0.13$

$\because r > P.Er$

The correlation co-efficient between pH and primary productivity was calculated and found to be negative as,

$r = -0.1687$

$P.Er. = 0.18$

$\because r < P.Er$

From the statistical analysis it was found that there existed negative correlation between DO and primary productivity.

r= -0.6523

P.Er. = 0.11

∵ r < P.Er

From the statistical analysis, the correlation co-efficient between free carbondioxide and primary productivity was positive.

r= 0.3329

P.Er = 0.17

∵ r > P.Er

A positive correlation has been observed between total alkalinity and primary productivity.

r=0.6327

P.Er. = 0.11

∵ r > P.Er

The correlation coefficient between total hardness and primary productivity was worked out to be positive.

r=0.7834

P.Er.= 0.07

∵ r > P.Er

A positive correlation co-efficient was found between dissolved calcium and primary productivity.

r=0.3392

P.Er=0.17

∵ r > P.Er

The correlation co-efficient between chloride and primary productivity has been calculated as follow.

r=-0.4438

P.Er.=0.15

∵ r < P.Er

The gross primary productivity was found highest in the month of September i.e., 95 $gm/c/m^3/hr$. A sharp decline was found in the month of July i.e. 36 $gm/c/m^3/hr$. Exactly similar was the case of net primary productivity with a highest record of 45 $gm/c/m^3/hr$. in September and lowest of 11 $gm/c/m^3/hr$. in July. The minimum, maximum and average values of primary productivity was 15.4 $gm/c/m^3/hr$., 45 $gm/c/m^3/hr$. and 29.95 $gm/c/m^3/hr$. respectively. (Table 3)

From the correlation co-efficient analysis between production and nutrient content of the pond, it was found that a direct relationship exist between CO_2, transparency, hardness, alkalinity and calcium. Likewise, inverse relation was found between temperature, depth, PH, DO and chloride.

CHAPTER - FIVE

DISCUSSION

The present investigation represents a comprehensive effort to understand the status of village pond in context of it's eco-biology.

The physico-chemical and primary productivity of present study pond are discussed below

a) Water colour:

During the study period, the colour of the pond water varied from muddy brown, brownish to greenish white may be due to the heavy rain fall, during monsoon, washing of clothes, suspended silt particles and swarms of planktons, algal blooms etc.

b) Temperature:

The variation in temperature of a water body has a great bearing upon it's productivity. All metabolic, physiological activities and life processes such as feeding reproduction, movements and distribution of aquatic organisms are greatly influenced by water temperature and every individual has a range of temperature tolerance. Air temperature influences the temperature of the surface water. Similarly the water temperatue also affects the chemical parameters of water. The oxygen content of water in general decreases with rise in temperature and increases at low temperature. In other words, temperature has direct but inverse effect on the dissolved oxygen was also reported by Upadhya (1991), Bhattarai (1996), Shrestha (2004). The present investigation also goes on concurrent result of the opcit workers.

c) Depth:

Depth of a body of water influences the physical and chemical properties of water. When the water is shallow, it allows the sunlight to penetrate up to bottom and increases productivity by photosynthesis so long as other parameters are not limited. When the water is too deep, the bottom layer will be cold and less productive.

The depth of water body varied from month to month. During the study period the average depth of the pond was 59.58 cm. During the summer season depth of the pond was maximum (78 cm). It may be due to rainfall. Where as, in the winter season the depth was minimum (45 cm) due to least rainfall and evaporation of water from the pond.

This showed that decline in depth favoured the primary productivity. Which is also supported by the findings of Bhattarai (1996), Shrestha (2004) but the findings of Kushwaha (1992), Shah (1994) were contrary to the present finding. Negative, correlation (-0.72) was found between depth and primary productivity.

d) Transparency:

Transparency is a very important physical parameter which directly or indirectly determines the productivity through the creation of turbidity blocking the penetration of light and causes the scarcity of food in water body.

During the study period, the transparency of pond ranged from 12 cm to 38 cm with an average of 22.41 cm.

Banerjee and Raj Chaudhary (1961) studied the physico-chemical feature of Chilka lake and reported that during the monsoon, lower transparency was due to the entry of silt, silt laden rain water and probably also due to the rise of phytoplanton density of water. The present study also agree with this view.

Colour and transparency were found directly correlated with each other. When colour was clear, the transparency was high and vice-versa.

During the present study period, the transparency was high in September due to the calm and clear atmosphere. So the productivity of the pond was increased. Shah (1994) also supported the present view.

