IMPACT OF EUGLENA BLOOM ON BIOLOGICAL PRODUCTIVITY OF POND

THESIS

By

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(S-2008-30-01)

Submitted to

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in

Partial fulfilment of the requirements for the degree

of

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(BIOLOGY)

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Is there anything I can say,

anything I can give

or do for you.....

Because all that I'm

all that I have

I owe to you.....

Affectionately Dedicated

to my

Revered Parents

Who sacrificed

their present

to make my future better

Dr. Rani Dhanze
Professor & Head

Department of Fisheries
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CERTIFICATE – I

This is to certify that the thesis entitled **"Impact of Euglena bloom on biological productivity of pond"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science Basic Sciences** in the discipline of **Biology** of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur is a bonafide research work carried out by **Mr. Ankit Kumar (Admission No. S-2008-30-01)** son of **Shri Chaman Lal** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place: Palampur
Dated: 4 January, 2011

(Dr. Rani Dhanze)
Major Advisor

CERTIFICATE – II

This is to certify that the thesis entitled **"Impact of Euglena bloom on biological productivity of pond"** submitted by **Mr. Ankit Kumar (Admission No. S-2008-30-01)** son of **Shri Chaman Lal** to the CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur in partial fulfilment of the requirements for the degree of **Master of Science (Basic Sciences)** in the discipline of **Biology** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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Needless to say, all omissions and errors are mine.

Ankit Kumar

(Ankit Kumar)

Place : Palampur

Dated : 4/1/11

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ABBREVIATIONS USED

%	per cent
°C	degree centigrade
$AgNO_3$	silver nitrate
APHA	American Public Health Assosiation
cm	centimetre
CO_2	carbon dioxide
EDTA	ethylenediaminetetraacetic acid
et al.	et alii (and others)
etc.	et cetra (and so forth)
g	gram
i.e.	idest (that is)
KCl	potassium chloride
m	meter
M	molar
mg/l	milligram per litre
N	nitrogen
$Na_2S_2O_3$	sodium thiosulphate
NaOH	sodium hydroxide
NO_3	nitrate
O_2	oxygen
$OH^{\cdot}$	hydroxyl radical
op. cet.	opera citeto (in the work cited)
P	phosphorus
pH	negative logarithm of hydrogen ion concentration
PO_4	Phosphate
TDS	total dissolved solids
u/l	unit per litre
viz.	videlicet (namely)

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ABSTRACT

Evaluation of different physico-chemical and biological parameters of Euglena free and Euglena infested pond was conducted during April 2009 – March 2010. The free carbon dioxide, chloride, total hardness, total dissolved solids and nitrate were high in euglena infested pond which favored the production of Euglena bloom. The evaluation of biological productivity in both types of pond revealed that there are 24 genera belonging to class bacillariophyceae (nine genera), euglenophyceae (one genus), chlorophyceae (seven genera), cynophyceae (four genera), rotifera (two genera) and copepoda (one genus). Further total number of plankton u/l was high in Euglena infested pond due to abundance of euglenophyceae. The impact of Euglena bloom on growth performance of common carp depicted that the physico-chemical parameters such as total dissolved solid, nitrate, and alkalinity remain high in Euglena infested trough whereas dissolved oxygen was high in control trough. This study revealed that the biological productivity of Euglena infested pond and trough was less than that of euglena free ponds and troughs. However in experimental troughs the planktonic diversity was less than that of ponds as a total of 18 genera instead of 24 genera have been recorded. The survivability of common carps was 100% in control trough as compared to 50 % in euglena infested trough where the growth of fish was also less. It was observed that the low dissolved oxygen, high total dissolved solid and nitrate accelerate the growth of Euglena bloom in ponds and trough. Thus it may be concluded that the Euglena bloom directly affects the pond's productivity, water quality and oxygen balance and the impact of these resulted in terms of low production and survivability of fish.

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Introduction

1. INTRODUCTION

Euglena is well known flagellate under the phylum Euglenophyta and family Euglinidae. It is a unicellular organism having cylindrical, oval spindle shaped body, with many bright chloroplasts and a single emergent flagellum. It is actually a green planktonic protist having a red eye spot and both plants and animal like characteristics. The chemical that causes the red eyespot is haematochrome and produced in excess when the Euglena cell is exposed to excessive sunlight creating the red bloom.

The formation of red bloom is due to nutrient enrichment and eutrophication. The enrichment of nutrient occurs due to heavy rains which increase the runoff agricultural and industrial wastes. The enormous number of these organisms imparts a distinct red or khaki colour to the water through eutrophication and many changes occur during the day time that is dark green to red or Khaki colour. These blooms have blanketing effect on the water as such cut the sunlight penetration as well as clog the gills of the fish.

Besides Euglena several species of algae as well as the cynobacteria are capable of causing various adverse effects in fresh water, such as excessive accumulation of foams, scums and discolouration of water under certain conditions. The abundance of algae in a lake or a river increases explosively leads to algal bloom. Lakes, ponds and slow moving rivers are most susceptible to bloom. Algal bloom is natural occurrences of warm, sunny calm conditions. However, human activities often may trigger or accelerate algal bloom by supplementing phosphorus or nitrogen compounds from natural resources, for example, in rural areas agricultural runoff from fields can wash fertilizers into the water but in urban areas, nutrient sources may include treated waste waters from septic systems and sewage treatment plants, and urban storm water runoff that carries non point source pollutants such as lawn fertilizers which can enhance the algal bloom formation as well as dumping of garbage in water body .

An algal bloom contributes to the natural aging process of a stagnant water bodies and in some such water body can provide important benefits by boosting primary productivity. But in other cases recurrent or severe bloom can cause dissolved oxygen depletion due to decay of the large number of algae. In highly eutrophic lakes, algal bloom may lead to anoxia and fish kill during the summer due to high temperature and fast decomposition of organic matter. In terms of human values the odours and unattractive appearance of algal bloom can detract the recreational value of reservoir, lakes and streams. Some algae produce toxic chemicals that pose a threat to fish, other aquatic organisms, wild and domestic animals as well as human beings (Brian *et al.* 2003). The toxins are released into water when the algae die and decay. Bloom of toxic species of algae can enrich the water environment with the biotoxins they produce. The toxic bloom can cause human illness such as gastroenteritis (if the toxin is ingested) and lung irritations (if the toxin becomes aerosolized). Other toxins are less drastic and cause skin irritation to people who swim through an algal bloom. Toxicity produced by algal bloom may sometimes cause severe illness and death of the animals that consume the biotoxin containing water. Algal bloom can affect the process of photosynthesis when it is present in irrigation as well as fish pond as a result reduces the productivity of the water.

Now a day with gradual increase of aquaculture specially intensive and semi-intensive culture practices high doses of fertilizers, feed etc. are used in the pond year after year to increase the fish production. The regular fertilization in the fish pond accumulates nutrients at the bottom of pond. The nutrient budget in these systems reveals that large quantity of these elements are not utilized by the fish and often accumulated in the pond (Boyd 1990). As a result most of the fish ponds become hyper nutrified and fish farmers experiencing many unexpected problems such as environment degradation, with noxious algal bloom, Euglena bloom, ammonia toxicity and different fish diseases etc. that ultimately hampered the fish production. Anderson (1989) and Samayda (1992) reported that toxic and noxious Euglena bloom have serious negative effects which cause severe economical loses to aquaculture and having major environment and human health impacts. Further they (*op. cit.)* also observed that toxic bloom of microscopic organisms such as *Ptiestera*, *Piscidia* dinoflagellites in Eastern United States kills fish and has been reported to cause skin rashes and other maladies in human. Harmful algal bloom affected the public health and ecosystems when fishes feed on toxic phytoplankton (John and Rodgers, 2008). Algal bloom formation can also affect the light penetration into the water thus changing the functions and structure of the aquatic ecosystem. Discoloration of water by bloom makes water aesthetically unpleasant. Harmful algal bloom also kills other important species of algae, which is performing a food web for fishes.

Zimba et al. (2004) noticed the outbreaks of toxic Euglena in North Carolina which cause the loss of more than 20,000 pounds of fish. Recent research has confirmed that Euglena species produce an icthyotoxin in fresh water aquaculture. Further they (*op. cit.)* have reported the mortality of hybrid stripped bass in North Carolina which was caused by *Euglena sanguina* a widely distributed species in many shallow, calm, eutrophic fresh water systems. This species also killed laboratory reared channel catfish. Based on behavioural changes found in exposed fish they (*op. cit.)* suggested that euglenoid toxins act as neurotoxin.

Padamavathi and Prasad (2007) reported that species of blue green algae such as *Microcystis sp., Oscillatoria sp., Arthrospire sp., Spirulina sp., Anabaena* sp. and *Raphidiopsis sp.* are frequently observed as bloom in fish ponds. Inspite of the harmful aspects of different types of bloom, it also has good impact on fish as when it is formed in lesser quantity because it also acts as fish food. The fish farmers artificially induce the bloom in their pond or lake for the feeding of fishes (Dutta *et al.* 2004).

However, in hills the bloom is mainly formed by the Euglena species which is found particularly after rainy season due to accumulation of allochthonous materials from nearby areas and favourable temperature which enhance the growth of Euglena bloom. This bloom directly affects the pond's productivity, water quality as well as oxygen balance. Thus, it becomes necessary to study the effect of Euglena bloom on water quality, plankton diversity and fish production to assess the biological productivity of the pond. A perusal of literature reveals that little work has been done on the various aspects of Euglena bloom in fish pond. Therefore, the present study is conducted with the following objectives;

(i) To study the physico-chemical and biological parameters of Euglena infested and Euglena free ponds.

(ii) To assess the impact of Euglena bloom on biological productivity.

Review of Literature

2. REVIEW OF LITERATURE

A comprehensive review of literature is most important for any research endeavour. The study on impact of Euglena bloom on biological productivity of pond is highly useful for water quality management, for optimum fish production, maintenance of sufficient amount of natural food for fish and management of environmental conditions for the growth of fish population in Euglena infested pond water system.

Historical Background

Limnology is a branch of science which deals with the study of waters in all aspects *viz.*, physical, biological and geological. It stems from the Greek word limne (lake) and logos (study). It started with the study of lakes and ponds which were defined as "microcosm" (little world with in itself) and later on the study of fresh water bodies was also included in limnology. For investigations on freshwaters many workers entered in this new field. Now besides lakes other inland water bodies such as reservoir, pond, tanks, rivers, stream, swamps bogs etc. also come under the domain of limnology.

The literature surveyed in respect of present investigation entitled **"Impact of Euglena bloom on biological productivity of pond"** has been reviewed and categorised under following subheadings:-

2.1 Physico-chemical parameters.

2.2 Biological parameters.

2.3 Impact of Euglena bloom on pond productivity.

2.1 Physico-chemical parameters.

Mock *et al.* (2003) described four most important environmental variables i.e. water temperature, total particulate nitrogen, daily irradiance and total nitrogen which help in predicting cynobacterial bloom abundance and changes in chlorophyll-a concentration.

Chinnasamy *et al.* (2004) explained the cynobacterial biodiversity from different freshwater ponds in Thanjavur, Tamilnadu and compared with the physico-chemical parameters such as dissolved oxygen, pH, carbonate, bicarbonate, nitrate, and total phosphorus. Further they observed a massive bloom of *Microcystis aeruginosa* which had a significant effect in reducing the cynobacterial population.

Mhlanga *et al.* (2006) reported that dissolved oxygen decreased when bloom started to die off and coincided with fish death when the average surface dissolved oxygen concentration in the lake was 3.9 mg/l. Mortality probably resulted from depressed oxygen levels which is caused by the massive algal die-off and released algal toxins.

Roksana *et al.* (2006) observed that underlying mechanisms and contributing factors related to the seasonal dynamic of harmful algal bloom in a shallow eutrophic pond. They have noted two conspicuous events simultaneously throughout the study period that is high concentration of phosphate–phosphorus and permanent cynobacterial bloom. Cynobacterial bloom was characterized by three abundance phases, each of which was associated with different ecological processes for example high nitrate–nitrogen was associated with high cynobacterial abundance, while low nitrate–nitrogen was recorded during moderate abundance phase. The extremely low NO_3–N/PO_4–P ratio was recorded, and all blooming taxa were negatively correlated with this ratio. Cynobacterial bloom was positively correlated with temperature and pH and negatively correlated with transparency. Although *Anabaena* showed similar relationship with water quality parameters as indicated by cyanobacteria. The co-dominant *Microcystis* exhibited negative relationship with temperature and nitrate–nitrogen. This was attributed to excessive growth of *Anabaena* that suppressed *Microcystis*'s growth. Planktothrix was the third most dominant taxa, while *Euglena* was regarded as opportunistic.

Dhingra and Ahluwalia (2007) reported that high nutrient levels, draining of fertilizers, sewage and disposal of industrial effluents in water bodies often promote bloom formation. They reported altogether 26 species of cynobacteria which belong to 11 genera and are very common in the formation of bloom in eutrophic water bodies of Punjab. They have also compared different physico-chemical parameters of ponds with cynobacterial diversity.

Guven and Howard (2007) identified the critical parameters of a cynobacterial growth and movement model by using generalized sensitivity analysis and observed that the light, nutrients and temperature are major factors, which affects cynobacterial bloom formation in rivers.

2.2 Biological parameters.

Robson and Hamilton (2000) observed the appearance of algal bloom within three weeks after rainfall. They also observed a large mono-specific bloom of the cynobacterium *Microcystis aeruginosa* in the estuary, which can be controlled by regulating salinity and temperature.

Seop *et al.* (2002) reported recolonization of *Zostera marina* following destruction caused by a red tide algal bloom and concluded that the reduction in light caused by the algal bloom which also destroy the eel grasses.

Paul *et al.* (2003) studied that cyanoprokaryotic algae, diatoms, haptophytes, dinoflagellates, euglenoids, and rhaphidophytes are known to produce algal toxins. A previous study by the authors reported euglenoid algae producing toxins in aquaculture ponds, with confirmation based on positive fish bioassays following exposure to the isolated clonal algal cultures. Toxicity was observed in euglenoid culture isolates obtained from the pond as well as a clonal culture collection taxon.

Peeters *et al.* (2007) studied earlier onset of the spring phytoplankton bloom in lakes of warmer climate. It affects competition within the plankton community as well as food web interactions with zooplanktons and fish. They further reported that the oligotrophication has negligible effect on the timing of the phytoplanktons growth. But it is only the high temperature and low wind speeds which enhance the growth of phytoplankton during spring.

2.3 Impact of Euglena bloom on pond productivity.

Samayda (1992) reported that toxic and noxious Euglena bloom causes severe economical loses to aquaculture and having major environment and human health impacts. Further they also observed that toxic bloom of microscopic organisms such as *ptiestera*, *piscidia* a dinoflagelltes kills fish in Eastern United States and also causes skin rashes in aquatic organisms.

Zimba *et al.* (2004) noticed that toxic Euglena bloom causes the loss of more than 20,000 pounds of fish in North Carolina. Thus it was confirmed that Euglena species produce an icthyotoxin in fresh water aquaculture which was responsible for the death of fish and other aquatic organisms.

Boaru *et al.* (2006) determined that the algal toxins are responsible for numerous cases of poisoning and death of aquatic animals. The water eutrophication can enhance the toxic cynobacterial growth hence increasing the risk of exposure to microcystins. Consequences of exposure to high levels of microcystins (toxin) include structural damage and apoptosis and its exposure for long periods of time may lead to liver tumours.

Padamavati and Parsad (2007) reported that the fish ponds receiving fertilizers become eutrophic in the course of time and quite often dominated by surface water algal bloom which deteriorates the water quality specially depletion of dissolved oxygen. This resulted in the poor growth and mortality of fish.

Rundberget *et al.* (2007) studied the marine biotoxins from micro algae, which accumulated in shellfish and lead to poisoning of human consumers as well as fish, marine mammals and sea birds.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation was carried out in the Department of Fisheries, College of Veterinary and Animal Sciences, CSKHPKV, Palampur, during 2009-2010. The detail of materials used and methods employed in the present investigation are discussed below.

3.1 Material

Fortnightly sampling was conducted during the period of April 2009 – March 2010 from the Euglena free and Euglena infested ponds for analysing physico-chemical and biological parameters.

3.2 Experimental site

Euglena free and Euglena infested ponds were selected at fish farm, CSKHPKV Palampur to study the physico-chemical and biological parameters of these water.

3.3 Experimental details

3.3.1 Sampling of water

The water samples were collected from the Euglena free and Euglena infested pond by agitating the container to avoid air bubble. The analysis of different physico-chemical parameters such as air temperature, water temperature, transparency, pH, dissolved oxygen (DO), free carbon dioxide, total alkalinity, and total hardness, total dissolved solids (TDS), nitrate and chloride have been done in different type of ponds. The water samples were collected in air tight neutral polythene bottles. The parameters of water were determined within few hours of collection in laboratory and nitrate was analysed within 48 hours of collection.

3.3.2 Sampling of plankton

The plankton was collected by filtering fifty litters of water through the bolting silk no.40 plankton net and reduced to 20 ml. This water was transferred in a tube and fixed in 4% formalin on the spot for detailed study.

3.4 Analytical method

3.4.1 Analysis of water

3.4.1.1 Physical parameters

Air temperature

Air temperature was recorded with the help of a good grade mercury thermometer ranging from 0 to 50 degree Celsius with the least count of 0.2 degree Celsius. Direct exposure of the mercury bulb to sunlight was avoided.

Water temperature

Water temperature varies at different times of the day and also during different seasons of the year, and from place to place. Water temperature was recorded by using a centigrade thermometer. The centigrade thermometer (0 to 50^{o} C) was kept against sunlight and dipped in an inclined position into the water body. The thermometer was held steady for a minute before taking reading.

Water transparency

Water transparency was measured by using a secchi disc. The secchi disc is a metallic plate of 20cm diameter with four (alternate black and white) quadrants on the upper surface and had a hook in the centre to tie a graduated rope. There is a weight in centre on lower surface to avoid floating of the disc. The secchi disc was lowered in the water body and the depth (cm) at which it disappeared was noted. The disc was slowly lifted upwards and the depth at which it reappeared in water was noted. The mean of the two readings gave the transparency of water.

3.4.1.2 Chemical parameters

pH

The pH was recorded by Electrometric method in which the electrode was adjusted with 4 and 9.2 pH solution and after standardization the electrode was washed with distilled water and wiped with tissue paper. The electrode was dipped in the different water samples for measuring the pH. The electrode was washed with distilled water and wiped after each dip. The reading was recorded when there was less fluctuation in reading.

Dissolved Oxygen (DO)

Dissolved oxygen was analysed following Winkler's/ Iodometric method (APHA, 1985). The dissolved oxygen bottle of 250ml was cleaned and dipped in water up to hand and agitated the bottle so that no air bubble entered in the bottle, allowed the bottle to be filled up to rim then mouth of bottle was closed with stopper inside the water. Fixation of dissolved oxygen was done by adding 2ml alkaline iodide and 2ml of $MnSO_4$ reagent right at the bottom of the bottle with separate pipettes one after the other. The mouth of the bottle was closed and inverted the bottle three to four times for a thorough mixing of reagents. A flocculent precipitate was formed and settled at the bottom within two to three minutes of time. The precipitate was dissolved by adding 2ml of conc. H_2SO_4 in similar manner as that of alkaline iodide. The mouth of the bottle was closed and it was shaken three to four times upside and down. The bottle was kept for two to three minutes to allow the settling of impurities at the bottom. Rinsed the conical flask and measuring cylinder with the same solution .Then transferred 50ml of this solution in a conical flask placed on a white background. Now the solution was titrated with 0.025N sodium thiosulphate ($Na_2S_2O_3$) solution drop by drop till the pale yellow colour appeared. Then added few drops of starch solution to give a blue colour and again titrated it till it turned colourless. The volume of $Na_2S_2O_3$ solution consumed was recorded. The following formula was adopted to calculate the dissolved oxygen per litter in the water sample-

$$\text{Dissolved oxygen} = \frac{(8 \times N \times 1000)}{V} \times v \text{ mg/l}$$

Where, N=Normality of sodium thiosulphate solution i.e. 0.025

V=Volume of sample titrated i.e. 50ml

v= Volume of titrant used i.e. in ml

Or

$$\text{Dissolved oxygen} = \frac{(8 \times 0.025 \times 1000)}{50} \times v \text{ mg/l}$$

Or

Dissolved oxygen = 4x v mg/l

Total dissolved solids (TDS)

Total dissolved solid was analysed using multipara meter instrument (Multi 340i). The instrument was calibrated by connecting the measuring cell to the measuring instrument. The conductivity measuring cell was immersed in the control standard solution of 0.01 M KCl. The 'cal' key was pressed to calibrated the instrument, cell constants (cm^{-1}) ranges from 0.450cm^{-1} to 0.500cm^{-1}. Now the instrument was ready to measure the conductivity of samples. The measuring cell was immersed in the water sample and 'run/enter' key was pressed. The value of conductivity was displayed on the monitoring instrument. The reading was noted and converted into total dissolved solids by dividing it with a factor 0.65 (APHA, 1985).