There was positive correlation (0.5641) between transparency and primary productivity

e) Hydrogen Ion Concentration (pH):

Natural water may be alkaline, acidic or neutral. It is an important environmental factor influencing the species and metabolism of all animal and plants inhabiting therein.

The hydrogen ion concentration i.e. pH of water is not a constant factor and varies in relation to chemicals present in water. This is one of the most important chemical factor for aquatic life. During the study period, the pH of water showed very little fluctuation. pH value fluctuates from 7.2 to 9.0 with an average value 8.25. This view is also supported by Shah (1994), Bhattarai (1996) and Shah (1996).

From the statistical analysis, it has been found that there was negative correlation (r=-0.1687) between pH and primary productivity.

f) Dissolved oxygen (D.O):

Dissolved oxygen is most important for the animal and plant life in a water body. It is available to the water by absorption from the surface and by photosynthesis. During day time, plants consume CO_2, and release O_2, while at night they consume oxygen and release CO_2 through respiration. All animals consume O_2 during respiration.

Dissolved oxygen is considered to be the ionic factor which to a great extent can reveal the nature of whole aquatic system at a glance even when information of other chemical, physical and biological parameters are not present.

Ellis (1937), reported that the D.O. in water must be 5 ppm. at $20^{°C}$ for maintaining the aquatic life. During the present study, max. D.O. was found to be 7 ppm. at 2.6 $^{°C}$ so the water of present study pond can support the aquatic life.

The minimum D.O. in present study (3.2 ppm) may due to low water volume and suspended particles. This view is supported by Shah (1994), Shrestha (2004) etc. A negative correlation (r=-0.6523) was found between the D.O. and primary productivity.

g) Free carbondioxide (CO_2):

Free carbondioxide plays an ambient role in photosymthesis for chlorophyll bearing organisms. Large amount of CO_2 is available to the water through respiration. It is also derived from atmosphere as well as by decomposition of organic matter. Presence of CO_2 is essential for photosynthesis but excess is harmful to animals.

Free CO_2 has negative correlation with dissolved oxygen. It means when the dissolve oxygen was maximum CO_2 was minimum and vice-versa.

In present study free CO_2 showed an inverse relation with dissolved oxygen. The average value of free CO_2 recorded was 19.16 ppm. Shah (1994) reported the average free CO_2 of Kirtipur Village pond as 16 ppm. Bhattarai (1996) investigated the average free CO_2 of Kamal Pokhari as 3.0 ppm. From the statistical analysis the correlation coefficient between free CO_2 and primary productivity was positive ($r = 0.3329$)

h) Total Alkalinity:

Alkality may be used as an important measure to determine the quality of water. The alkalinity of water is mainly caused by the cations of Ca, Mg, Na, K, NH_4 and Fe combined either as carbonates, bicarbonates or occasionally as hydroxide.

A water body with 41-90 ppm, total alkalinity has a medium to high productivity (Bennett, 1970). Similarly, Cole (1975) quotes alkanity of 51-67 ppm, to indicate a very productive water body. The average alkalinity of the presently studied pond was 100.58 ppm. suggesting the pond can be categorized as productive.

The above observation is supported by Shah (1994), Bhattarai (1996), Kushwaha (1996), Shrestha (2004).

The correlation coefficient calculated between total alkalivity and primary productivity was found to be positive ($r=0.6327$).

i) Total Hardness:

Hardness in principle is the total of soluble of calcium and magnesium salts present in water.

In most natural waters, the predominant ions are those of bicarbonate associated mainly with calcium to a lesser degree with magnesium all still less with sodium and potassium.

According to Swingle (1967) water having hardness of 15ppm or above may be considered suitable for the growth of fish while less than 5 ppm is not good for fish growth. In the present investigation, the total hardness ranged from 17 to 105 ppm with an average value of 84.08 ppm. Thus, the total hardness of this pond support for fish culture. Bhattarai (1996) found the total hardness of 15 ppm in Kamal Pokhari, Kushwaha (1996) recorded the hardness of 123.42 ppm in Sewage stabilization pond. The positive correlation (r=0.7834) has been found between total hardness and primary productivity.

j) Dissolved Calcium (Ca):

Calcium is an essential element for plants and animals. The calcium ion in water influences the chemical density of environment, abundance and composition of the biotic community. It occurs normally in combination with carbonate ions, which is related to temperature, pH, pressure and nature of substance present in the water.