Free carbon dioxide

Free carbon dioxide was calibrated by using titration method. 50ml of sample was taken in a conical flask/Nessler's tube and two drops of phenolphthalein indicator was added to it. The water remained colourless which indicated the presence of free carbon dioxide. This solution was titrated by adding N/44 NaOH drop by drop from a 1ml graduated pipette with a very gentle stirring till the light pink colour appeared. Then the number of ml of N/44 NaOH consumed was recorded and calculation of free carbon dioxide was done by using the following formula-

$$\text{Free carbon dioxide} = \frac{\text{No. of ml of N/44 NaOH consumed} \times 1000 \times 44 \text{ mg/l}}{50 \times 44}$$

$$= \text{No. of ml of N/44NaOH consume} \times 20 \text{ mg/l}$$

Alkalinity

Alkalinity includes carbonate and bicarbonate. For the analyses of alkalinity due to carbonate 50ml of water sample was taken in a conical flask and two drops of phenolphthalein indicator was added to this solution. The water turned pink which indicated the presence of carbonate. Now it was titrated with 0.02N H_2SO_4 from a 1ml graduated pipette and added drop by drop with gentle stirring till it became colourless. The number of ml of 0.02N H_2SO_4 consumed was noted and carbonate in water sample was calculated by using the formula-

$$\text{Carbonate} = \frac{\text{No. of ml of 0.02N } H_2SO_4 \text{ consumed x 1000x 0.02}}{50 \times 0.02} \text{ mg/l}$$

Or

Carbonate= No. of ml of 0.02 N H_2SO_4 consumed x20 mg/l

Alkalinity due to bicarbonate was analysed by taking 50ml of water sample in a conical flask and added a few drops of methyl orange as indicator. Then the solution was titrated with 0.02N H_2SO_4 from a 1ml graduated pipette and added drop by drop with gentle stirring. The end point was indicated by a colour change from yellow to faint orange. The number of ml of 0.02N H_2SO_4 consumed was recorded and bicarbonate of sample water was calculated by using the formula-

$$\text{Bicarbonate} = \frac{\text{No. of ml of 0.02N } H_2SO_4 \text{ consumed x 1000x0.02 mg/l}}{50\text{x}0.02}$$

Or

Bicarbonate = No. of ml of 0.02N H_2SO_4 consumed x20 mg/l

Total Hardness

Total hardness was measured by using EDTA titrimetric method. 50 ml of water sample was taken in a conical flask and added 1ml of ammonia buffer and a few drops of Eriochrome black –T indicator. The colour of the sample was turned wine red, it was titrated with standard EDTA solution till the colour changes from wine red to blue. Recorded the ml of EDTA solution used and total hardness was calculated as-

$$\text{Total hardness} = \frac{\text{No. of ml of EDTA solution used x 1000}}{\text{ml of sample (50ml)}} \text{ mg } l^{-1}$$

$$\text{Total hardness} = \text{No. of ml of EDTA solution used x20 mg } l^{-1}$$

Chloride

Chloride was analysed by using silver nitrate which is also known as argentometric method. 50ml of water sample was taken in a conical flask and added five drops of potassium chromate as indicator. This gave yellow colour to the sample. Titrated this water sample with standard silver nitrate solution ($AgNO_3$) until a brick red end point appeared. The volume of $AgNO_3$ was recorded and calculated by using following formula-

$$\text{Chloride} = \frac{\text{ml of titrant used x N 35.40 x}10^3}{\text{ml of sample (50ml)}} \text{ mg } l^{-1}$$

Where, N= Normality of titrant

Or

$$\text{Chloride mg} = \frac{\text{ml of titrant used x 0.014x35.46 x } 10^3}{50} \text{ mg } l^{-1}$$

$$\text{Chloride} = \text{ml of titrant used x 10 mg } l^{-1}$$

Nitrate

Nitrate was analysed using water analysis TROLL-9500. The instrument was connected with computer for display of value. First the particular sensor which determines the level of nitrate was inserted in the troll. The details of the parameters were displayed on the monitor, then nitrate parameter was selected and the instrument was calibrated with two standard solutions of nitrate that is 14.0 ppm and 140.0 ppm. Now the instrument was ready to read the value of nitrate in water samples. The sensor was dipped in the water samples which are taken in a devised container and the reading was displayed on the monitor. The precaution was taken while attaching the different parts of the instruments as well as particular sensors.

3.4.2 Biological parameters

Plankton

The quantitative analysis of plankton was done by applying drop count method. This method involved the plankton enumeration in one drop of the concentrated sample taken on a slide using a standard calibrated dropper. The concentrated sample was shaken and one drop was quickly taken on a clean micro slide with the help of a standard dropper. The whole drop was covered with the cover glass of suitable size in order to avoid the sample from oozing out. The micro slide was observed under the microscope by focusing one edge of the cover glass. Counting of plankton was done by moving the slide with the help of a movable stage to the other edge. The slide was shifted to the next field. The process was repeated on the path parallel to that of earlier one, but in opposite direction. In this way the whole cover glass was observed and the planktonic estimations was worked out for three different drops depending on the density of plankton. Calculation of the total number of plankton per drop was done by taking the sum of total number of all plankton in each drop and calculating the average total number of plankton per drop. Then finally the total number of plankton per litter was calculated by using the formula-

$$\text{Plankton per litter} = \frac{A \times 1}{L} \times \frac{n}{V}$$

Where, A = Number of organisms per drop

V = Volume of one drop (ml)

n = Total volume of the concentrated sample (ml)

L = Volume of original sample (l)

Then qualitative analysis was done under the compound microscope by using 10x X 10x magnifications and sometime 10x X 40x magnification power was also used to clear the doubt. The identification of plankton was done by following Welch (1952), Adoni *et al.* (1985), APHA (1985), Wards and Whipple (1959).

3.4.3 Impact of Euglena bloom on fish growth.

The experiment was set up in replicate by using Euglena infested water and Euglena free water in troughs and carried out for a period of 3 months i.e. March, April and May 2010. The size of trough was 1m x1m x 0.4m in length, width and depth. The 10 numbers of common carp (*Cyprinus carpio communis*) weighed 240 gm were stocked into each experimental trough including control one. The different physico-chemical and biological parameters i.e. dissolved oxygen and pH were recorded weekly and total alkalinity, total dissolved solids, nitrate and plankton of control trough and Euglena infested trough were estimated fortnightly but the temperature was recorded daily.

Results and Discussion

4. RESULTS AND DISCUSSIONS

4.1 Physico-chemical parameters

The analysis of different physico-chemical parameters such as air temperature, water temperature, transparency, pH, dissolved oxygen (DO), free carbon dioxide, alkalinity, chloride, total hardness, total dissolved solids (TDS) and nitrate have been done in different type of ponds. All the physico-chemical parameters were monitored in Euglena free pond (table-4.1) and Euglena infested ponds (table-4.2) at fortnightly interval during the period of April 2009 to March 2010.

Air temperature

Air temperature varied from 12^0C - 29^0C and the maximum temperature was recorded in June (29^0C) but minimum in January (12^0C). The magnitude of variation was 17^0C. The air temperature has a direct effect on the water temperature as such indirectly all the aquatic fauna and flora were affected by variation in air temperature.

Water temperature

The water temperature of Euglena infested and Euglena free ponds ranged from 9.5^0C to 26^0C and 9^0C to 25.5^0C respectively. In Euglena free and Euglena infested pond maxima falls in June (25.5^0C, 26^0C) and minima in January and December (9^0C, 9.5^0C) respectively. The magnitude of variation was 16.5^0C. This depicted that the variation in the water temperature was almost equal to that of air temperature. The direct relationship between air and water temperature was also reported by Islam *et al.* (1974), Miah *et al.* (1981) and Begum *et al.* (1989).

Table 4.1 Physico-chemical parameters of Euglena free pond.

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air Temp. (^0C)	12.0	17.0	21.5	25.5	21.5	29.0	27.0	24.5	23.5	22.0	19.5	13.0
Water Temp. (^0C)	9.0	11.0	16.5	21.0	19.0	25.5	23.5	21.5	19.5	17.0	14.0	9.5
Transparency	32.00	16.00	24.00	25.25	26.50	28.00	21.75	27.75	26.50	28.50	23.25	33.75
pH	7.65	7.30	7.39	7.85	6.90	7.10	6.85	6.60	6.75	6.75	7.17	7.65
DO (mg/l)	7.25	6.75	10.00	15.00	8.00	7.80	7.50	7.80	8.25	7.10	9.25	8.70
Free CO_2 (mg/l)	15.00	11.25	16.00	13.50	13.00	18.50	15.00	7.75	14.25	13.25	13.00	14.75
HCO_3 (mg/l)	33.75	34.75	19.00	17.50	18.50	17.00	18.00	22.00	28.00	27.00	30.00	33.00
Chloride (mg/l)	12.75	7.00	9.00	8.50	7.00	7.50	7.00	7.00	5.40	6.75	10.45	11.50
Total Hardness	33.50	36.75	54.00	67.50	45.00	28.00	22.50	15.00	17.00	14.45	28.45	31.00
TDS (mg/l)	39.05	106.45	64.79	64.64	191.45	206.51	170.35	140.00	125.00	90.21	84.21	45.77
Nitrate (mg/l)	7.18	24.35	17.07	12.45	10.57	10.67	22.44	54.80	107.31	67.61	7.93	7.04

Table 4.2 Physico-chemical parameters of Euglena infested pond.

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air Temp. (^0C)	12.0	17.0	21.5	25.5	21.5	29.0	27.0	24.5	23.5	22.0	19.5	13.0
Water Temp. (^0C)	9.5	11.0	17.0	22.0	20.0	26.0	24.5	22.5	21.5	18.5	15.0	9.5
Transparency	28.25	15.75	21.50	30.50	22.25	31.50	32.50	32.25	28.00	27.75	31.50	28.50
pH	6.40	7.75	7.15	7.60	7.50	7.40	7.20	7.20	7.60	7.40	7.10	6.40
DO (mg/l)	5.90	5.75	9.25	12.00	5.30	6.25	5.85	6.60	6.00	5.10	6.90	6.70
Free CO_2 (mg/l)	16.50	17.75	17.50	15.75	19.00	20.50	18.50	9.50	16.50	15.25	14.90	16.50
HCO_3 (mg/l)	35.50	37.00	21.00	19.50	22.00	21.00	21.50	24.00	30.75	28.75	32.45	34.75
Chloride (mg/l)	14.00	15.00	10.25	10.00	8.00	8.25	8.15	8.75	6.70	7.81	11.55	13.50
Total Hardness	35.75	39.50	62.50	72.40	64.00	31.00	27.00	19.00	21.25	17.95	30.00	34.00
TDS (mg/l)	52.57	59.44	84.62	73.53	209.95	252.5	205.1	185	119.5	82.32	102.80	61.86
Nitrate (mg/l)	9.36	29.84	20.08	14.26	12.08	13.28	40.05	87.50	109.32	71.83	10.76	7.88

Transparency

The transparency of water was affected by the suspended particles, which may be clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. It plays an important role in pond productivity as clear water is an indicator of low productivity of the pond. In Euglena free pond transparency was varied from 16 cm. to 33.75 cm. The minimum value was reported in February (16 cm) and maximum in December (33.75). The magnitude of variation was 17.75 cm. In Euglena infested pond it ranged from 15.75 cm to 32.5 cm. The minima fall in February (15.75 cm) and maxima in July (32.5c.m.) which differs from that of Euglena free pond. Islam and Pramanik (2009) have reported that there is gradual increase of transparency during the month of spring when the air and water temperature is high. The magnitude of variation was 16.75 cm. The Minima recorded in the same month in both types of ponds but the maxima fall in different months. The transparency of water more than 20 cm. is considered suitable for fish pond and 40 to 60 cm will be best for the fish production (APHA 1985) as such the aforesaid ponds fall under the category of medium productivity. Further in Euglena infested pond it showed a direct relationship with water temperature. Datta *et al.* (1985) and Dhanze et al. (2002) observed high transparency during winter and lower during summer which coincides with the present observation of Euglena free pond.

pH

The pH serves as an indicator of the aquatic environmental condition such as free carbon dioxide, dissolved oxygen and other gases. The pH of Euglena free pond ranged from 6.60 to 7.85. The minima was reported in August (6.60) and maxima in April (7.80). The magnitude of variation was (1.20) which was very less and water remains slightly alkaline throughout the year. In case of Euglena infested pond the pH varied from 6.40 to 7.75 which are almost equal to that of Euglena free pond. The minima were recorded in January and December (6.40) and maximum value in February (7.70) and the magnitude of variation was 1.30. The pH of the both ponds remains almost alkaline which confirmed the view of Hossain et al. (2008). The minima and maxima were reported in different months in both types of pond. pH showed a direct or parallel relationship with dissolved oxygen which was also observed by Ali *et al.* (1982).

Dissolved oxygen (DO)

The availability of dissolved oxygen was one of the most critical factors for the survival of the aquatic organisms. Dissolved oxygen in Euglena free pond ranged from 6.75 to 15 mg/l. Peak value was reported during April (15 mg/l) and lowest in February (6.75 mg/l) and the magnitude of variation was 8.25 mg/l. whereas in case of Euglena infested pond the dissolved oxygen was ranged from 5.10 to 12 mg/l. The minima was recorded in October (5.1 mg/l) which is lower than the recommended value for cold water fishes and maxima was reported in April (12 mg/l). The magnitude of variation was 6.90 mg/l which was less than that of Euglena free pond. Further, the maximum value was noted in the month of April and showed a direct relation with water temperature in both types of pond but minima was observed in different months. Hossain *et al.* (2008) have also reported the maximum value of dissolved oxygen in the month of April which proves true in the present study. The quantity of dissolved oxygen is comparatively high in Euglena free pond than that of Euglena infested pond (table 4.3 and fig.4.3) as Euglena consumes oxygen in night time also and confirmed the view of Khan *et al.* (2004).

Free carbon dioxide

Free Carbon dioxide is a minor constituent of atmosphere and regulates different chemical parameters of water. It varied from 7.75 mg/l to 18.50 mg/l in Euglena free pond. The highest value was noted in June (18.50 mg/l) and lowest in August (7.75 mg/l) due to dilution of water. The magnitude of variation was 10.75 mg/l. whereas in Euglena infested pond free carbon dioxide ranged from 9.50 mg/l to 20.5 mg/l. The maximum (20.50 mg/l) and minimum (9.50 mg/l) values were reported in same months as that of Euglena free ponds and coincide with the view of Dhanze *et al.* (2002). The magnitude of variation was 11mg/l which is almost equal in both type of ponds but in Euglena infested pond (table 4.4 and fig. 4.4) the peak value is comparatively higher and considered to be detrimental to aquatic animals (Nath *et al.* 1994). It showed more or less inverse relation with pH which was also observed by Chawdhury *et al.* (1978). The high free carbon dioxide content during summer months were possibly due to the high temperature which was also observed by Islam and Pramanik (2009) and confirmed the present observation.

Table 4.3 Comparative Account of Dissolved Oxygen (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	7.25	6.75	10.00	15.00	8.00	7.80	7.50	7.80	8.25	7.10	9.25	8.70
Euglena infested	5.90	5.75	9.25	12.00	5.30	6.25	5.85	6.60	6.00	5.10	6.90	6.70

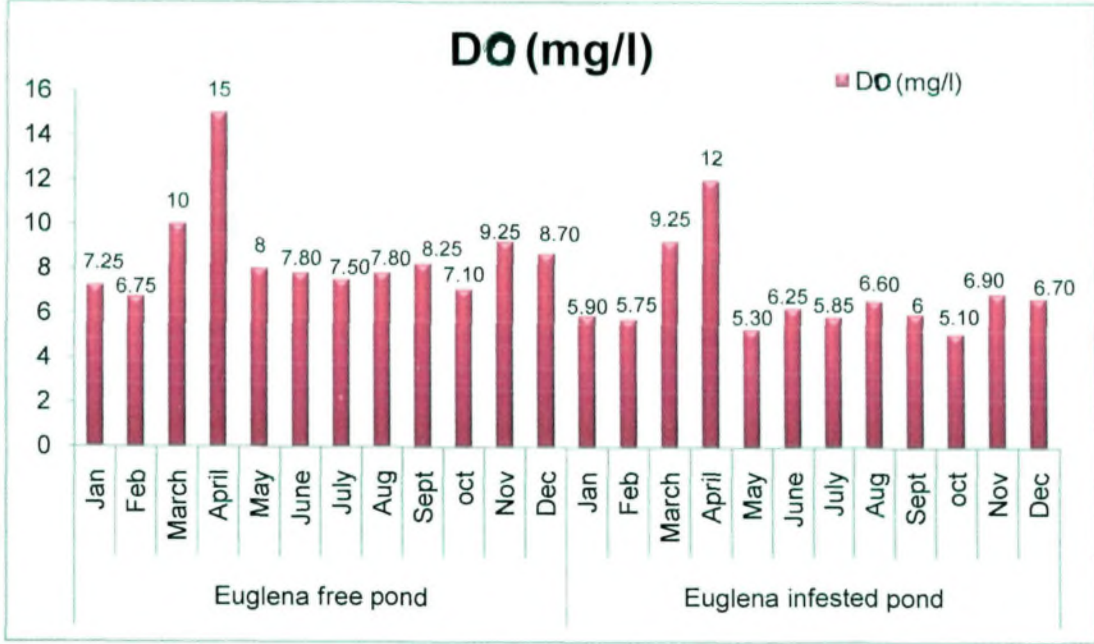

Fig. 4.3 Comparative Account of Dissolved Oxygen (mg/l) in Euglena free and Euglena infested pond.

Table 4.4 Comparative Account of Free carbon dioxide (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	15.00	11.25	16.00	13.50	13.00	18.50	15.00	7.75	14.25	13.25	13.00	14.75
Euglena infested	16.50	17.75	17.50	15.75	19.00	20.50	18.50	9.50	16.50	15.25	14.90	16.50

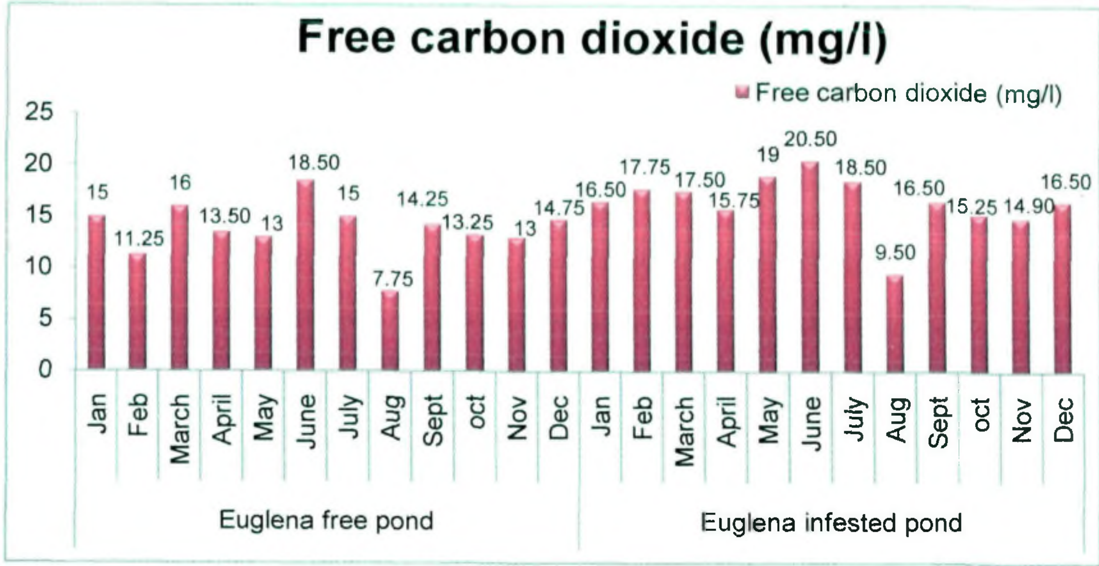

Fig. 4.4 Comparative Account of Free carbon dioxide (mg/l) in Euglena free and Euglena infested pond.

Alkalinity

Alkalinity of water is primary function of carbonate, bicarbonate and hydroxide content and considered as indicators of these constituents. As such it is the indicator of productivity of water body. Alkalinity of water due to bicarbonate in Euglena free pond ranged from 17 mg/l to 34.75 mg/l and the magnitude of variation was 17.75 mg/l. The peak value was reported during February (34.75 mg/l) and lowest in June (17 mg/l) which depicted an inverse relation with free carbon dioxide. In Euglena infested pond it varied from 19.50 mg/l to 35.5 mg/l and the magnitude of variation was 16 mg/l. The highest value was noted in January (35.50 mg/l) and lowest in April (19.50 mg/l). Hossain *et al.* (2008) have observed the maximum value of alkalinity in pond water during January which coincides with the view of present study. This depicted that alkalinity has an indirect relationship with temperature in both types of ponds. Islam and Pramanik (2009) have also reported similar observations while studying relationship between physico-Chemical and Meteorological Conditions of a fishpond at Rajshahi, Bangladesh. Moyle (1946) considered that alkalinity above 48 ppm has a good sign of productivity as such both types of pond depicted medium productivity. The level of alkalinity in both types of pond remains almost equal throughout the year (table 4.5 and fig.4.5).

Chloride

Chloride is one of the important anions which determined total salinity of water and its higher limits may cause osmoregulatory problems to aquatic organisms specially fishes. Chloride level in Euglena free pond fluctuated from 5.40 mg/l to 12.75 mg/l. The highest value was noted in January (12.75 mg/l) but lowest in September (5.40 mg/l) and the magnitude of variation was 7.35 mg/l. In case of Euglena infested pond it varied from 6.70 mg/l to 15 mg/l. The lowest value was observed in September (6.70 mg/l) but highest in February (15 mg/l) when the bicarbonate alkalinity was also high. The magnitude of variation was 8.20 mg/l which is higher than that of Euglena free pond. Further the higher limit of chloride was more but lower limit is less in Euglena infested pond as compare to control one (table 4.6 and fig.4.6). In both types of ponds the chloride content showed an indirect relation with water temperature and direct relation with free

Table 4.5 Comparative Account of Alkalinity (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	33.75	34.75	19.00	17.50	18.50	17.00	18.00	22.00	28.00	27.00	30.00	33.00
Euglena infested	35.50	37.00	21.00	19.50	22.00	21.00	21.50	24.00	30.75	28.75	32.45	34.75

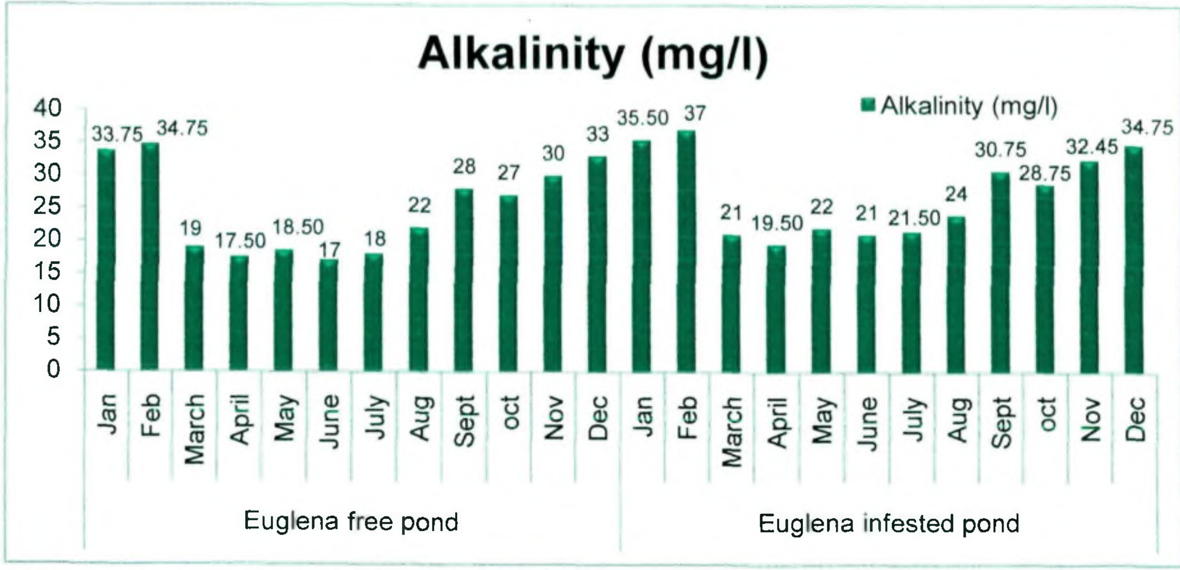

Fig. 4.5 Comparative Account of Alkalinity (mg/l) in Euglena free and Euglena infested pond.

Table 4.6 Comparative Account of Chloride (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	12.75	7.00	9.00	8.50	7.00	7.50	7.00	7.00	5.40	6.75	10.45	11.50
Euglena infested	14.00	15.00	10.25	10.00	8.00	8.25	8.15	8.75	6.70	7.81	11.55	13.50

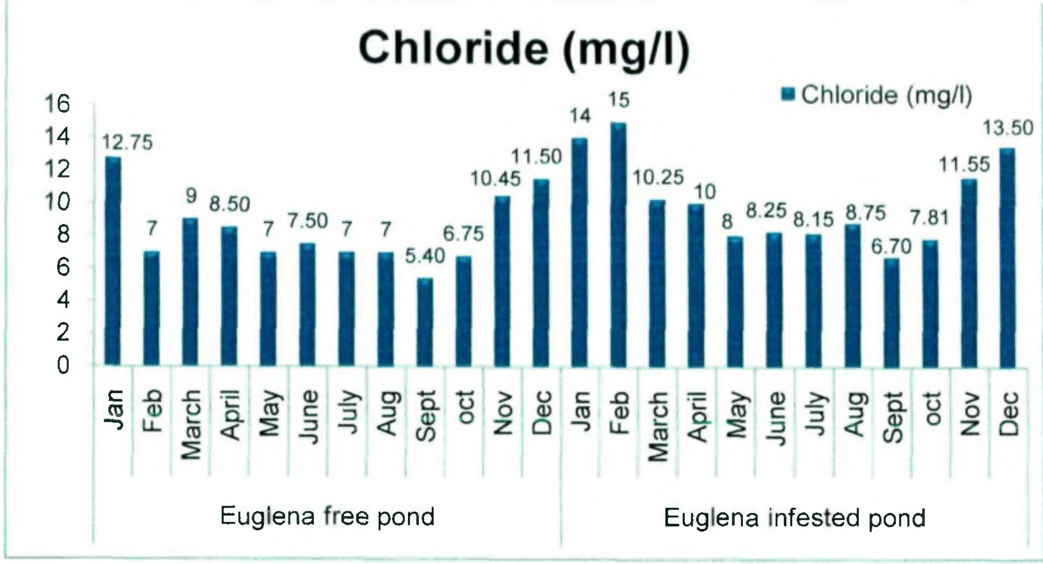

Fig. 4.6 Comparative Account of Chloride (mg/l) in Euglena free and Euglena infested pond.

carbon dioxide. The chloride concentration is low and coincides with the range given by Singh *et al.* (1999) and he was of opinion that the chloride concentration in water indicates the presence of organic waste primarily of animal origin. Thus low concentration of chloride in both types of ponds reflects less amount of organic waste of animal origin.

Total Hardness

Hardness is the property of water which prevents leather formation with soap. Principle cations indicating hardness are calcium and magnesium. The hardness of water varies considerably from place to place and reflects geological formation. In Euglena free pond the total hardness ranged from 14.45 mg/l to 67.5 mg/l. The peak value was recorded in April (67.50 mg/l) but minima in October (14.45 mg/l) as such the magnitude of variation was 52.50 mg/l which is correlated with the observations of Dhanze *et al.* (2002). In Euglena infested pond it varied from 17.95 mg/l to 72.40 mg/l and the magnitude of variation was 54.55 mg/l, which is higher than that of Euglena free ponds (table 4.7 fig4.7). Further, the maxima and minima were reported in the months similar to that of Euglena free pond but the upper limit is quite high. It exhibited an indirect relation with water temperature but direct relation with dissolved oxygen. Jhingran (1988) have reported that hardness ranged between 40 to 200 ppm is most suitable for higher growth of fishes thus it showed that these ponds have medium productivity.

Total dissolved solids (TDS)

Total dissolved solids are the measure of all kind of solids (suspended, dissolve, volatile etc. in water). The total dissolved solid content of freshwater ranges from 20 mg/l to 100 mg/l. Total dissolved solids are composed of mainly carbonate, bicarbonate, Chloride and nitrates of Calcium, Magnesium, Sodium, Potassium, Iron and Manganese, as a rule hardness of water increases with level of total dissolved solids. Total dissolved solids of Euglena free pond were varied from 39.05 mg/l to 206.50 mg/l. The minima fall in January (39.05 mg/l) and maxima in June (206.51 mg/l) and the magnitude of variation was

Table 4.7 Comparative Account of Total Hardness (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	33.50	36.75	54.00	67.50	45.00	28.00	22.50	15.00	17.00	14.45	28.45	31.00
Euglena infested	35.75	39.50	62.50	72.40	64.00	31.00	27.00	19.00	21.25	17.95	30.00	34.00

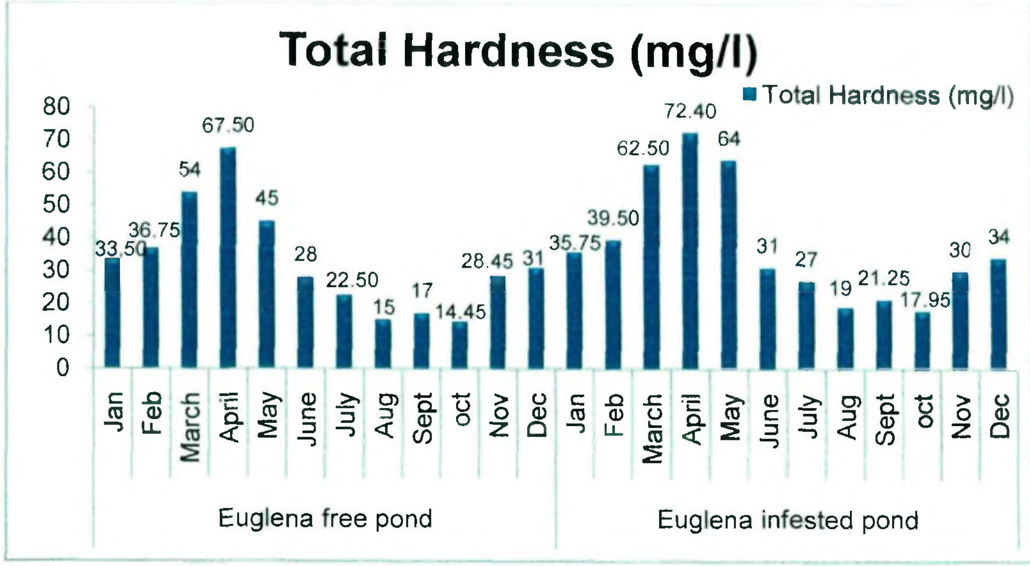

Fig. 4.7 Comparative Account of Total Hardness (mg/l) in Euglena free and Euglena infested pond.

Table 4.8. Comparative Account of Total Dissolved Solids (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	39.05	106.45	64.79	64.64	191.45	206.51	170.35	140.00	125.00	90.21	84.21	45.77
Euglena infested	52.57	59.44	84.62	73.53	209.95	252.50	205.10	185.00	119.50	82.32	102.80	61.86

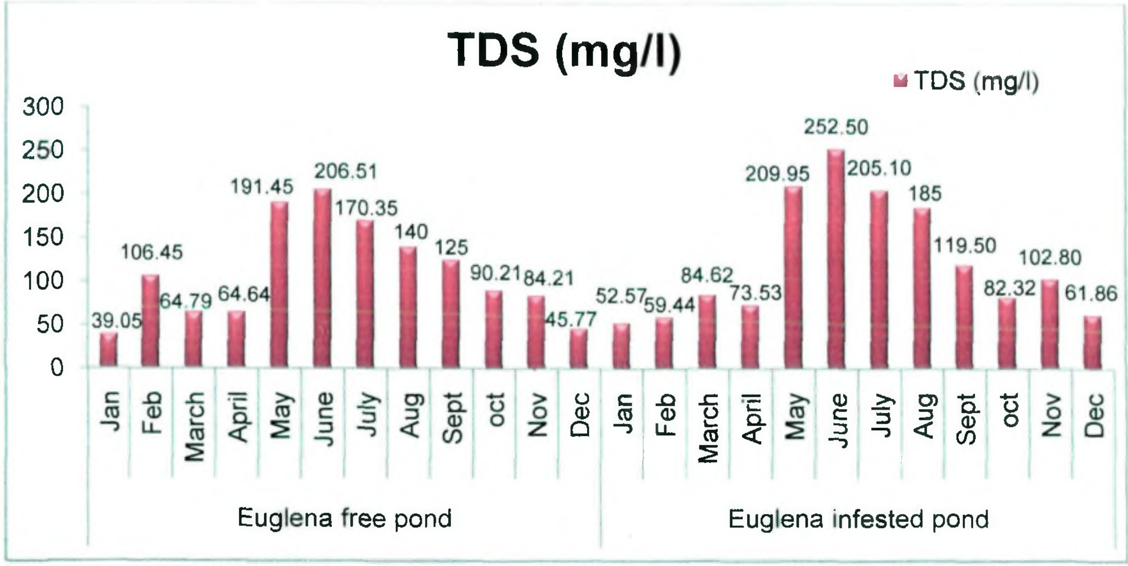

Fig.4.8. Comparative Account of Total Dissolved Solids (mg/l) in Euglena free and Euglena infested pond.

167.46 mg/l. However in Euglena infested pond total dissolved solid ranged from 52.57 mg/l to 252.5 mg/l. The highest value was reported in June (252.50 mg/l) and lowest in January (52.57 mg/l) similar to that of Euglena free ponds and the magnitude of variation was 199.93 mg/l which was quite higher than that of Euglena free pond (table 4.8 and fig.4.8). However, in both types of pond total dissolved solids showed a direct relationship with water temperature and free carbon dioxide but indirect relation with chloride and bicarbonate. The present observation is confirmed with the findings of Chowdhury and Mamun (2006).

Nitrate

Nitrate is the most oxidized form of nitrogen and an important plant nutrient. Due to its higher mobility as compared to other vital nutrients, its concentration in freshwaters apart from autochthonous production is largely regulated by wastewater loading, agricultural runoff and ground water inputs. Nitrate content in Euglena free pond was varied from 7.04 mg/l to 107.31 mg/l. The peak value was observed in September (107.31 mg/l) but lowest in December (7.04 mg/l) and the magnitude of variation was 100.27 mg/l. whereas in Euglena infested pond it varied from 7.80 to 109.32 mg/l. The highest value was recorded in September (109.32 mg/l) and lowest in December (7.88 mg/l), similar to that of Euglena free pond (table 4.9 fig.4.9). The magnitude of variation was 101.52 mg/l which is almost similar in both types of ponds but the quantity of nitrate remains high in Euglena infested pond in all the months as compare to Euglena free pond. The value of nitrate depicted a direct relation with water temperature but indirect relation with dissolved oxygen, free carbon dioxide, chloride and alkalinity. Dhanze *et al.* (2002) have also reported its highest concentration in August and September due to influx of allochthonous material and lowest value in November-December due to high production of Chlorophyceae. Thirugnanamoorthy and Selvaraju (2009) have explained that high concentration of nitrates were responsible for the luxuriant growth of *Euglena*.

Table 4. 9. Comparative Account of Nitrate (mg/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	7.18	24.35	17.07	12.45	10.57	10.67	22.44	54.80	107.31	67.61	7.93	7.04
Euglena infested	9.36	29.84	20.08	14.26	12.08	13.28	40.05	87.50	109.31	71.83	10.76	7.88

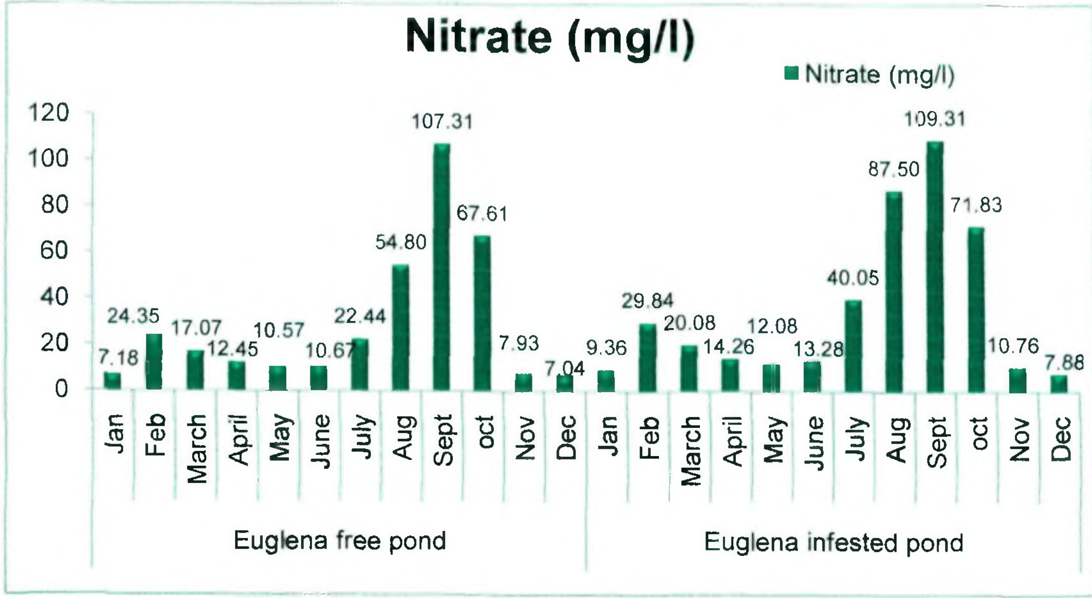

Fig. 4.9 Comparative Account of Nitrate (mg/l) in Euglena free and Euglena infested pond.

4. 2. Evaluation of plankton diversity in Euglena free and Euglena infested pond.

Plankton

The plankton collected from Euglena free pond (table 4.10) and Euglena infested pond (table 4.11) comprises of both phyto and zooplanktons. The population of phytoplankton was comparatively higher and mainly dominated by chlorophyceae in Euglena free pond and by Euglenophyceae in Euglena infested pond (table 4.12). The zooplanktons were reported in few months and represented by class rotifera and copepoda.

4. 2 .1. Phytoplankton

The biological samples of Euglena free and Euglena infested ponds have been analyzed and qualitative analysis of these samples depicted that a total of 21 genera belonging to class bacillariophyceae, euglenophyceae, chlorophyceae and cynophyceae have been identified. Bacillariophyceae includes nine genera which are *Amphora, Coconeis, Cymbella, Diatoma, Fragilaria, Gomphonema, Navicula, Synedra* and *Tabellaria.* Euglenophyceae is represented by one genus only i.e. *Euglena.* The most encountered seven genera identified under chlorophyceae are *Ankistrodesmus*, *Closterium, Pediastrum, Scenedesmus, Mesotaenium, Spirogyra* and *Volvox.* There are four genera which reflect cynophyceae are *Agmenellum, Anabaena, Gompospheria*, and *Synechocystis.* In Euglena free pond the total plankton u/l depicted that the plankton population remain less as compare to Euglena infested pond and a peak was observed in month of April but in month of October in Euglena infested pond (table 4.13 and Fig.4.13).

Table 4.10 Plankton Diversity in Euglena free pond.

Plankton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bacillariopyhceae												
Amphora	1.16		2.50	1.00								5.16
Coconeis					1.16	1.00		4.83	8.25	2.16		5.00
Diatoma						1.00	1.00					
Fragilaria	2.66	3.33			2.50	2.33						4.00
Gomphonema			2.66	1.00							1.00	5.00
Navicula	2.33	3.66	2.00	1.25	2.50	5.66	1.50	1.00	2.00	3.33	12.00	4.83
Synedra	11.00	25.33			4.16	2.00	10.66		1.00		2.83	15.00
Tabellaria	1.00			1.00							6.66	
Total	**18.15**	**32.32**	**7.16**	**4.25**	**10.32**	**11.99**	**13.16**	**5.83**	**11.25**	**5.49**	**22.49**	**38.99**
Euglenophyceae												
Euglena		5.60					8.66	149.33	2.50			9.66
Total		**5.60**					**8.66**	**8.66**	**2.50**			**9.66**
Chlorophyceae												
Closterium			1.00	1.00	1.66	2.16	16.66	5.00	3.16	1.00	2.66	10.33
Mesotaenium					2.00							
Pediastrum		2.33		2.25								
Scenedesmus	12.83	16.66	76.00	56.00	3.66	5.23	4.50	3.00	1.00	2.66	11.33	4.83
Spirogyra	17.16	19.50	15.33	427.25	12.83	9.50	1.00	1.99	45.99	12.66	17.50	31.66
Volvox	4.00	1.80		2.00			2.50	1.16			2.66	
Total	**33.99**	**40.29**	**92.33**	**486.50**	**20.15**	**16.89**	**24.66**	**11.15**	**50.15**	**16.32**	**34.15**	**46.82**
Cynophyceae												
Agmenelum			12	1.00								
Anabaena	6.00	2.16	2.33		2.00				4.83			2.66
Gomphospheria	7.16	4.75	13.33	3.00		20.00		40.00				
Synechocystis		10.00										
Total	**13.165**	**16.91**	**27.66**	**4.00**	**2.00**	**20.00**		**40.00**	**4.83**			**2.66**
Brachionus							2.00	1.00				
Keratella				2.00								
Total				**2.00**			**2.00**	**1.00**				
Cyclops				1.83		2.00	2.00					
Total						**2.00**	**2.00**					
				1.83								

Table 4.11 Plankton Diversity in Euglena infested pond.