The dissolved calcium was noted regularly and was found in the range of 32-160 ppm. Shah (1994) found that calcium fluctuated from 48.06 to 160.2 ppm., Bhattarai (1996) reported the dissolved calcium in the range of 19.4 to 43.6 ppm. There existed a positive correlation (r=0.33) between dissolved calcium and primary productivity.

k) Dissolved chloride (Cl^-):

Chloride is considered as pollution indicator when present in excess amount (Pandey and Verma 1992). During the period of investigation chloride content ranged between 30.5 to 45 ppm which might be due to intense bathing. This view is supported by Bhattarai (1996), slightly lower value of chloride was reported by Mahato (1994) and Shah (1994). The correlation co-efficient between dissolved chloride and primary productivity was found to be negative (r=-0.44).

Primary Productivity

The primary productivity is the most important biological phenomenon in nature on which the entire diverse array of life depends, either directly or indirectly. It is determined by measuring the change in oxygen and carbondioxide concentration. The physico-chemical properties of water, geographical location, climate and season play a deciding role in determining the rate of primary production.

In the present investigatin, the fortnightly high gross productivity was observed in the month of September i.e. (95 $gm/c/m^3/hr$). A sharp decline was found in the month of July i.e. (36 $gm/c/m^3/hr$). The net primary productivity was calculated high i.e. (45 $gm/c/m^3/hr$) in September and the lower i.e. (11 $gm/c/m^3/hr$) in July.

The maximum primary productivity (45 gm/c/m^3/hr) was observed in September and minimum (15.4 gm/c/m^3/hr) was observed in July.

The trend of net primary productivity was similar to the principle of the aquatic production, as the gross primary productivity was always higher than the net primary productivity. The rate of primary production in autotrophic layer is affected by light intensity. This view was supported by Thomas (1955)

It was seen in the study period that the pH and temperature is directly related to the primary productivity. The higher rate of productivity in high temperature was also reported by, Karki (1988), Shah (1994), Bhattarai (1996) and Shrestha (2004). Similar results were also pointed out by Goldman (1968).

CHAPTER - SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The present dissertation deals on physico-chemical parameters in relation to primary productivity of a village pond Kirtipur for a period of six months.

The present study has been mainly divided into five chapters besides summary recommendations and bibliography. The first chapter deals with introduction and the second chapters with literature review. Materials and methods used in the present study were kept in the chapter third. Chapter fourth includes the results and the discussion is dealt in chapter fifth.

In the present study water colour changed from muddy, brownish to greenish white. Depth ranged from 45 to 78 cm. While transparency from 12 to 38 cm. The water temperature varied from 18 to 28°c.

The dissolved oxygen (D.O.) value was 4.90 ppm while that of free carbondioxide (CO_2) was 19.16 ppm.

The total alkalinity fluctuated from 65 to 210 ppm while total hardness from 70 to 105 ppm. The dissolved calcium varied from 32 to 160 ppm and chlorides from 30.5 to 45 ppm.

The average primary productivity of present study pond was 29.95 $gm/c/m^3/hr$. Despite of other limitations, the estimated productivity suggested the pond to be moderately productive and may be suitable for pisciculture practices.

The statistical analysis showed that the primary productivity is directly regulated by the factors like depth, temperatures, transparency, pH, D.O., hardness, total alkalinity, and dissolved calcium and chlorides. These factors like free Co_2, transparency total hardness, total alkalinity and dissolved calcium showed positive correlation with primary productivity while rest other showed inverse relationship.

6.2 Recommendation

The present investigation pond is situated near the houses and domestic wastages are discharged in this water body. People wash their cloths, utensils making the water unfit for human consumption. Thus, following measures should be strongly adopted for the proper utilization of the pond.

1. It should be maintained by the general awareness of the local people.
2. Before utilizing the pond for fish culture, the phyico-chemical and biological parameters must be worked out at least for a period of one year.
3. Bathing washing and other domestic activities should be avoided.
4. Pesticides are lethal both to the fish food organisms and to the fish. Therefore, the use of pesticides by farmers around the pond should be avoided.
5. It is necessary to fence by a boundary wall.
6. A longer experiment of primary and secondary productivity of pond is needed.
7. Study of soil analysis from time to time should be done.

8. The pond has been under fish culture since long period of time but because of the polluted water, fishes could not have good growth. Therefore pollution in the pond should be avoided. The pond lacks inlet and outlet, and source of water is the surface runoff from surrounding areas as a result the pond water level decreases in dry season therefore, extra water source to the pond should be arranged to maintain the water level.

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