Plankton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bacillariopyhceae												
Amphora											2.83	
Coconeis									3.00	2.00		
Cymbella	1.00					2.00	2.00		1.00		1.00	
Diatoma								1.00				
Fragilaria	2.33				2.00	1.00						
Gomphonema	2.00											
Navicula	2.33	3.00	12.00	1.50	1.66	1.50	8.32		2.00	1.66	1.00	5.00
Synedra		100.50	22.33	3.00	12.66	71.16	32.13	1.00			10.33	23.33
Total	**7.66**	**103.50**	**34.33**	**4.50**	**16.32**	**75.66**	**42.45**	**2.00**	**6.00**	**3.66**	**15.66**	**28.33**
Euglenophyceae												
Euglena	5.83	148.66	233.33	62	618.33	87.66	269.17	438	633.96	2242.60	155.30	134.83
Total	**5.83**	**148.66**	**233.33**	**62**	**618.33**	**87.66**	**269.17**	**438**	**633.96**	**2242.60**	**155.30**	**134.83**
Chlorophyceae												
Ankistodesmus		26.83	6.83	1.00								
Closterium		4.16		1.00	11.60	3.50	2.16					
Pediastrum				1.50						1.00		
Scenedesmus	13.00	33.00	38.83	11.00	24.00	61.50	15.80	3.00	4.00	2.80		12.00
Spirogyra	6.16	45.00	11.16	48.00	8.33	31.99	29.60	20.83	95.83	55.30	23.66	26.00
Volvox						6.00	3.50	2.00	12.50	4.00		
Total	**19.16**	**108.99**	**56.82**	**62.50**	**43.93**	**102.99**	**51.06**	**25.83**	**112.33**	**63.10**	**23.66**	**38.00**
Cynophyceae												
Agmenelum				2.66								
Anabaena	2.33	2.50	4.00		1.33				2.33	2.33		8.00
Gomphospheria	3.33		13.50	3.66	2.83			82.16		1.66		
Synechocystis		17.50	7.33	6.66								
Total	**5.66**	**20.00**	**24.83**	**12.98**	**4.16**			**82.16**		**3.99**		**8.00**
Rotifera												
Brachionus				1.00		3.66	3.15			2.00	2.00	
Keratella				1.00	2.00	3.66		2.00	1.66			
Total				**2.00**	**2.00**	**7.32**	**3.15**	**2.00**	**1.66**	**2.00**	**2.00**	
Copepoda												
Cyclops			2.00	2.66	1.00	2.00	1.00	1.00	1.00	1.00	2.66	2.00
Total			**2.00**	**2.66**	**1.00**	**2.00**	**1.00**	**1.00**	**1.00**	**1.00**	**2.66**	**2.00**

Table 4.12 Comparison of Plankton Diversity and Abundance in Euglena free and Euglena infested ponds.

	Euglena free pond	Euglena infested pond
Bacillariopyhceae		
Amphora	+++	++
Coconeis	+++	++
Cymbella	-	+++
Diatoma	+	+
Fragilaria	+++	++
Gomphonema	+++	++
Navicula	+++	++
Synedra	++	+++
Tabellaria	+++	-
Euglenophyta		
Euglena	+	+++
Chlorophyceae		
Ankistrodesmus	-	+++
Closterium	+++	++
Mesotaenium	++	-
Pediastrum	+++	+
Scenedesmus	++	+++
Spirogyra	++	+++
Volvox	++	+++
Cynophyceae		
Agmenellum	+++	++
Anabaena	++	+++
Gomphospheria	++	+++
Synechocystis	++	+++
Rotifera		
Brachionus	++	+++
Keratella	-	+++
Copepoda		
Cyclops	++	+++

- absent   + present

++ common   +++ abundance

Table 4.13 Comparative Account of Total Plankton (u/l) in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	39.18	57.07	76.89	298.05	12.98	21.15	29.68	39.38	41.23	13.08	33.98	58.87
Euglena infested	22.98	28.69	210.79	87.98	273.89	110.25	220.09	330.59	452.97	1389.84	119.56	126.69

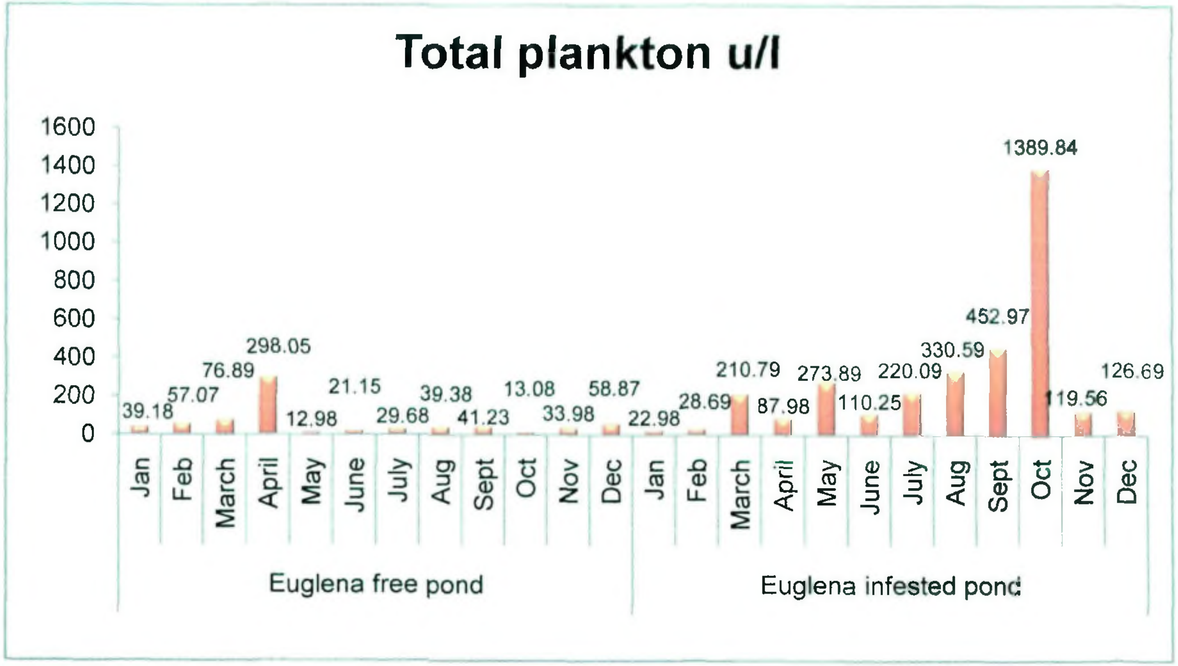

Fig.4.13 Comparative Account of Total Plankton (u/l) in Euglena free and Euglena infested pond.

4.2.1.1. Bacillariophyceae

The population of Bacillariophyceae in Euglena free pond was varied from 0.85% to 39.73% of total plankton and the magnitude of variation was 38.88%. The maximum population was reported during December (39.73%) when the temperature was low but the transparency, dissolved oxygen and chloride were high. The similar observations were reported by Khanna *et al.* (2000) and Dhanze *et al.* (2002). The lowest value was recorded in April (0.85%) which exhibited an indirect relation with total hardness and free carbon dioxide. It comprises of eight genera *viz., Amphora, Coconeis, Diatoma, Fragilaria, Gomphonema, Navicula, Synedra* and *Tabellaria.* In Euglena infested pond it ranged from 0.16% to 27.45% which is comparatively less than that of Euglena free pond and the magnitude of variation was also less i.e. 27.29%. The highest value was observed in June (27.45%) and depicted a direct relationship with free carbon dioxide, temperature, transparency, and total dissolved solids. Thus it can be concluded that free carbon dioxide and total dissolved solids play an important role to enhance the productivity of Bacillariophyceae. Thirugnanamoorthy and Selvaraju (2009) have also reported that presence of high dissolved oxygen and total dissolved solids enhance the growth of bacillariophyceae. The lowest value was recorded in October (0.16%) when the level of total hardness was very low. It comprises of eight genera *viz., Amphora, Coconeis, Cymbella, Diatoma, Fragilaria, Gomphonema, Navicula* and *Synedra.* The percentage of bacillariophyceae in Euglena free pond was high as compared with that of Euglena infested pond (table 4.14 and fig. 4.14). Further, it was observed that genus *Cymbella* was absent in Euglena free pond and present in Euglena infested pond whereas genus *Tabellaria* was absent in Euglena infested pond but present in Euglena free pond (table 4.12). Table 4.12 depicted that both type of ponds differ in planktonic diversity as a result six genera viz. *Amphora, Coconeis, Fragilaria, Gomphonema, Navicula* and *Tabellaria* were in abundance in Euglena free ponds but the abundance of only two genera i.e. *Cymbella* and *Synedra* was recorded in Euglena infested ponds.

Table 4.14 Comparative Account of Percentage of Bacillariophyceae in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	27.79	33.98	5.58	0.85	31.78	22.67	26.59	8.88	16.37	25.17	39.70	39.73
Euglena infested	19.99	27.15	9.77	3.07	2.38	27.45	11.57	0.36	0.79	0.16	7.86	13.42

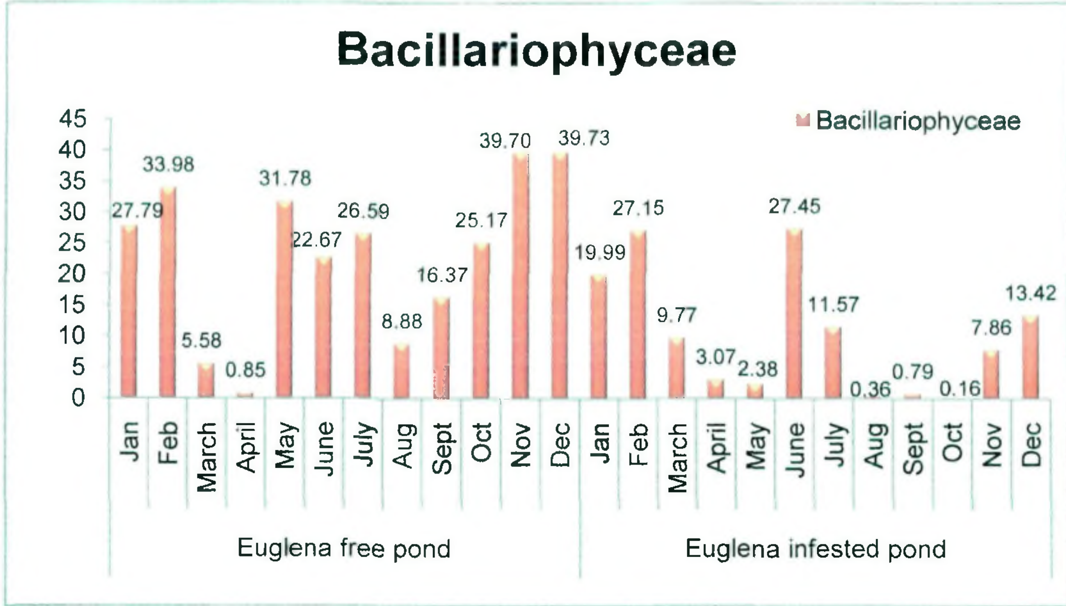

Fig.4.14 Comparative Account of Percentage of Bacillariophyceae in Euglena free and Euglena infested pond.

4.2.1.2. Euglenophyceae

The populations of the Euglenophyceae in Euglena free pond ranging from 3.64% to 17.51% of total plankton and the magnitude of variation was 13.87%. It was noticed only five months during study period. Its presence was mainly recorded during rainy season. The minima fall in September (3.64%) and depicted a direct relation with the temperature and nitrate. The maxima were observed in July (17.51%) when the dissolved oxygen and total hardness were low but temperature, free carbon dioxide, transparency and the concentration of nitrate were very high which is correlated with the observation of Munawar (1970). It comprises of one genus i.e. *Euglena.* In Euglena infested pond it varied from 15.22% to 96.82% of total plankton and the magnitude of variation was 81.6% which is quite high than that of Euglena free pond. Its presence was observed throughout the year during period of study. The minimum value was reported in January (15.22%) and exhibited a direct relation with temperature and the level of nitrate similar to that of Euglena free pond. The maxima were observed in October (96.82%) when the free carbon dioxide, nitrate and total dissolved solid were high but dissolved oxygen, transparency and total hardness were comparatively low. Further another peak was noticed in May which is favoured by high total dissolved solid and total hardness but less transparency. Thirugnanamoorthy and Selvaraju (2009) have reported that high temperature, free carbon dioxide, alkalinity and nitrate were responsible for the luxuriant growth of *Euglena*. Euglenophyceae showed high density in Euglena infested pond as compared to that of Euglena free pond which is more insidious for eutrophication (table 4.15 and fig.4.15).

Table 4.15 Comparative Account of Percentage of Euglenophyceae in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free		5.88					17.51	13.19	3.64			9.84
Euglena infested	15.22	39.01	66.42	42.28	90.17	31.81	73.37	79.49	83.97	96.82	77.93	63.85

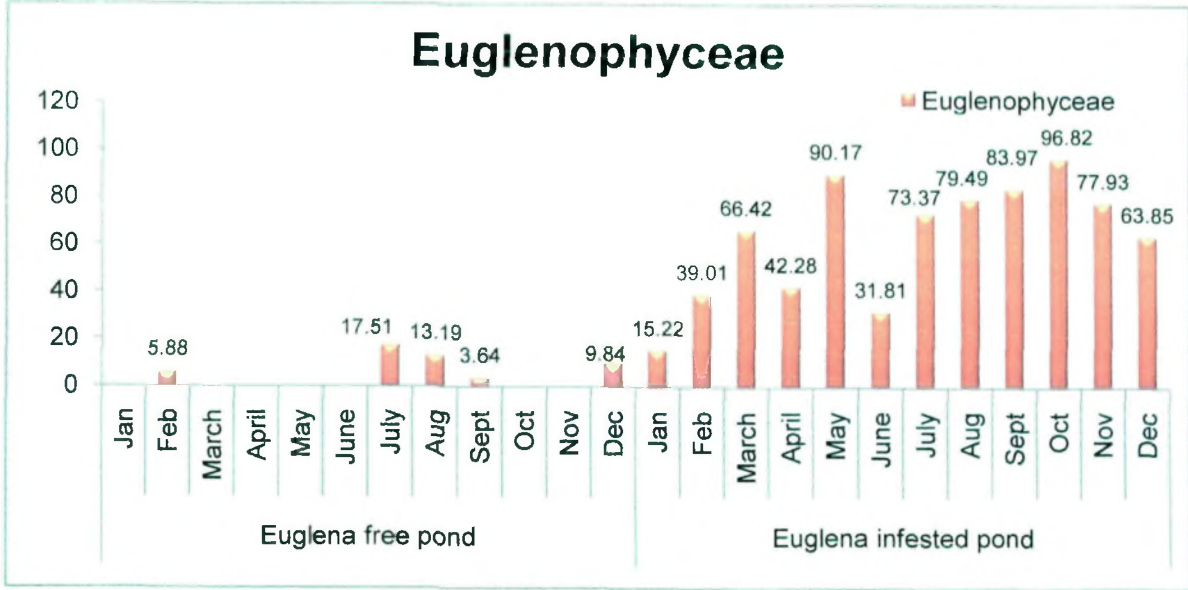

Fig.4.15 Comparative Account of Percentage of Euglenophyceae in Euglena free and Euglena infested pond.

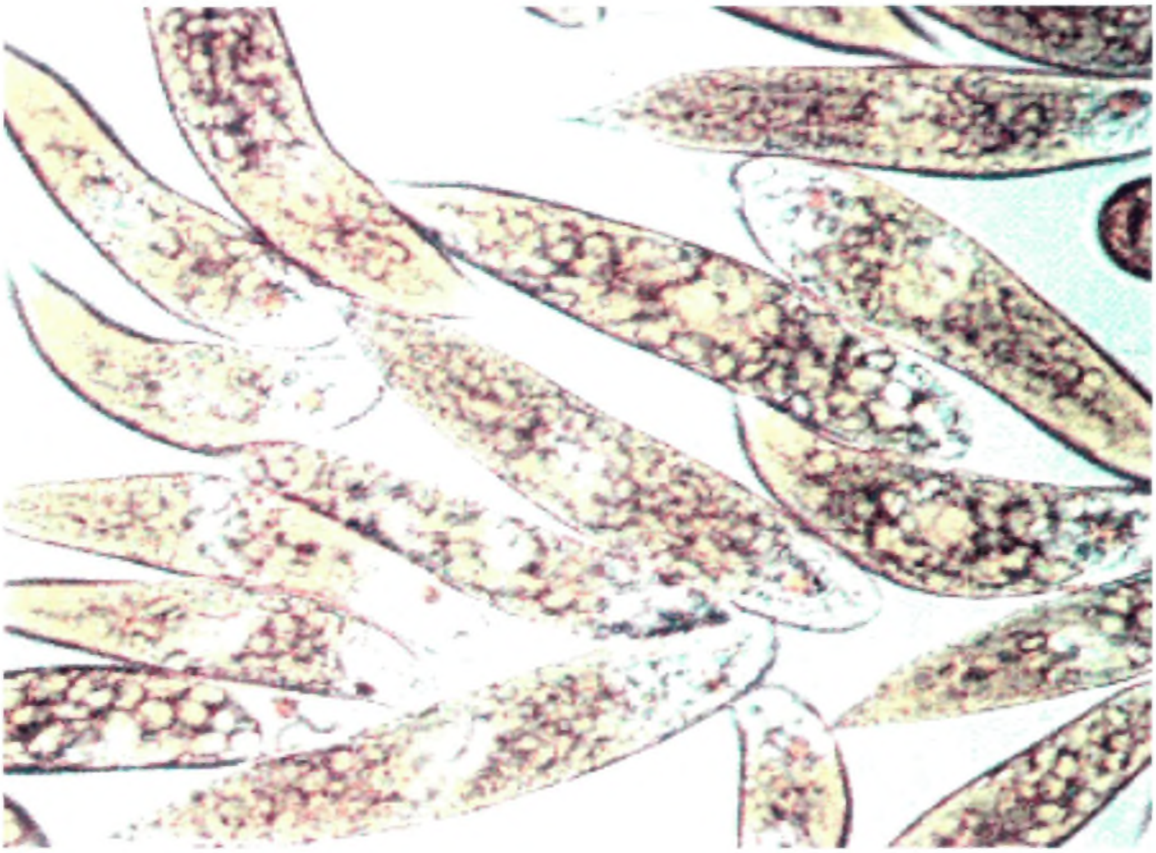

Plate 4.1 Microscopic Structure of Euglena

4.2.1.3. Chlorophyceae

The total number of Chlorophyceae in Euglena free pond fluctuated from 31.94% to 97.98% of total plankton and the magnitude of variation was 66.04%. The lowest value was reported during June (31.94%) when the temperature and free carbon dioxide were high. The highest value was recorded in April (97.98%) when dissolved oxygen and total hardness were high and coincide with the view of Hosmani (1988). It comprises of six genera i.e. *Mesotaenium*, *Closterium, Pediastrum, Scenedesmus, Spirogyra* and *Volvox*. In Euglena infested pond it ranged from 2.72% to 50.02% of total plankton and the magnitude of variation was 47.30%. The minima were observed in October (2.72%) and showed a direct relation with dissolved oxygen and total hardness. The maxima were noticed in January (50.02%) when dissolved oxygen was low but concentration of total hardness was high. Kulshrestha and Joshi (1991) have also reported high density of chlorophyceae during winter. These observations were also in agreement with our findings. It comprises of six genera *viz*., *Ankistrodesmus*, *Closterium, Pediastrum, Scenedesmus, Spirogyra* and *Volvox*. The percentage of chlorophyceae was comparatively high in Euglena free pond as compared to that of Euglena infested pond as a result it may be concluded that in Euglena infested pond chlorophyceae was partially replaced by the euglenophyceae (table 4.16 and fig.4.16). Further, the presence of genus *Ankistrodesmus* was noticed in Euglena infested pond similarly genus *Mesotaenium* was observed only in Euglena free pond. In Euglena free pond only two genera *viz. Closterium* and *Pediastrum* were in abundance where as in Euglena infested ponds abundance of four genera was noticed i.e. *Ankistrodesmus*, *Scenedesmus, Spirogyra* and *Volvox* (table 4.12).

Table 4.16 Comparative Account of Percentage of Chlorophyceae in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	52.05	42.36	72.05	97.98	62.06	31.94	49.84	16.98	72.96	74.83	60.29	47.72
Euglena infested	50.02	28.59	16.17	42.62	6.34	37.36	13.92	4.68	14.88	2.72	11.87	17.99

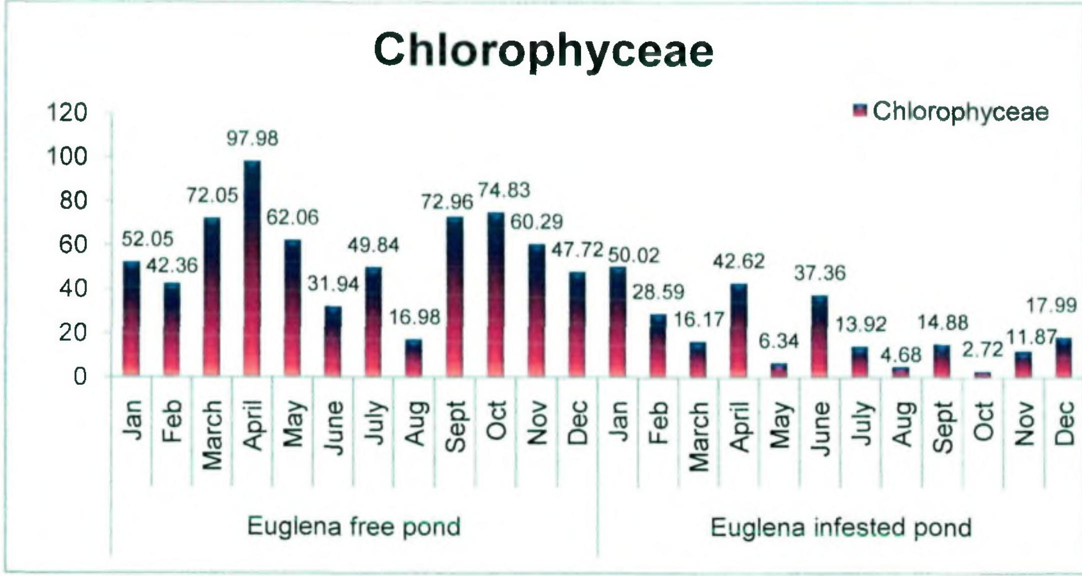

Fig.4.16 Comparative Account of Percentage of Chlorophyceae in Euglena free and Euglena infested pond.

4.2.1.4. Cynophyceae

The population of Cynophyceae in Euglena free pond was ranged from 0.81% to 60.94% of total plankton and the magnitude of variation was 60.13%. The minima were noticed in April (0.81%) and exhibited an indirect relationship with dissolved oxygen and total hardness. The peak value was observed in August (60.94%) when free carbon dioxide was low and level of nitrate was high. Thirugnanamoorthy and Selvaraju (2009) have reported that high level of phosphate and nitrate might have favoured the growth of the cynophyceae which supported the present findings. In Euglena infested pond it varied from 0.17% to 14.91% of total plankton and the magnitude of variation was 14.74% which is quite less than that of Euglena free pond. The minimum value was reported in October (0.17%) and depicted a direct relation with the dissolved oxygen and total hardness just opposite to that of Euglena free pond. The maxima fall in August (14.91%) when free carbon dioxide was low but level of nitrate was high and this observation is similar to that of Euglena free pond. Further another peak was noticed in month of January (14.77%) due to high alkalinity. Philipose *et al.* (1959) have emphasized that natural factors like alkalinity, nitrates and phosphates are responsible for the luxuriant growth of Cynophyceae which supported the present findings. It represented by four genera *viz., Agmenellum, Anabaena, Gompospheria* and *Synechocystis.* The percentage of cynophyceae was high in Euglena free pond when compared with that of the Euglena infested pond (table 4.17 and fig.4.17). Though abundance of only one genus i.e. *Agmenellum* was recorded in Euglena free pond where as rest three genera showed their abundance in Euglena infested pond (table 4.12).

4.2.1.5. Zooplankton

Zooplankton was represented by two taxa i.e. rotifera and copepoda but their population was less as compared to the phytoplankton. The two genera i.e. *Brachionus* and *Keratella* belong to rotifera and one genus *Cyclops* belongs to copepoda have been observed during this study. Presence of zooplankton was comparatively more in Euglena infested pond and noticed throughout the year except January and February.

Table 4.17 Comparative Account of Percentage of Cynophyceae in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free	20.15	17.77	21.58	0.81	6.16	37.82		60.94	7.03			2.72
Euglena infested	14.77	5.25	7.07	8.87	0.61			14.91		0.17		3.78

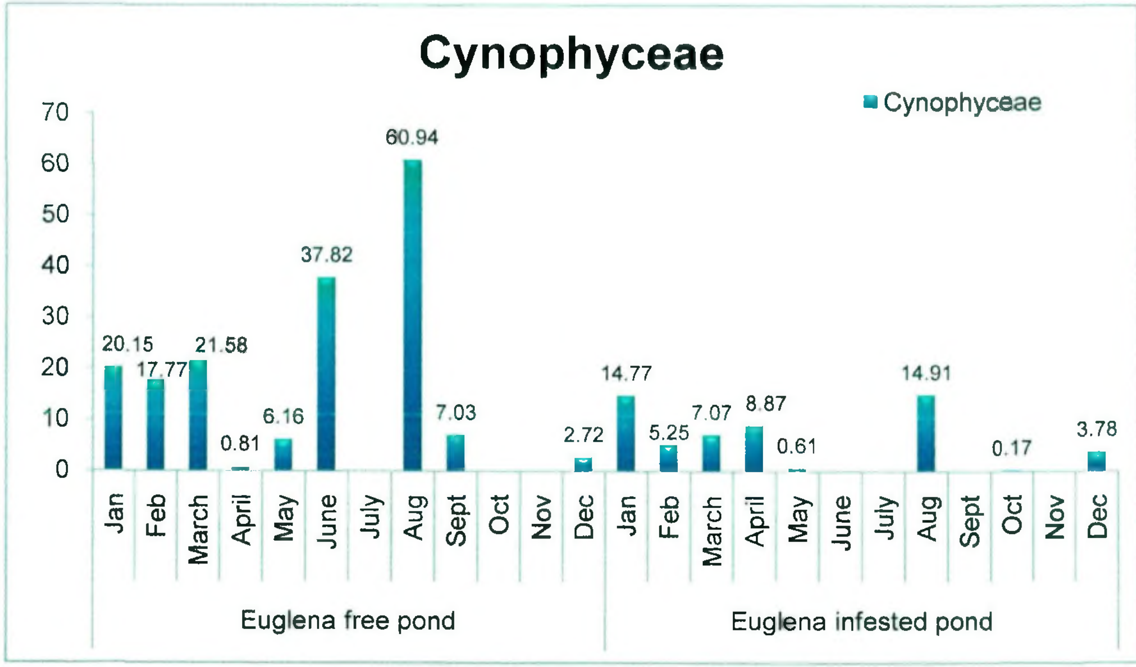

Fig.4.17 Comparative Account of Percentage of Cynophyceae in Euglena free and Euglena infested pond.

4.2.1.6. Rotifera

The number of Rotifers in Euglena free pond was ranged from 0.41% to 3.78% of total plankton and the magnitude of variation was 3.37%. Its presence was noticed only in three month i.e. April, June and July and represented by only one genus i.e. *Brachionus*. The lowest value was recorded in April (0.41%) and exhibited an indirect relation with the level of dissolved oxygen and total hardness. The highest value was observed in June (3.78%) when the temperature, free carbon dioxide and total dissolved solids were high and coincide with the view of Dhanze *et al.* (2002). In Euglena infested pond it varied from 0.08% to 2.65% of total plankton and the magnitude of variation was 2.57%. The minimum value noticed in October (0.08%) and depicted a direct relation with dissolved oxygen and total hardness just opposite to that of Euglena free pond. The maximum value was reported in June (2.65%) when temperature, free carbon dioxide and total dissolved solids were high and have a similarity to that of Euglena free pond. Similar observations have been reported by Kiran *et al.* (2007). It is represented by two genera i.e. *Brachionus* and *Keratella* which were noticed through out the year except during winter months. Rotifers exhibited high percentage in Euglena free pond as compared with that of Euglena infested pond (table 4.18 and fig.4.18) and the abundance of *Brachionus* and *Keratella* was reported from Euglena infested ponds. The genus *Keratella* was observed in Euglena infested pond but absent in Euglena free pond (table 4.12).

4.2.1.7. Copepoda

The population of copepoda in Euglena free pond was varied from 0.37% to 4.04% of total plankton and the magnitude of variation was 3.67%. It was observed only three months of the study period when rotifers were also present. The minima were noticed in April (0.37%) similar to that of rotifers and showed an indirect relation with dissolved oxygen and total hardness. The peak value was observed in July (4.04%) when dissolved oxygen was low but total hardness was high. Kiran *et al.* (2007) have also observed that copepods densities were high in rainy season. Though in Euglena infested pond it was ranged from 0.04%

Table 4.18 Comparative Account of Percentage of Rotifera in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free				0.41		3.78	2.02					
Euglena infested				1.36	0.29	2.65	0.86	0.36	0.22	0.08	1.00	

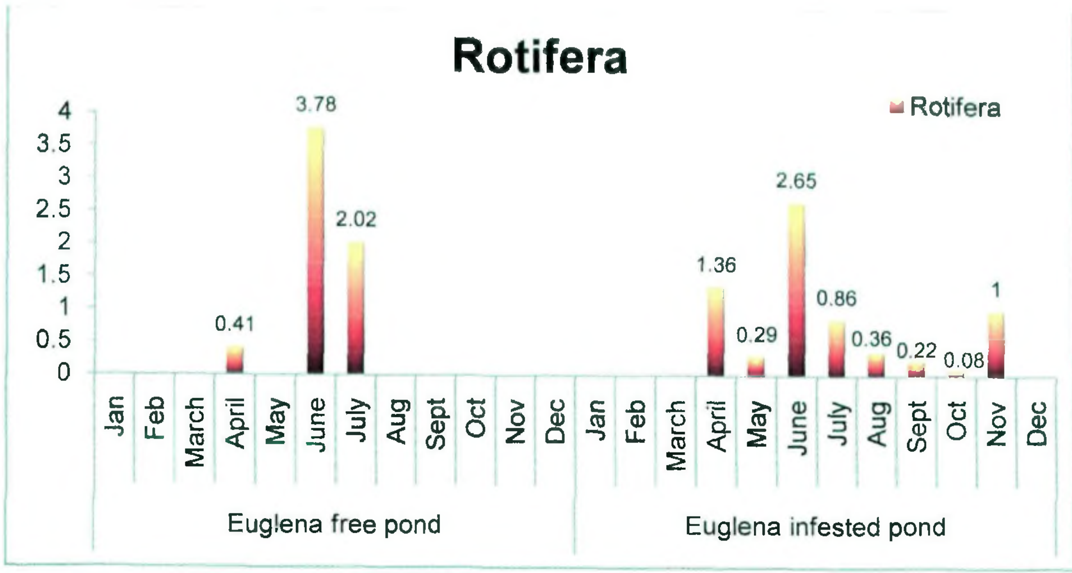

Fig.4.18 Comparative Account of Percentage of Rotifera in Euglena free and Euglena infested pond.

Table 4.19 Comparative Account of Percentage of Copepoda in Euglena free and Euglena infested pond.

Pond	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Euglena free				0.37		3.78	4.04					
Euglena infested			0.57	1.82	0.15	0.73	0.27	0.18	0.13	0.04	1.33	0.94

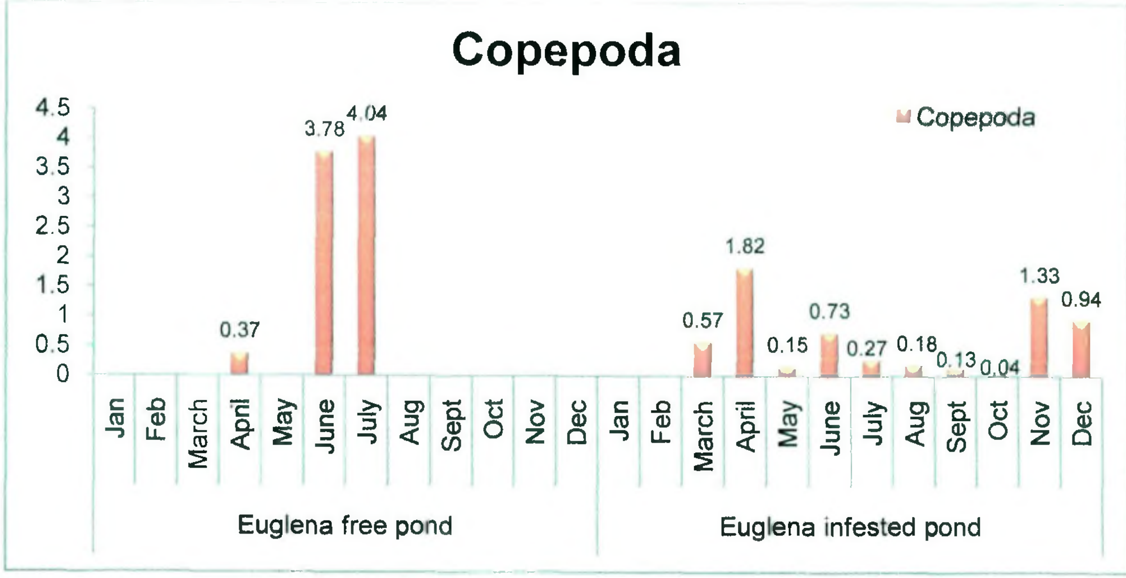

Fig.4.19 Comparative Account of Percentage of Copepoda in Euglena free and Euglena infested pond.

to 1.82% of total plankton and observed almost through out the year except few months. The magnitude of variation was 1.78% which is less than that of Euglena free pond. The lowest value was reported in October 0.04% when dissolved oxygen and total hardness was low. The highest value was recorded in April (1.82%) when dissolved oxygen and total hardness were high. Islam (2007) has also reported the high density of copepoda during the month of April due to high dissolved oxygen and high alkalinity. It is represented by one genus i.e. *Cyclops*. The percentage of copepoda has been observed comparatively high in Euglena infested pond (table 4.19, fig.4.19) as such it may be concluded that Euglena infested pond inclined towards high density of organic matter.

4.3. Impact of Euglena bloom on growth performance of carps.

The experiment was set up in replicate by using Euglena infested water and Euglena free water in troughs to find out the impact of Euglena bloom on growth of common carp. The experiment was carried out for a period of 3 months i.e. March, April and May 2010. The size of trough was 1m x1m x 0.4m in length, width and depth. Stocking of 10 numbers of common carp (*Cyprinus carpio communis*) weighed 240 gm were introduced into each experimental trough including control one (Euglena free trough). The different physico-chemical and biological parameters i.e. dissolved oxygen and pH were recorded weekly and total alkalinity, total dissolved solids, nitrate and plankton of control trough and Euglena infested trough were estimated fortnightly but the temperature was recorded daily. The monthly average of different physico chemical and biological parameters has been summarized in different tables (Table 4.20 to 4.36).

Table 4.20 Average Physico-chemical parameters of control trough.

Parameters	March	April	May
Air Temp. (^{0}C)	20.0	26.0	28.0
Water Temp. (^{0}C)	18.0	21.0	25.0
pH	7.28	7.90	7.10
DO (mg/l)	5.60	7.50	9.00
HCO_3 (mg/l)	16.00	14.00	16.00
TDS (mg/l)	61.63	73.04	120.00
Nitrate (mg/l)	25.00	33.37	30.15

Plate 4.2 Euglena free pond

Plate 4.3 Euglena infested pond

Table 4.21 Average Physico-chemical parameters of Euglena infested trough.

Parameters	Mar	Apr	May
Air Temp. (^{0}C)	20.0	26.0	28.0
Water Temp. (^{0}C)	18.0	21.0	25.0
pH	7.09	7.70	7.30
DO (mg/l)	4.70	5.50	6.00
HCO_3 (mg/l)	17.50	15.10	20.50
TDS (mg/l)	80.50	93.77	150.00
Nitrate (mg/l)	50.00	58.02	42.73

4.3.1. Physico-chemical parameters of experimental troughs:

Air temperature

Air temperature varied from 20^{0}C to 28^{0}C, the maximum temperature was recorded in May and magnitude of variation was 8^{0}C. The water temperature has a direct relationship with air temperature as such indirectly all the aquatic fauna and flora were affected by variation in air temperature.

Water temperature

The water temperature of Euglena infested and control trough ranged from 18^{0}C to 25^{0}C which is less that that of air temperature and magnitude of variation was 7^{0}C. There is no difference between water temperature of control and Euglena infested trough and it depicted direct relationship with air temperature and confirmed the views of Islam *et al.* (1974), Miah *et al.* (1981) and Begum *et al.* (1989).

pH

The pH of control trough ranged from 7.10 to 7.90, the minima were reported in May (7.10) and maxima in April (7.9). The magnitude of variation was 0.80 and water remains neutral. In case of Euglena infested trough the pH varied from 7.00 to 7.70 which are almost equal to that of control trough but differs in time of maxima and minima. The minima were recorded in March and maximum value in April (7.70). The pH showed a direct relationship with temperature.

Dissolved oxygen (DO)

Dissolved oxygen in control trough ranged from 5.60 to 9 mg/l which seems to be suitable for the growth and survivability of fish. The magnitude of variation was 3.40 mg/l. In Euglena infested trough the dissolved oxygen was ranged from 4.70 to 60 mg/l. which were lower than that of control trough. The magnitude of variation was 1.30 mg/l which is also less than that of Euglena free trough. It showed a direct relation with water temperature and total dissolved solids in both types of troughs (table 4.22 and Fig.4.22) similar relationship has been observed by Hossain *et al.* (2008).

Table 4.22 Comparative Account of Dissolved Oxygen (mg/l) in Control and Euglena infested troughs.

Trough	March	April	May
Control	5.60	7.50	9.00
Euglena infested	4.70	5.50	6.00

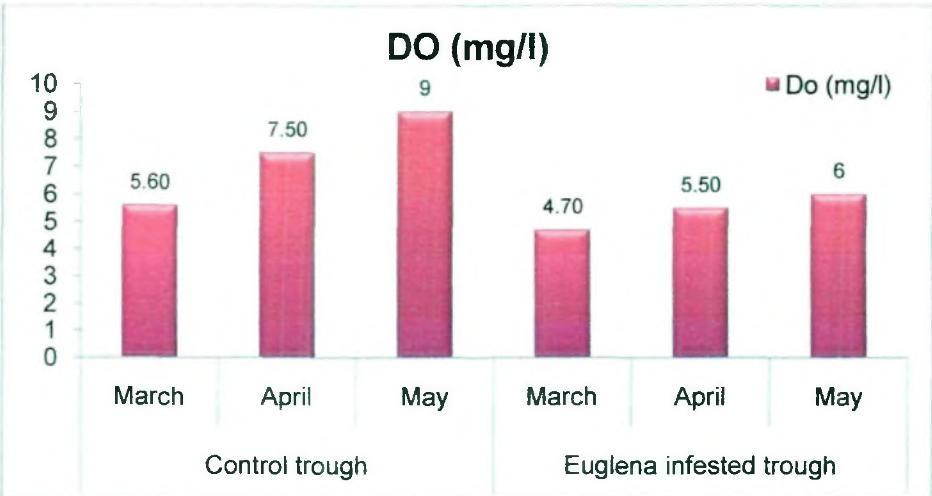

Fig.4.22 Comparative Account of Dissolved Oxygen (mg/l) in Control and Euglena infested troughs.

Alkalinity

Alkalinity in control trough ranged from 14 to 16 mg/l. The peak value was recorded during March and April (16 mg/l) but lowest in May (14 mg/l) and the magnitude of variation was 2 mg/l. In Euglena infested trough it varied from 15.10 to 20.50 mg/l which revealed that the alkalinity was higher in latter one. The highest value was noticed in May (20.50 mg/l) and has a direct relation with water temperature, dissolved oxygen and total dissolved solid whereas lowest value was noticed in April (15.10 mg/l) similar to that of control trough. The magnitude of variation was 5.40 mg/l which was higher than that of control one. Moyle (1946) reported that alkalinity above 48 ppm is considered good for productivity as such both types of trough depicted low productivity (table 4.23 and fig.4.23).

Table 4.23 Comparative Account of Alkalinity (mg/l) in Control and Euglena infested troughs.

Trough	March	April	May
Control	16.00	14.00	16.00
Euglena infested	17.50	15.10	20.50

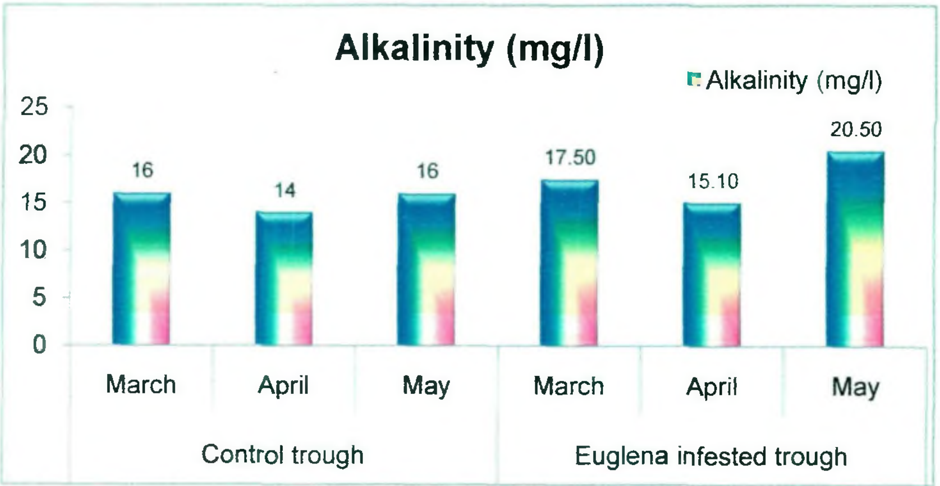

Fig.4.23 Comparative account of alkalinity (mg/l) in control and Euglena infested troughs.

Total dissolved solids (TDS)

The total dissolved solid of control trough was varied from 61.63 to 120 mg/l and the magnitude of variation was 58.37 mg/l. However in Euglena infested trough total dissolved solid was varied from 80.50 to 150 mg/l and the magnitude of variation were 69.50 mg/l. which is higher than that of control trough (table 4.24 and fig.4.24). However, in both types of troughs total dissolved solids showed a direct relationship with water temperature and alkalinity. Similar observation quoted by Chowdhury and Mamun (2006).

Table 4.24 Comparative Account of Total Dissolved Solids (mg/l) in Control and Euglena infested troughs.

Trough	March	April	May
Control	61.63	73.04	120
Euglena infested	80.50	93.77	150

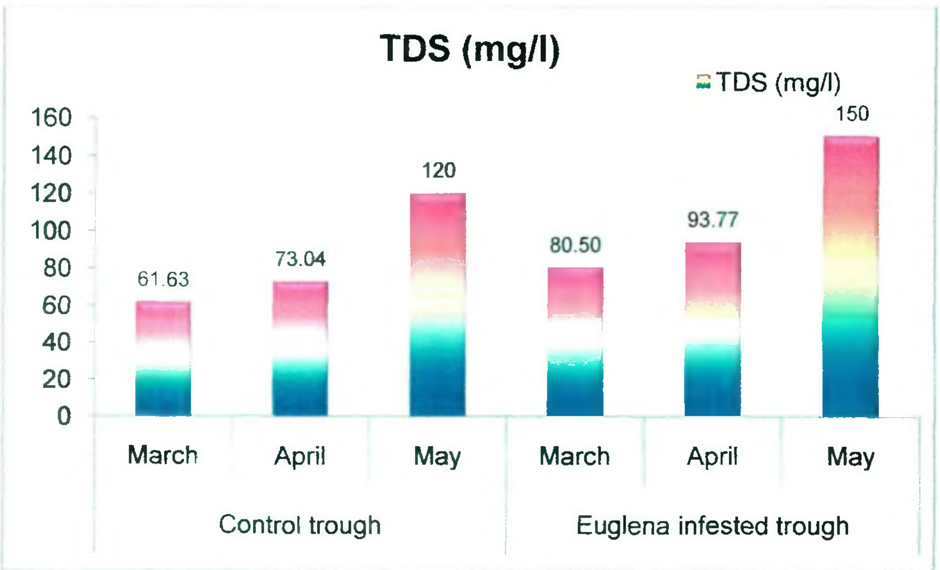

Fig.4.24 Comparative Account of Total Dissolved Solids (mg/l) in Control and Euglena infested trough.

Nitrate

Nitrate content in control trough was varied from 25 to 33.37 mg/l. The peak value was observed in April (33.37 mg/l) and lowest in March (25 mg/l). The magnitude of variation was 8.37 mg/l. In Euglena infested trough it varied from 42.73 to 58.02 mg/l. The highest value was recorded in April (58.02 mg/l) similar to that of control one and lowest in May (42.73 mg/l). The magnitude of variation was 15.29 mg/l. which were significantly higher than that of control trough (table 4.25 and fig.4.25). Further, the quantity of nitrate remains higher in Euglena infested troughs as such accelerated the production of Euglena bloom and confirmed the findings of Thirugnanamoorthy and Selvaraju (2009). It showed a direct relation with water temperature and total dissolved solids and confirmed the view of Thirugnanamoorthy and Selvaraju (*op.cit.*).

Table 4.25 Comparative Account of Nitrate (mg/l) in Control and Euglena infested troughs.

Trough	March	April	May
Control	25.00	33.37	30.15
Euglena infested	50.00	58.02	42.73

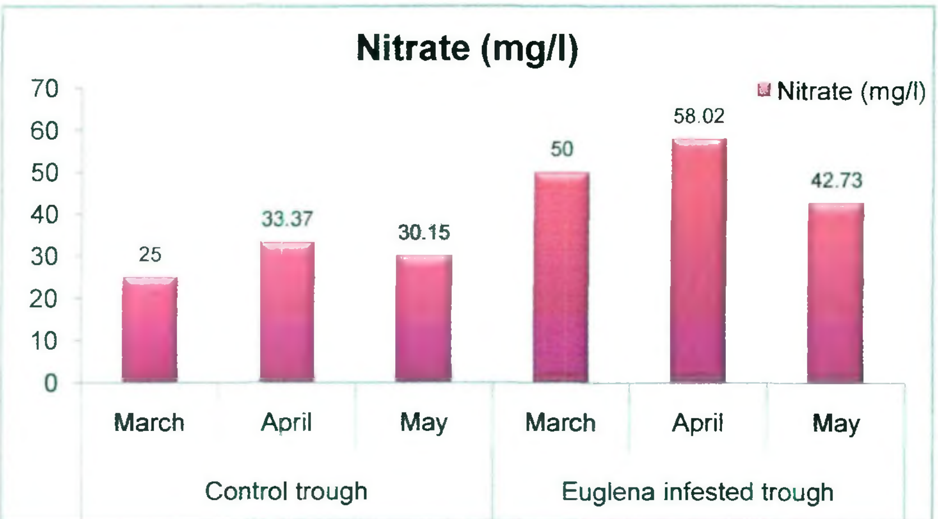

Fig.4.25 Comparative Account of Nitrate (mg/l) in Control and Euglena infested troughs.

4.3.2. Evaluation of planktonic diversity in experimental troughs.

4.3.2.1. Phytoplankton

The biological samples of control trough (table 4.26) and Euglena infested trough (table 4.27) have been monitored as a result 15 genera belonging to class bacillariophyceae, euglenophyceae, chlorophyceae and cynophyceae have been identified. Bacillariophyceae includes four genera which are *Coconeis, Fragilaria, Navicula and Synedra.* Euglenophyceae is represented by one genus i.e. *Euglena*. The most encountered six genera identified under chlorophyceae are *Ankistrodesmus*, *Closterium, Pediastrum, Scenedesmus, Spirogyra* and *Volvox.* There are four genera under cynophyceae such as *Agmenellum, Anabaena, Gomposphería*, and *Oscillatoria.* Further, the total plankton u/l remained higher in Euglena infested trough and showed highest peak in April in both types of trough (table 4.29). The highest population in Euglena infested trough was due to higher density of Euglena (table Fig.4.28) that is the indication of eutrophication.

Table 4.26 Plankton Diversity in Control trough.

Plankton	March	April	May
Bacillariopyhceae			
Navicula	1.66	9.66	
Synedra		2.00	
Total	**1.66**	**11.66**	
Euglenophyceae			
Euglena			
Total			
Chlorophyceae			
Ankistodesmus		21.50	1.66
Closterium		75.00	37.33
Pediastrum		2.66	1.00
Scenedesmus		87.83	21.66
Spirogyra	13.66	2.00	8.00
Total	**13.66**	**188.99**	**69.65**
Cynophyceae			
Agmenelum	2.33		
Anabaena		3.83	
Gomphospheria	4.33	2.33	
Oscillatoria			1.33
Total	**6.66**	**6.16**	**1.33**
Rotifera			
Brachionus	3.00	1.00	1.00
Keratella		1	
Total	**3.00**	**2**	**1.00**
Copepoda			
Cyclops		1.00	1.00
Total		**1.00**	**1.00**

Table 4.27 Plankton Diversity in Euglena infested trough.

Plankton	March	April	May
Bacillariopyhcrae			
Coconeis		1.00	
Fragilaria		1.00	
Navicula	1.00		
Synedra	4.00		
Total	**5.00**	**2.00**	
Euglenophyta			
Euglena	200.00	164.66	49.00
Total	**200.00**	**164.66**	**49.00**
Chlorophyceae			
Ankistodesmus		6.33	8
Closterium	44.00	10.00	
Pediastrum		1.00	1.00
Scenedesmus	3.33	13.00	12.00
Spirogyra		72.50	35.66
Volvox		1.00	
Total	**47.33**	**103.83**	**56.66**
Cynophyceae			
Agmenelum		1.00	
Anabaena	3.66	1.00	
Gomphospheria		3.33	
Oscillatoria		10.00	
Total	**3.66**	**15.33**	
Rotifera			
Brachionus	4.66	1.66	2.33
Keratella		1.00	2.00
Total	**4.66**	**2.66**	**4.33**
Copepoda			
Cyclops		4.16	4.66
Total		**4.16**	**4.66**

Table 4.28 Plankton Diversity and Abundance in Control and Euglena infested troughs.

	Control trough	Euglena infested trough
Bacillariopyhceae		
Coconeis	-	+
Fragilaria	-	+
Navicula	+	+
Synedra	+	++
Euglenophyta		
Euglena	-	+++
Chlorophyceae		
Ankistodesmus	++	+
Closterium	+++	++
Pediastrum	++	+
Scenedesmus	+++	++
Spirogyra	++	+++
Volvox	-	+
Cynophyceae		
Agmenelum	++	+
Anabaena	+	++
Gomphospheria	++	+
Oscillatoria	+	++
Rotifera		
Brachionus	+	++
Keratella	+	++
Copepoda		
Cyclops	+	+

- absent + present

++ common +++ abundance

Table 4.29 Total Plankton (u/l) in Control and Euglena infested troughs.

Trough	March	April	May
Control	17.98	125.88	43.78
Euglena infested	156.39	175.58	68.79

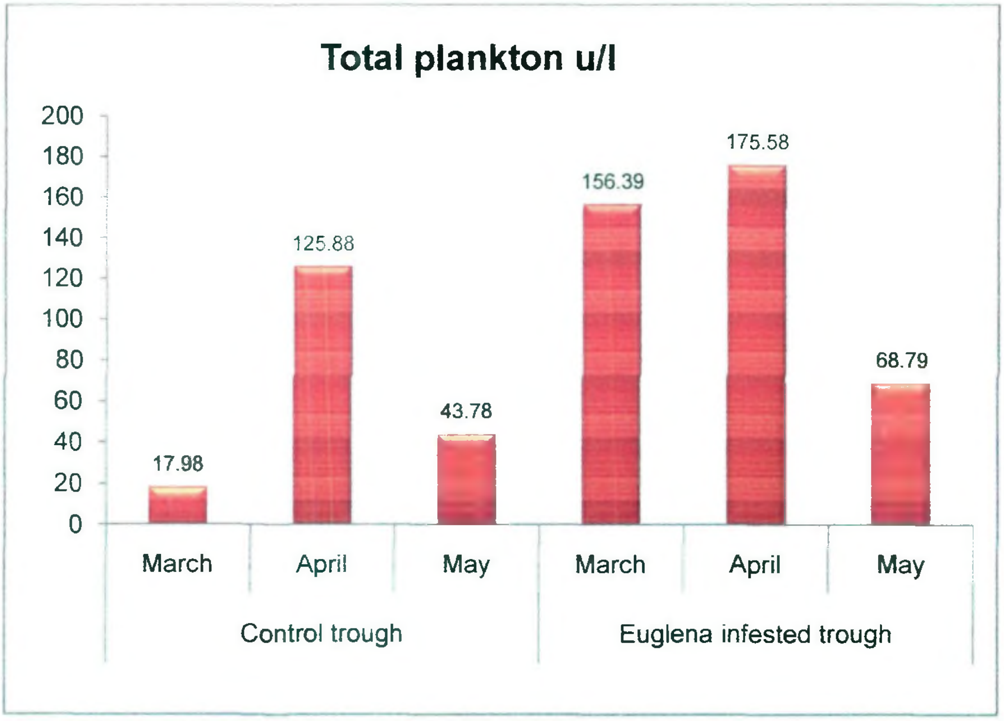

Fig. 4.29 Comparative Account of Percentage of Total Plankton in Control and Euglena infested troughs.

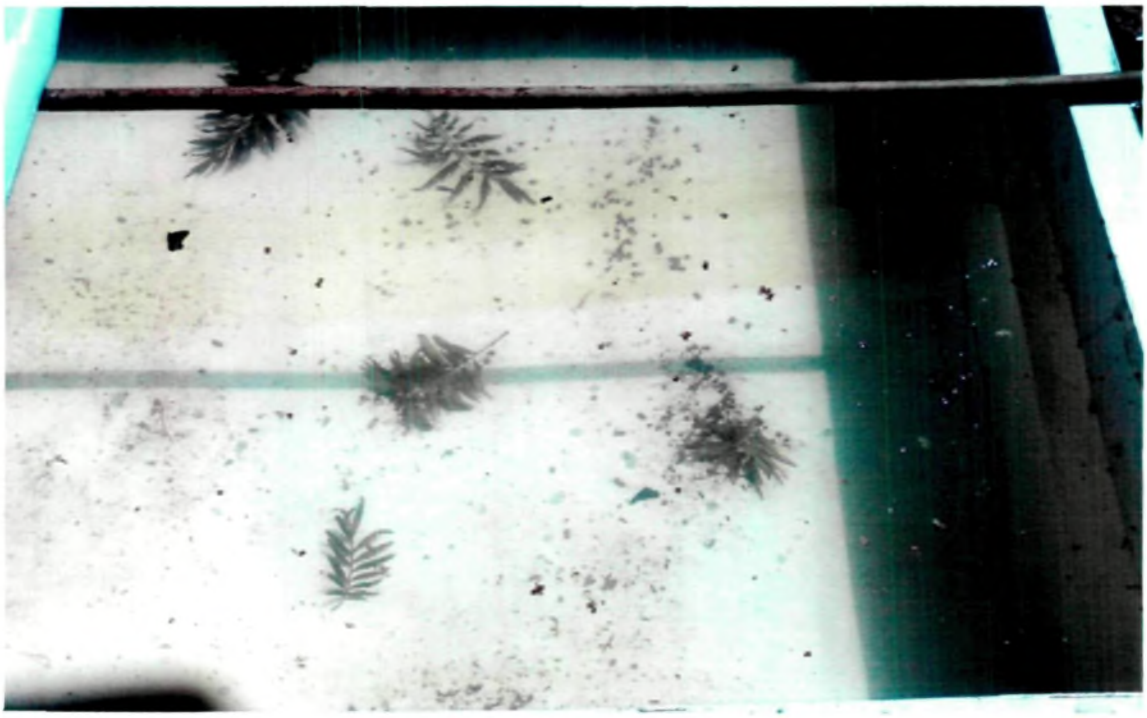

Plate 4.4 Euglena free trough

Plate 4.5 Euglena infested trough

4.3.2.2. Bacillariophyceae

The population of bacillariophyceae in control trough was varied from 5.55% to 6.64% of total plankton and the magnitude of variation was 1.09%. The maximum population was reported during March (6.64%) when the level of total dissolved solids was high and confirmed the observations of Thirugnanamoorthy and Selvaraju (2009). The lowest value was recorded in April (5.55%) and exhibited a direct relation with the dissolved oxygen and alkalinity but indirect relation with nitrate. It comprises of two genera that is *Navicula and Synedra.* In *Euglena infested trough it ranged from 0.68% to 1.91% and the magnitude of* variation was 1.23% which is higher than that of control trough. The highest value was observed in March (1.91%) and lowest in April (0.68%) similar to that of control trough but difference was noticed in presence of genera. It comprises of four genera *viz., Coconeis Fragilaria, Navicula* and *Synedra* and the genus *Synedra* was common but rare in control one (table 4.28). The percentage of bacillariophyceae in control trough was high as compared to the Euglena infested trough during experimental period (table 4.30 and fig.4.30) and also supported by the findings of Euglena free pond. Further, observation revealed that the bacillariophyceae was absent in May in both types of trough.

Table 4.30 Comparative Account of Percentage of Bacillariophyceae in Control and Euglena infested troughs.

Trough	March	April	May
Control	6.64	5.55	
Euglena infested	1.91	0.68	

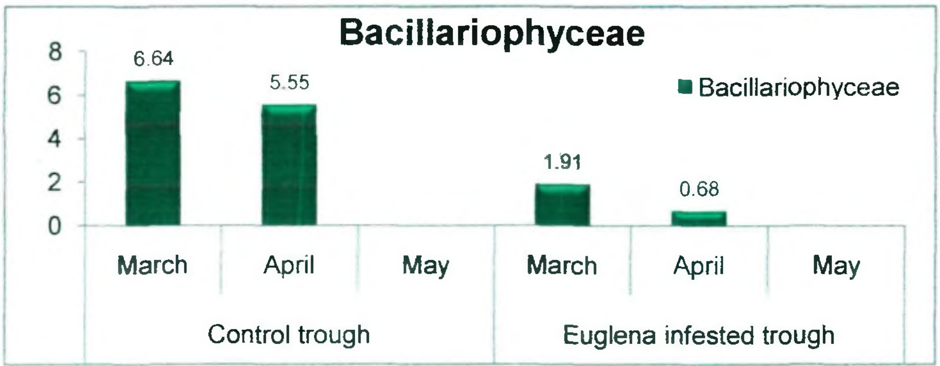

Fig.4.30 Comparative Account of Percentage of Bacillariophyceae in Control and Euglena infested troughs.

4.3.2.3. Euglenophyceae

Plankton belonging to class euglenophyceae was absent in control trough during the study period (table 4.31 and Fig.4.31). In Euglena infested trough it varied from 42.73% to 76.73% of total plankton and the magnitude of variation was 34%. The minimum value was reported in May (42.73%) and exhibited an indirect relation with the water temperature. The maxima were observed in March (76.73%) when the concentration of bacillariophyceae, nitrate and total dissolved solids was also high but water temperature was low and confirmed the view of Thirugnanamoorthy and Selvaraju (2009).

Table 4.31 Comparative account of percentage of Euglenophyceae in Control and Euglena infested troughs.

Trough	March	April	May
Control			
Euglena infested	76.73	56.26	42.73

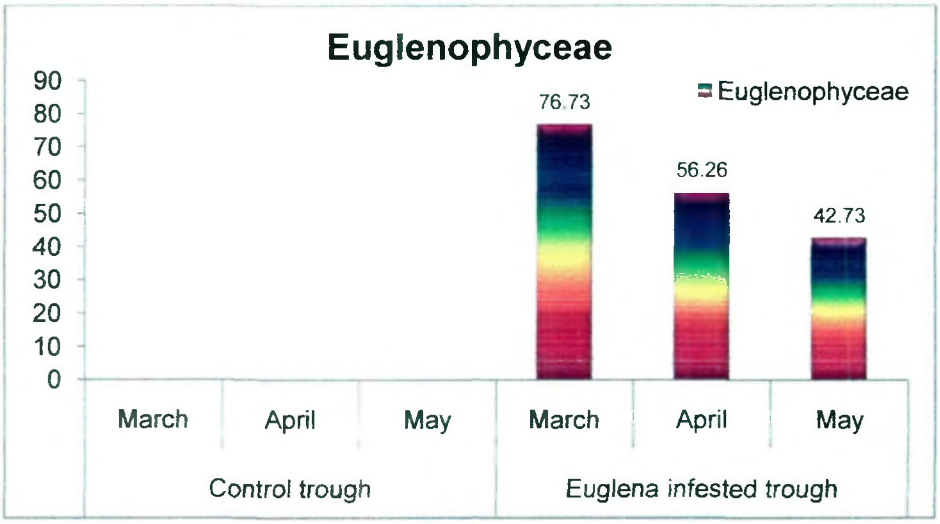

Fig.4.31 Comparative Account of Percentage of Euglenophyceae in Control and Euglena infested troughs.

4.3.2.4. Chlorophyceae

The total number of chlorophyceae in control trough was fluctuated from 54.68% to 95.43% of total plankton and the magnitude of variation was 40.75%. The lowest value was reported during March (54.68%) when dissolved oxygen was low. The highest value was recorded in May (95.43%) when dissolved oxygen, total dissolved solids and alkalinity were high and coincide with the view of Hosmani (1988). In Euglena infested trough chlorophyceae comprises of five genera *viz.*, *Ankistrodesmus*, *Closterium*, *Pediastrum*, *Scenedesmus and Spirogyra*. In Euglena infested trough it ranged from 18.15% to 49.41% of total plankton and the magnitude of variation was 31.26% which was less than that of control trough. The minima were observed in March (18.15%) and maxima in May (49.41%) similar to that of control trough. In Euglena infested trough chlorophyceae comprises of six genera *viz.*, *Ankistrodesmus*, *Closterium*, *Pediastrum*, *Scenedesmus*, *Spirogyra* and *Volvox*. The genera *Closterium* and *Scenedesmus* were abundant in control trough whereas in Euglena infested trough genus *spirogyra* was in abundance (table 4.28). The percentage of chlorophyceae was high in control trough as compare to that of Euglena infested trough (table 4.32 and fig.4.32) and supported the findings of Euglena free and Euglena infested ponds. Further, it was noticed that the genus *Volvox*, algae of odour and taste was absent in control trough but present in Euglena infested trough (Table 4.28).

Table 4.32 Comparative Accounts of Percentage of Chlorophyceae in Control and Euglena infested of troughs.

Trough	March	April	May
Control	54.68	90.07	95.43
Euglena infested	18.15	35.48	49.41

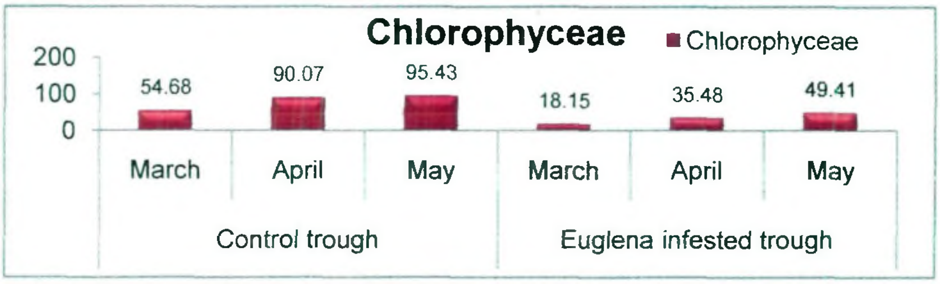

Fig.4.32 Comparative Account of Percentage of Chlorophyceae in Control and Euglena infested of troughs.

4.3.2. 5. Cynophyceae

The population of cynophyceae in control trough was ranged from 1.82% to 26.66% of total plankton and the magnitude of variation was 24.84%. The minima were noticed in May (1.82%) when the water temperature was high. The peak value was observed in March (26.66%) and depicted a direct relation with bacillariophyceae, nitrate, total dissolved solids and alkalinity and confirmed the findings of Thirugnanamoorthy and Selvaraju (2009). In Euglena infested trough it was varied from 1.40% to 5.23% of total plankton and the magnitude of variation was 3.83% as such the quantity as well as magnitude of variation was less than that of control trough. The minimum value was reported in March (1.4%) when the water temperature was low. The maxima fall in April (5.23%) when euglenophyceae, nitrate, alkalinity and total dissolved solids were high. Similar observation was also recorded by Philipose *et al.* (1959) while studying the phytoplanktons periodicity in three lakes around Udaipur. It represented by four genera *viz.*, Agmenellum, *Anabaena*, *Gompospheria*, and *Oscillatoria* similar to that of Euglena free and infested ponds. Its percentage was high in control trough as compared to that of Euglena infested trough (table 4.33 and fig.4.33). Further the genera Agmenellum and *Gompospheria* were common in control trough but *Anabaena* and *Oscillatoria* in Euglena infested trough (table 4.28) as well as in ponds.

Table 4.33 Comparative account of percentage of Cynophyceae in control and Euglena infested troughs.

Trough	March	April	May
Control	26.66	2.93	1.82
Euglena infested	1.40	5.23	

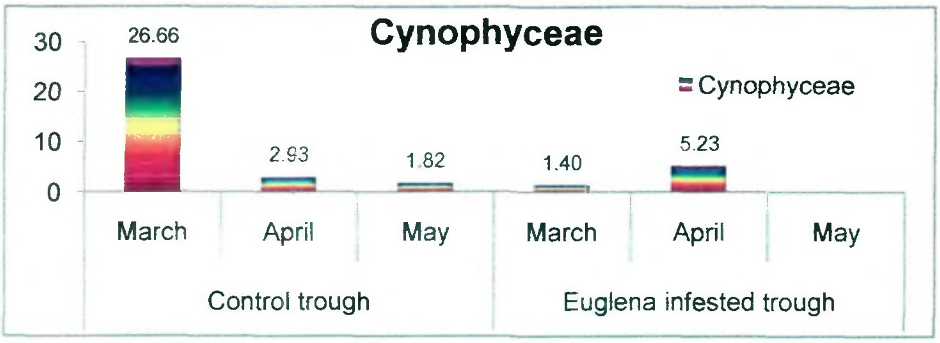

Fig.4.33 Comparative account of percentage of Cynophyceae in control and Euglena infested troughs.

4.3.2.6. Zooplankton

Zooplankton was represented by two taxas i.e. rotifera and copepoda but their population was less as compared to the phytoplankton. The two genera i.e. *Brachionus* and *Keratella* belong to rotifera and one genus *Cyclops* belongs to copepoda have been observed during the study period and exhibited similarity with that of Euglena free and Euglena infested ponds.

4.3.2.7. Rotifera

The number of rotifers in control trough was ranged from 0.95% to 12% of total plankton and the magnitude of variation was 11.05%. The lowest value was recorded in April (0.95%) when the level of alkalinity was low but the population of bacillariophyceae and cynophyceae was high. The highest value was observed in March (12%) when alkalinity and total dissolved solids were high. Kiran *et al.* (2007) have noted high density of rotifers during the summer which supports the present findings. It comprises of two genera i.e. *Brachionus* and *Keratella* whereas only *Brachionus* was recorded from Euglena free ponds. In Euglena infested trough it varied from 0.90% to 3.77% of total plankton and the magnitude of variation was 2.87% which are less than that of control trough similar to that of Euglena infested ponds. The minimum value was noticed in April (0.90%) similar to that of control trough. The maximum value was reported in May (3.77%) when alkalinity and total dissolved solids were high similar to that of control trough. It represented by two genera i.e. *Brachionus* and *Keratella*. It has been observed that high percentage of rotifers was present in control trough as compared to the Euglena infested trough (table 4.34 and fig.4.34) just opposite the findings of Euglena free and Euglena infested ponds due to absent of data of June month in experiment when its peak value was recorded in ponds.

Table 4.34 Comparative Account of Percentage of Rotifera in Control and Euglena infested troughs.

Trough	March	April	May
Control	12.00	0.95	1.37
Euglena infested	1.78	0.90	3.77

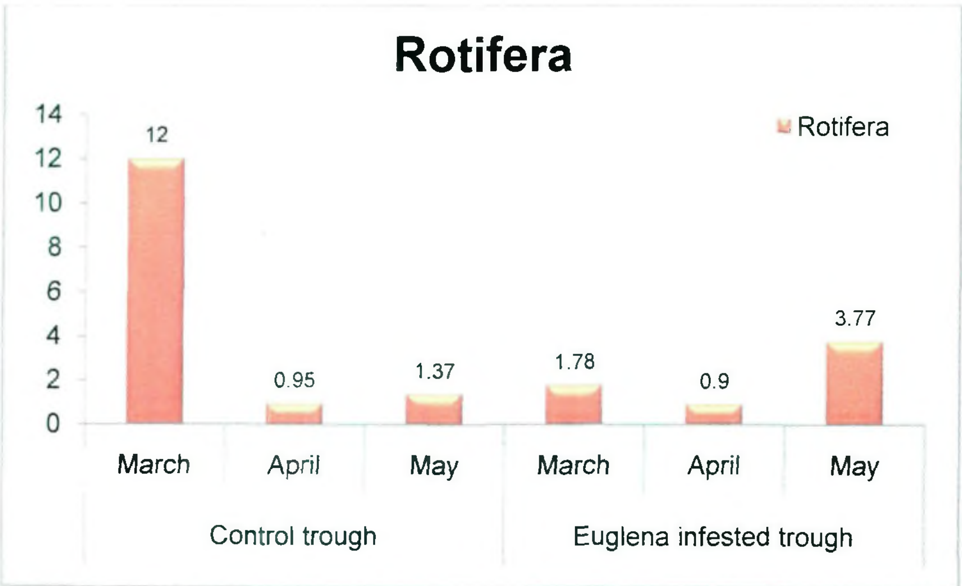

Fig.4.34 Comparative Account of Percentage of Rotifera in Control and Euglena infested troughs.

4.3.2.8. Copepoda

The population of copepoda in control trough was varied from 0.47% to 1.37% of total plankton and the magnitude of variation was 0.90%. The minima were noticed in April (0.47%) when alkalinity and population of rotifer was low. The peak value was observed in May (1.37%) when rotifer, nitrate level and total dissolved solids were high. In Euglena infested trough it ranged from 1.42% to 4.06% of total plankton and the magnitude of variation was 2.64%. The lowest value was reported in April (0.04%) and highest value in May (4.06%) similar to that of control trough. Islam (2007) has reported high density of copepoda during the summer due to high dissolved oxygen and high alkalinity which coincide with the present findings. The percentage of copepoda was comparatively high in Euglena infested trough (table 4.34 and fig.4.34) and mainly dominated by *Cyclops* similar to that of Euglena infested ponds.

Table 4.35 Comparative Account of Percentage of Copepoda in Control and Euglena infested trough.

Trough	March	April	May
Control		0.47	1.37
Euglena infested		1.42	4.06

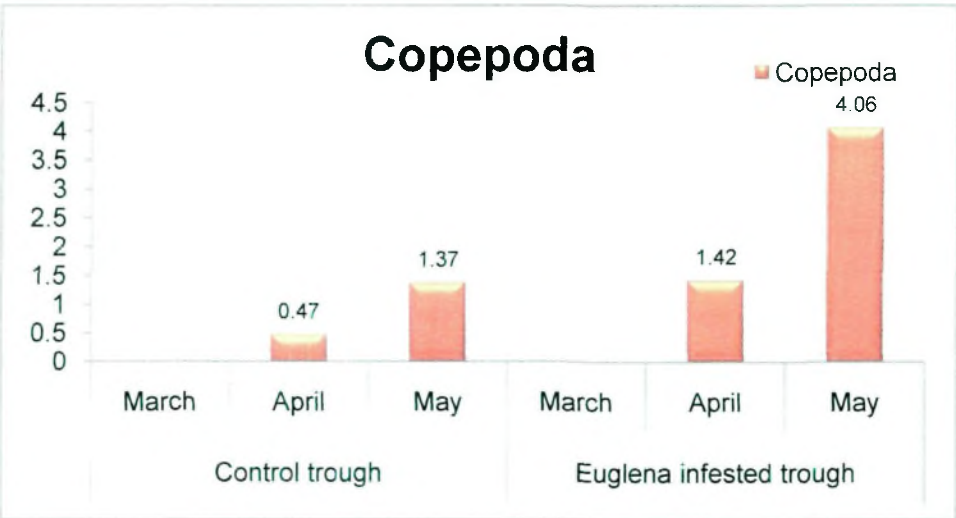

Fig.4.35 Comparative Account of Percentage of Copepoda in Control and Euglena infested trough.

4.3.3. Growth performance of common carps:

The growth performance of common carps in different troughs was monitored and summarized in table 4.36 which revealed that in Euglena infested trough mortality was 40 per cent after 16th days of the experiment when dissolved oxygen was low and content of nitrate was high which accelerated the production of Euglena bloom. Further, 10 per cent mortality was reported on 37th day of the experiment whereas no mortality in control trough. The total body weight of fishes in control and Euglena infested trough was monitored monthly. In control trough after one month the average body weight was recorded 26 gram whereas in Euglena infested trough only 25 gram. The average body weight after second month was 30 gram in control trough but 19.64 gram in the Euglena infested trough. The experiment was terminated after third months and the fish was harvested. The average weight of fish in control trough was 36 gram whereas 18.57 gram in Euglena infested trough. The above observation depicted that there was a gain of 12 gram in the total body weight of fishes in control trough but loss of 5.4 gram in Euglena infested trough was reported besides heavy mortality. The total weight harvested was 360 gram in control trough against 185.71 gram in Euglena infested trough. Further the survivability was 100 per cent in control trough as compared to 50 percent in Euglena infested trough (table 4.36). Based on these findings it may be concluded that high density of Euglena (Fig.4.20) is disastrous for fish, as it clogs the gills of fish and fish dies due to respiratory blocked. Further it reduces the production of other groups of plankton (Table 4.27) and dissolved oxygen but increases the contents of nitrogen and total dissolved solids which indirectly affected the growth of the fish. Zimba *et al.* (2004) noticed the outbreaks of toxic Euglena in North Carolina which causes the loss of more than 20,000 pounds of fish which supports the view of the present study. The present observations also supported by Padmavathi and Prasad (2007) while studying the effect of algal bloom in carp culture pond. They reported that surface water algal bloom deteriorates the water quality specially depletion of dissolved oxygen which result the poor growth and mortality of fish. In the present study the difference in water quality parameters was noticed in terms of low dissolved oxygen but high total dissolved solid and nitrate which supported the high growth of Euglena bloom thus confirmed the findings of Padmavathi and Prasad (*op.cit.*).

Table 4.36 Impact of Euglena on Growth Performance of Common Carps.

Parameters	Control trough	Euglena infested trough
Initial group weight (g)	240	240
No. of fish	10	10
Avg. initial wt. (g)	24.00	24.00
After 1st month		
Avg. weight (g)	26.00	25.00
After 2nd month		
Avg. weight (g)	30.00	19.64
After 3rd month		
Avg. weight (g)	36.00	18.57
Gain/ Loss	12.00 (gain)	5.40 (loss)
Total harvested	360.00	185.71
Survivality (%)	100	50

4.4 Statistical analysis

Statistical analysis was done by using simple correlations and Shannon weaver index. The data pertaining to different parameters has been summarized in table 4.37 to 4.44.

4.4.1. Simple Correlation

The simple correlation was applied for different pysico- chemical and biological parameters of Euglena free and Euglena infested ponds. The result obtained so far revealed that it has positive and significant relationship with some of the parameters whereas negative and significant relationship with others.

Air temperature exhibited positive and significant relationship with water temperature (r = 0.9, 0.9) in both type of ponds and confirmed the view of Islam et al. (1974).

pH showed positive and significant relationship with dissolved oxygen in Euglena free pond (r = 0.5) and Euglena infested ponds (r = 0.1) which exhibited high value of r in Euglena free pond . Similar observations were reported by Islam and Pramanik (2009)

Dissolved oxygen furnished positive and significant relationship with water temperature (r = 0.1, 0.1) in both types of pond.

Free carbon dioxide proved a positive and significant relationship with pH in Euglena free (r = 0.3) and Euglena infested ponds (r= 0.1). Nargis and Pramanik (2008) have also observed the significant relationship with pH and free carbon dioxide and supported the present findings. The value of r is comparatively more in Euglena free ponds.

Alkalinity exhibited negative and significant relationship with free carbon dioxide (r = -0.2, -0.1) and water temperature (r = -0.8, -0.8) in Euglena free and Euglena infested ponds. Similar observations were noticed by Ali *et al.* (1982).

Chloride showed negative and significant relationship with water temperature (r = -0.6, -0.8) in Euglena free and Euglena infested ponds whereas positive and significant relationship with free carbon dioxide in Euglena free pond (r = 0.2) but negative and significant relationship in Euglena infested pond (r= -0.002) as such confirmed the view of Singh *et al.* (1999).

Total hardness furnished negative and significant relationship with water temperature in Euglena free (r = -0.07) and Euglena infested ponds (r = -0.04).

Total dissolved solids exhibited positive and significant relationship with water temperature (r = 0.7, 0.7) whereas negative and significant relationship with alkalinity (r =-0.5, -0.6) in Euglena free and Euglena infested ponds.

Nitrate showed positive and significant relationship with water temperature (r =0.2), dissolved oxygen (r = 0.2) and alkalinity (r = 0.09) whereas negative and significant relationship with chloride (r = -0.6) and free carbon dioxide (r = -0.2) in Euglena free pond. Bhuiyan and Gupta (2007) have also observed significant relationship with nitrate and dissolved oxygen which confirmed the view of present study. In Euglena infested pond nitrate exhibited positive and significant relationship with water temperature (r =0.3), and alkalinity (r = 0.01) but negative and significant relationship with dissolved oxygen (r = -0.2), free carbon dioxide (r = -0.4) and chloride (r = -0.5). Hossain *et al.* (2008) have observed similar relationship which confirmed the present findings.

Bacillariophyceae exhibited positive and significant relationship with chloride (r = 0.4), euglenophyceae (r = 0.2) and copepoda (r = 0.9) whereas negative and significant relationship with water temperature (r = -0.7), transparency (r = -0.01), dissolved oxygen (r = -0.2), chlorophyceae (r = -0.2), cynophyceae (r = -0.3), rotifers (r = -0.6) and total plankton (r = -0.2) in Euglena free pond. In Euglena infested pond bacillariophyceae revealed a positive and significant relationship with free carbon dioxide (r = 0.5), total dissolved solids (r = 0.1), chlorophyceae (r = 0.5), rotifers (r = 0.9) and copepoda (r = 0.1) whereas negative and significant relationship with water temperature (r = -0.08), transparency (r = -0.4), euglenophyceae (r = -0.3), cynophyceae (r = -0.08) and total plankton (r = -0.3). Chowdhury and Mamun (2006) have demonstrated that phytoplankton populations have positive and significant relationship with dissolved oxygen and zooplankton and supported the present findings.

Euglenophyceae showed positive and significant relationship with transparency (r = 0.3), dissolved oxygen (r = 0.1), total hardness (r = 0.1), cynophyceae (r = 0.3) and total plankton (r = 0.01) and negative and significant relationship with water temperature (r = -0.6), nitrate (r = -0.7), free carbon dioxide (r = -0.1), chlorophyceae (r = -0.2) and rotifers (r = -0.6) in Euglena free pond. In Euglena infested pond euglenophyceae exhibited positive and significant relationship with water temperature (r = 0.1), nitrate (r = 0.5), chlorophyceae (r = 0.08) and total plankton (r = 0.9) whereas negative and significant relationship with dissolved oxygen (r = -0.3), free carbon dioxide (r = -0.1), total hardness (r = -0.3), cynophyceae (r = -0.1), rotifers (r = -0.3) and copepoda (r = -0.5). Similar observations were noticed by Chowdhury and Mamun (2006).

Chlorophyceae executed a positive and significant relationship with dissolved oxygen (r = 0.9), total hardness (r = 0.7), rotifers (r = 0.4) and total plankton (r = 0.9) whereas negative and significant relationship with cynophyceae (r = -0.3) and copepoda (r = -0.9) in Euglena free pond. In Euglena infested pond chlorophyceae showed positive and significant relationship with rotifers (r = 0.4) and total plankton (r = 0.08) and negative and significant relationship with dissolved oxygen (r = -0.05), total hardness (r = -0.05) cynophyceae (r = -0.2) and copepoda (r = -0.1) and confirmed the view of Chowdhury and mamun (2006).

Cynophyceae showed positive and significant relationship with nitrate (r = 0.09) and copepoda (r = 1) but negative and significant relationship with free carbon dioxide (r = -0.3) and total plankton (r = -0.2) in Euglena free pond. In Euglena infested pond cynophyceae executed positive and significant relationship with nitrate (r = 0.6) and negative and significant relationship with free carbon dioxide (r = -0.8), copepoda (r = -0.2) and total plankton (r = -0.09) which confirmed the view of Hulyal and Kaliwal (2008).

Rotifers exhibited positive and significant relationship with total dissolved solids (r = 0.6) and free carbon dioxide (r = 0.5) whereas negative and significant relationship with copepoda (r = -0.5) and water temperature (r = -0.06) in Euglena free pond which confirmed the view of Islam (2007). Though in Euglena infested pond rotifers showed positive and significant relationship with total dissolved solids (r = 0.6), free carbon dioxide (r = 0.5) and copepoda (r = 0.1) and negative and significant relationship with total plankton (r = -0.2) and water temperature (r = -0.06).

Copepoda revealed a negative and significant relationship with dissolved oxygen (r = -0.09), total hardness (r = -0.09), total plankton (r = -0.9) in Euglena free pond. In Euglena infested pond copepoda exhibited positive and significant relationship with dissolved oxygen (r = 0.6) and total hardness (r = 0.4) and negative and significant relationship with total plankton (r = -0.5). Similar observations were reported by Islam (2007).

Thus, based on above observations it is summarized that a positive and significant relationship of chloride with free carbon dioxide; nitrate with dissolved oxygen; chlorophyceae with dissolved oxygen and total hardness and cynophyceae with copepods have been reported in Euglena free pond which differs from that of Euglena infested pond. Further, a negative and significant relationship of bacillariophyceae with chlorophyceae and rotifers; euglenophyceae with water temperature, nitrate and chlorophyceae; rotifers with copepoda and copepoda with dissolved oxygen and total hardness was noticed in Euglena free ponds but positive and significant relationship in Euglena infested ponds. As a result it may be inferred that Euglena bloom affected the physico chemical and biological parameters of the ponds.

4.4.2. Shannon Weaver index

Shannon Weaver index was applied to find out the plankton diversity in Euglena free and Euglena infested ponds. The different planktonic group, their numbers, abundance and diversity were monitored and summarized in tabulated form (table 4.42 to 4.44). This table exhibited that the chlorophyceae (0.70) is most dominating group in Euglena free pond but euglenophyceae (0.80) in Euglena infested pond. Further, the second dominating group in Euglena free pond is bacillariophyceae (0.14) whereas chlorophyceae (0.11) in Euglena infested pond though the relative abundance of chlorophyceae (0.70) is comparatively high in Euglena free pond. The third dominating group is cynophyceae (0.10) in Euglena free pond but bacillariophyceae (0.05) in Euglena infested pond whereas the relative abundance of Cynophyceae (0.10) is higher in Euglena free pond.

The species diversity index (Shannon Weaver index) varies from 2.49 to 2.02 in Euglena free and Euglena infested pond respectively (table 4.44). The highest value of Shannon Weaver index was reported for Euglena free pond (2.49) which is due to more equal proportion of taxas in Euglena free pond than that of Euglena infested pond. Yigit and Tarihi (2006) reported that the Shannon-Weaver index gave higher values when the proportions of species in a sample were close to each other and the Shannon-Weaver index was not affected by the number of species as such confirmed the present observations. The planktonic diversity and abundance of different taxa have been reported in different types of ponds for example in Euglena free pond the chlorophyceae stands first then bacillariopyceae and cynophyceae but in Euglena infested pond similar groups were observed in sequence of euglenophyceae, chlorophyceae and bacillariophyceae

Thus based on this study it is concluded that the physico-chemical parameters particularly water temperature, dissolved oxygen, total hardness and nitrate favoured the production of Euglena in Euglena infested pond as a result the biological productivity of pond is less than that of Euglena free pond. Similar observations were reported from the experiment carried out to monitor the growth of common carp in Euglena infested water. The Euglena bloom affected the growth of the fish and fish die due to depletion of oxygen.

Table 4.37 Correlation of Different Physico-chemical Parameters of the Euglena free pond.

Correlation between	Value of "r"	Remarks
Air temperature and water temperature	0.979324011	Positively correlated
pH and dissolved oxygen	0.564253005	Positively correlated
Dissolved oxygen and water temperature	0.184473489	Positively correlated
Free carbon dioxide and pH	0.336028019	Positively correlated
Alkalinity and free carbon dioxide	-0.220486864	Negatively correlated
Alkalinity and water temperature	-0.87277682	Negatively correlated
Chloride and water temperature	-0.673367166	Negatively correlated
Chloride and free carbon dioxide	0.229573003	Positively correlated
Total hardness and water temperature	-0.079995449	Negatively correlated
Total dissolved solid and water temperature	0.750353872	Positively correlated
Total dissolved solid and alkalinity	-0.578821867	Negatively correlated
Nitrate and water temperature	0.237429832	Positively correlated
Nitrate and dissolved oxygen	0.260036547	Positively correlated
Nitrate and free carbon dioxide	-0.287985208	Negatively correlated
Nitrate and Chloride	-0.645954953	Negatively correlated
Nitrate and Alkalinity	0.094151543	Positively correlated

Table 4.38 Correlation of Different Physico-chemical Parameters of the Euglena infested pond.

Correlation between	Value of "r"	Remarks
Air temperature and water temperature	0.976560606	Positively correlated
pH and dissolved oxygen	0.101701754	Positively correlated
Dissolved oxygen and water temperature	0.127861749	
Free carbon dioxide and pH	0.137017468	Positively correlated
Alkalinity and free carbon dioxide	-0.128640581	Negatively correlated
Alkalinity and water temperature	-0.82868561	Negatively correlated
Chloride and water temperature	-0.876342839	Negatively correlated
Chloride and free carbon dioxide	-0.002620411	Negatively correlated
Total hardness and water temperature	-0.042648844	Negatively correlated
Total dissolved solid and water temperature	0.78324868	Positively correlated
Total dissolved solid and alkalinity	-0.628297508	Negatively correlated
Nitrate and water temperature	0.371785905	Positively correlated
Nitrate and dissolved oxygen	-0.276356346	Negatively correlated
Nitrate and free carbon dioxide	-0.491134941	Negatively correlated
Nitrate and Chloride	-0.55377367	Negatively correlated
Nitrate and Alkalinity	0.013540855	Positively correlated

Table 4.39 Correlation of Plankton with Physico-chemical Parameters of the Euglena free pond.

Correlation between	Value of "r"	Remarks
Bacillariophyceae and water temperature	-0.708745608	Negatively correlated
Bacillariophyceae and transparency	-0.013424723	Negatively correlated
Bacillariophyceae and dissolved oxygen	-0.292818601	Negatively correlated
Bacillariophyceae and chloride	0.467520909	Positively correlated
Euglenophyceae and water temperature	-0.060657045	Negatively correlated
Euglenophyceae and nitrate	-0.795293201	Negatively correlated
Euglenophyceae and transparency	0.359556711	Positively correlated
Euglenophyceae and dissolved oxygen	0.153095637	Positively correlated
Euglenophyceae and free carbon dioxide	-0.106159179	Negatively correlated
Euglenophyceae and total hardness	0.135549214	Positively correlated
Chlorophyceae and dissolved oxygen	0.942998554	Positively correlated
Chlorophyceae and total hardness	0.742696159	Positively correlated
Cynophyceae and free carbon dioxide	-0.347122484	Negatively correlated
Cynophyceae and nitrate	0.093787241	Positively correlated
Rotifera and total dissolved solids	0.667001012	Positively correlated
Rotifera and water temperature	-0.06401844	Positively correlated
Rotifera and free carbon dioxide	0.564937937	Positively correlated
Copepoda and free dissolved oxygen	-0.999375845	Negatively correlated
Copepoda and Total hardness	-0.993705122	Negatively correlated

Table 4.40 Correlation of Plankton with Physico-chemical Parameters of the Euglena infested pond.

Correlation between	Value of "r"	Remarks
Bacillariophyceae and water temperature	-0.087447439	Positively correlated
Bacillariophyceae and free carbon dioxide	0.561941303	Positively correlated
Bacillariophyceae and total dissolved solids	0.145727082	Positively correlated
Bacillariophyceae and transparency	-0.483974776	Negatively correlated
Euglenophyceae and water temperature	0.15284924	Positively correlated
Euglenophyceae and nitrate	0.523294524	Positively correlated
Euglenophyceae and dissolved oxygen	-0.373692723	Negatively correlated
Euglenophyceae and free carbon dioxide	-0.183409758	Negatively correlated
Euglenophyceae and total hardness	-0.357856609	Negatively correlated
Chlorophyceae and dissolved oxygen	-0.059570773	Negatively correlated
Chlorophyceae and total hardness	-0.05353031	Negatively correlated
Cynophyceae and free carbon dioxide	-0.843809775	Negatively correlated
Cynophyceae and nitrate	0.67639651	Positively correlated
Rotifera and total dissolved solids	0.667001012	Positively correlated
Rotifera and water temperature	-0.06401844	Positively correlated
Rotifera and free carbon dioxide	0.564937937	Positively correlated
Copepoda and free dissolved oxygen	0.699322623	Positively correlated
Copepoda and total hardness	0.444638139	Positively correlated

Table 4.41 Correlation between Different Classes of Plankton in Euglena free pond.

Correlation between	Value of "r"	Remarks
Bacillariophyceae and euglenophyceae	0.221263745	Positively correlated
Bacillariophyceae and chlorophyceae	-0.280909673	Negatively correlated
Bacillariophyceae and cynophyceae	-0.308853508	Negatively correlated
Bacillariophyceae and rotifera	-0.600970462	Negatively correlated
Bacillariophyceae and copepoda	0.992674423	Positively correlated
Bacillariophyceae and total plankton	-0.205761994	Negatively correlated
Euglenophyceae and chlorophyceae	-0.522198408	Negatively correlated
Euglenophyceae and cynophyceae	0.321874848	Positively correlated
Euglenophyceae and rotifera	-0.169589326	Negatively correlated
Euglenophyceae and total plankton	0.014884977	Positively correlated
Chlorophyceae and cynophyceae	-0.305580629	Negatively correlated
Chlorophyceae and rotifera	0.487436375	Positively correlated
Chlorophyceae and copepoda	-0.999895637	Negatively correlated
Chlorophyceae and total plankton	0.990225968	Positively correlated
Cynophyceae and copepoda	1	Positively correlated
Cynophyceae and total plankton	-0.244464747	Negatively correlated
Rotifera and copepoda	-0.5	Negatively correlated
Copepoda and total plankton	-0.999632588	Negatively correlated

Table 4.42 Correlation between Different classes of Plankton in Euglena infested pond.

Correlation between	Value of "r"	Remarks
Bacillariophyceae and euglenophyceae	-0.333390979	Negatively correlated
Bacillariophyceae and chlorophyceae	0.574706162	Positively correlated
Bacillariophyceae and cynophyceae	-0.08906665	Negatively correlated
Bacillariophyceae and rotifera	0.942608045	Positively correlated
Bacillariophyceae and copepoda	0.183139083	Positively correlated
Bacillariophyceae and total plankton	-0.377894422	Negatively correlated
Euglenophyceae and chlorophyceae	0.087123334	Positively correlated
Euglenophyceae and cynophyceae	-0.150432817	Negatively correlated
Euglenophyceae and rotifera	-0.305792036	Negatively correlated
Euglenophyceae and copepoda	-0.545928946	Negatively correlated
Euglenophyceae and total plankton	0.988338719	Positively correlated
Chlorophyceae and cynophyceae	-0.21148659	Negatively correlated
Chlorophyceae and rotifera	0.455674379	Positively correlated
Chlorophyceae and copepoda	-0.137055417	Negatively correlated
Chlorophyceae and total plankton	0.082438616	Positively correlated
Cynophyceae and copepoda	-0.267624047	Negatively correlated
Cynophyceae and total plankton	-0.093270559	Negatively correlated
Rotifera and copepoda	0.196472286	Positively correlated
Rotifera and total plankton	-0.28189414	Negatively correlated
Copepoda and total plankton	-0.52766791	Negatively correlated

Table 4.43 Shannon Weaver Index for Plankton Diversity in Euglena free pond.

Group	Number	Relative Abundance	LN(pi)	Pi*ln(Pi)
Bacillariophyceae	181.40	0.147248626	-1.9156	-0.2820743
Euglenophyceae	35.08	0.028475644	-3.5587	-0.10133645
Chlorophyceae	873.40	0.708968854	-0.3439	-0.24384536
Cynophyceae	131.22	0.106515792	-2.2395	-0.23853807
Rotifera	5	0.004058672	-5.5069	-0.0223507
Copepoda	5.83	0.004732412	-5.3533	-0.02533412
Total	**1231.93**	**1.000000000**	**-18.918**	**-0.91347899**
				0.91347899
Species Index				**2.49298052**

Table 4.44 Shannon Weaver Index for Plankton Diversity in Euglena infested pond.

Group	Number	Relative abundance	LN(pi)	Pi*ln(Pi)
Bacillariophyceae	340.07	0.05423418	-2.9144	-0.15806248
Euglenophyceae	5029.70	0.802133835	-0.2205	-0.17685431
Chlorophyceae	708.37	0.112970464	-2.1806	-0.24634666
Cynophyceae	153.78	0.024524751	-3.7081	-0.09093955
Rotifera	22.13	0.00352928	-5.6467	-0.01992865
Copepoda	16.32	0.002602705	-5.9512	-0.01548923
Total	**6270.4**	**0.999995216**	**-20.621**	**-0.70762088**
				0.70762088
Species Index				**2.0291579**

Table 4.45 Species Index in Euglena free and Euglena infested ponds.

Pond	Plankton						Species Index
	Bacill.	Eugleno.	Chloro	Cyno.	Rotifera	copepoda	
Euglena free	0.147	0.028	0.708	0.106	0.004	0.004	2.49
Euglena infested	0.054	0.80	0.112	0.024	0.003	0.002	2.02

Summary and Conclusions

5. SUMMARY AND CONCLUSIONS

The salient findings of the study based on field and laboratory investigation on Euglena free and Euglena infested ponds and troughs are summarized as follows:

The maximum value of transparency in Euglena free pond was recorded in December when water temperature was less whereas in Euglena infested pond in July when water temperature was high. The value of transparency was comparatively low than that of recommended value (40-60cm) in both types of pond and depicted that these ponds fall in the category of medium productivity.

Air temperature has a direct effect on the water temperature in both types of pond as such indirectly all the aquatic fauna and flora were affected by variation in air temperature.

pH in both types of pond remained slightly alkaline through out the year thus supported the growth of aquatic fauna. The maximum value was noticed in Euglena free pond in April but in Euglena infested pond in February and have direct relation with dissolved oxygen.

Dissolved oxygen was comparatively high in Euglena free pond through out study period as compared to Euglena infested pond and maximum value was noticed in April in both types of pond which has direct relation with water temperature. Thus it is confirmed that Euglena bloom is responsible for the oxygen depletion as it consume oxygen in night also. Thus directly affects the survivability as well as growth of aquatic fauna.

The level of free carbon dioxide was high in Euglena infested pond as compared to that of Euglena free pond which is considered to be detrimental to aquatic animals. Further, the value of free carbon dioxide was found high in June and have a direct relation with pH in both types of pond.

The level of alkalinity due to bicarbonates in both types of pond remained almost equal throughout the year and the peak fall in winter but in different month. The alkalinity was low than that of recommended value (50ppm) for good productivity as a result both types of pond can be categorized under medium productivity. Further, it was found that alkalinity has an indirect relation with free carbon dioxide and temperature.

The highest value of chloride was reported in January in Euglena free pond whereas in Euglena infested pond in February. Chloride constituent was comparatively high in Euglena infested pond and showed an indirect relation with water temperature whereas direct relation with free carbon dioxide. Thus it is concluded that higher limits of chloride in Euglena infested pond may cause osmoregulatory problems to aquatic organisms specially fishes.

The total hardness was reported almost similar in both types of pond and its maximum value was observed in April and depicted an indirect relation with water temperature. The value of total hardness in both types of pond was comparatively low than that of recommended value of 40 to 200 ppm as a result these ponds belong to category of medium production. Further, it was noticed that the value of total hardness was high as compared to alkalinity and known as non carbonate hardness.

The total dissolved solids in Euglena infested pond were high as compared to that of Euglena free pond and its value was found high during the month of June in both types of pond and have a direct relationship with water temperature and alkalinity.

Nitrate was comparatively high in Euglena infested pond than that of Euglena free pond and its peak value was reported during September in both type of ponds and showed a direct relation with temperature and indirect relation with dissolved oxygen, free carbon dioxide, chloride and alkalinity. Based on present observation it may be inferred that high level of nitrate was due to influx of allochthonous materials during rainy season and responsible for the luxuriant growth of Euglena bloom which is considered as an indicator of pond eutrophication.

A total of 21 genera belonging to class bacillariophyceae (nine genera), euglenophyceae (one genus), chlorophyceae (seven genera) and cynophyceae (four genera) have been identified in both types of pond during the study period. The total number of plankton u/l depicted that the plankton population remained high in Euglena infested pond due to the abundance of Euglena.

Bacillariophyceae was found to be high in Euglena free pond as compared to that of Euglena infested pond because of low organic matter and high content of dissolved oxygen. The highest value was observed in winters in Euglena free pond due to high transparency, dissolved oxygen and chloride content. Summer peak was recorded in Euglena infested pond which is favoured by high content of free carbon dioxide, temperature, transparency, and total dissolved solids. Further, it was observed that both type of ponds differ in planktonic diversity as a result six genera viz. *Amphora, Coconeis, Fragilaria, Gomphonema, Navicula* and *Tabellaria* were in abundance in Euglena free pond but the abundance of only two genera i.e. *Cymbella* and *Synedra* was recorded in Euglena infested pond. The present findings inferred that genus *Cymbella* was absent in Euglena free pond and genus *Tabellaria* were absent in Euglena infested pond.

Euglenophyceae was comparatively high in Euglena infested pond and mainly dominated by genus *Euglena* and its two peaks was observed that is May and October which is due to high concentration of free carbon dioxide, total dissolved solids, nitrate and total hardness. In Euglena free pond the maxima were observed in monsoon due to high temperature, free carbon dioxide, transparency and the concentration of nitrate but low dissolved oxygen and total hardness.

Chlorophyceae was high in Euglena free pond as compared with that of Euglena infested pond. Its maximum density was recorded during April month due to high dissolved oxygen and total hardness. In Euglena infested pond highest value was recorded during January due to low temperature and high concentration of total dissolved solid and alkalinity. Further, the presence of genus *Ankistrodesmus* was noticed in Euglena infested pond similarly genus

Mesotaenium was observed only in Euglena free pond. In Euglena free pond only two genera *viz.*, *Closterium* and *Pediastrum* were in abundance where as in Euglena infested ponds abundance of four genera was noticed i.e. *Ankistrodesmus*, *Scenedesmus, Spirogyra* and *Volvox.*

Cynophyceae was comparatively high in Euglena free pond during August due to low content of free carbon dioxide and high level of nitrate. In Euglena infested pond maximum value of cynophyceae was noticed in two different months that is January and August and supported by different physicochemical parameters in different months particularly nitrate and alkalinity. Though abundance of only one genus i.e. *Agmenellum* was recorded in Euglena free pond where as rest three genera i.e. *Anabaena, Gomphospheria, Synechocystis* showed their abundance in Euglena infested pond.

Rotifer showed high percentage in Euglena free pond as compared to Euglena infested pond. In both types of pond maximum density of rotifers was noticed in the month of June due to high temperature, free carbon dioxide and total dissolved solids. Further, the abundance of *Brachionus* and *Keratella* was reported from Euglena infested ponds but *Keratella* was absent in Euglena free pond which is an indicator of polluted water.

Copepoda has been observed comparatively high in Euglena infested pond in the month of April due to high dissolved oxygen and total hardness. In Euglena free pond the peak value was reported in the month of June and July due to high free carbon dioxide.

Statistical analysis of physico-chemical and biological parameters revealed that following physico-chemical parameters exhibited positive and highly significant relationship in Euglena free and Euglena infested ponds that is pH and dissolved oxygen ($r = 0.5, 0.1$), dissolved oxygen and water temperature ($r = 0.1, 0.1$), Free carbon dioxide and pH ($r = 0.3, 0.1$), total dissolved solid and water temperature ($r = 0.7, 0.7$), nitrate and water temperature ($r = 0.2, 0.3$) as well as alkalinity ($r = 0.09, 0.01$). On the other hands some parameters showed negative and significant relationship in Euglena free and Euglena infested ponds which are alkalinity and free carbon dioxide (r = -0.2, -0.1) as well as water temperature (r = -0.8), chloride and water temperature (r = -0.6, -0.8), total hardness and water temperature (r = -0.07, -0.04), total dissolved solid and alkalinity (r = -0.5, -0.6).

The statistical analysis of biological parameters particularly plankton together with physico-chemical parameters in Euglena free pond revealed that positive and significant relationship was obtained between Bacillariophyceae - chloride (r = 0.4), euglenophyceae (r = 0.2) and copepoda (r = 0.9); Euglenophyceae – transparency (r = 0.3), dissolved oxygen (r = 0.1), total hardness (r = 0.1), cynophyceae (r = 0.3) and total plankton (r = 0.01); Chlorophyceae - dissolved oxygen (r = 0.9), total hardness (r = 0.7), rotifers (r = 0.4) and total plankton (r = 0.9); Cynophyceae - nitrate (r = 0.09) and copepoda (r = 1); Rotifers – total dissolved solids (r = 0.6) and free carbon dioxide (r = 0.5) and Copepoda - free carbon dioxide (r = 0.7). Similarly in Euglena infested pond the positive and significant relationship was furnished between Bacillariophyceae – free carbon dioxide (r = 0.5), total dissolved solids (r = 0.1), chlorophyceae (r = 0.5), rotifers (r = 0.9) and copepoda (r = 0.1; Euglenophyceae - water temperature (r = 0.1), nitrate (r = 0.5), chlorophyceae (r = 0.08) and total plankton (r = 0.9); Chlorophyceae - water temperature (r = 0.2), rotifers (r = 0.4) and total plankton (r = 0.08).; Cynophyceae - nitrate (r = 0.6); Rotifers - total dissolved solids (r = 0.6), free carbon dioxide (r = 0.5) and copepoda (r = 0.1) and Copepoda - dissolved oxygen (r = 0.6) and total hardness (r = 0.4).

The species diversity index (Shannon Weaver index) revealed that the highest value of Shannon Weaver index was calculated for Euglena free pond (2.49) which is due to more equal proportion of taxas. The planktonic diversity and abundance of different taxa differs in different types of pond for example in Euglena free pond the chlorophycae stands first then bacillariopyceae and cynophyceae but in Euglena infested pond similar groups were observed in sequence of euglenophyceae, chlorophyceae and bacillariophyceae.

The growth performance of common carps in control and Euglena infested troughs revealed that the survivability of carps was 100 per cent in control trough as compared to 50 per cent in Euglena infested trough where the growth of fish was also less. The difference in water quality parameters of control and Euglena infested trough was noticed in terms of low dissolved oxygen but high total dissolved solid and nitrate which accelerated the growth of Euglena bloom. Thus it may be inferred that the density of Euglena bloom affected the physico-chemical and biological parameters besides the growth and survivability of fish.

The impact of Euglena bloom on growth performance of common carp depicted that the total dissolved solid, nitrate and alkalinity remain higher in Euglena infested trough where as dissolved oxygen was high in control trough and similar observation was noticed in ponds also.

The study of biological parameters exhibited that the plankton population u/l was high in Euglena infested trough due to higher density of *Euglena* that is the indication of eutrophication. A total of 15 genera instead of 21genera of phytoplankton in different ponds belonging to class bacillariophyceae, euglenophyceae, chlorophyceae and cynophyceae have been recorded. The percentage of bacillariophyceae in control trough was high as compared to the Euglena infested trough due to high content of dissolved oxygen and total dissolved solids. Euglena infested trough comprises four genera *viz., Coconeis Fragilaria, Navicula* and *Synedra* whereas only two genera *(Navicula* and *Synedra)* were reported from control one and the genus *Synedra* was common but rare in control one. The presence of *Coconeis* and *Fragillaria* in Euglena infested trough indicated greater tolerance of high profile of nutrients.

Further Euglena was totally absent in control trough and its maxima in Euglena infested trough was recorded in March due to high nitrate, alkalinity and total dissolved solids which are the major parameters for the growth of Euglena bloom.

The percentage of chlorophyceae, cynophyceae and rotifers was high in control trough but Euglena and copepods in Euglena infested trough. These groups have a direct or indirect relation with physico-chemical parameters. The absence of *Volvox, algae* of odour and taste was reported in Euglena free trough may be due to presence of less nutrient/organic matter.

The results of this study inferred that the physico-chemical parameters particularly low dissolved oxygen and high value of free carbon dioxide, Chloride, total hardness, total dissolved solids, and nitrate favoured the production of Euglena bloom as a result the population of plankton unit per litter increased and suppressed the growth of other plankton liked by fishes. The planktonic diversity of Euglena infested pond and trough differs from Euglena free pond and trough. The biological productivity of Euglena infested pond and trough is less than that of Euglena free ponds and troughs. Thus it may be concluded that the Euglena bloom directly affects the pond's productivity, water quality and oxygen balance and the impact of these resulted in terms of low production and survivability of fishes.

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