INFLUENCE OF HYDROGRAPHICAL PARAMETERS ON THE COMPOSITION AND SEASONAL VARIATION OF THE PLANKTON POPULATION

IN A PRAWN FILTRATION POND

By

MAYA RAMACHANDRAN, B.F.Sc.

THESIS

Submitted in partial fulfillment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

2009

DEPARTMENT OF FISHERY HYDROGRAPHY

COLLEGE OF FISHERIES

PANANGAD, COCHI

Dedicated To
My Family, Teachers
And Friends

DECLARATION

I hereby declare that this thesis entitled **"INFLUENCE OF HYDROGRAPHICAL PARAMETERS ON THE COMPOSITION AND SEASONAL VARIATION OF THE PLANKTON POPULATION IN A PRAWN FILTRATION POND"** is a bonafide record of research work done by me during the course of research and that the thesis has not formed the basis for the award to me of any degree, diploma, associateship, or other similar title, of any other University or Society.

Panangad,
31-01-2009. MAYA RAMACHANDRAN

CERTIFICATE

Certified that this thesis entitled **"INFLUENCE OF HYDROGRAPHICAL PARAMETERS ON THE COMPOSITION AND SEASONAL VARIATION OF THE PLANKTON POPULATION IN A PRAWN FILTRATION POND"** is a record of research work done independently by **Smt. MAYA RAMACHANDRAN** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

Panangad,
31.01.2009

Sri. N. N. RAMAN
(Chairman, Advisory Committee),
Assistant Professor (Sel. Gr.) and Head i/c
Department of Fishery Hydrography,
College of Fisheries,
Panangad, Kochi.

NAME AND DESIGNATION OF THE MEMBERS OF THE ADVISORY COMMITTEE / EXAMINATION COMMITTEE

CHAIRMAN **Signature**

Sri. N. N. RAMAN
ASSISTANT PROFESSOR (SEL. GR.) AND
HEAD i/c
DEPARTMENT OF FISHERY HYDROGRAPHY,
COLLEGE OF FISHERIES,
PANANGAD, KOCHI.

MEMBER

Dr. THRESSIAMMA JAMES
PROFESSOR,
DEPARTMENT OF AQUACULTURE,
COLLEGE OF FISHERIES,
PANANGAD, KOCHI.

MEMBER

Dr. J. RAJASHEKHARAN NAIR
PROFESSOR,
DEPARTMENT OF FISHERY BIOLOGY,
COLLEGE OF FISHERIES,
PANANGAD, KOCHI.

MEMBER

Sri. MATHEW SEBASTIAN
ASSISSTANT PROFESSOR (SEL. GR.),
DEPARTMENT OF MANAGEMENT STUDIES,
COLLEGE OF FISHERIES,
PANANGAD, KOCHI.

EXTERNAL EXAMINER

ACKNOWLEDGMENTS

I am deeply indebted to Sri. N.N. Raman, Assistant professor (Sel.Gr.) and Head i/c, Dept. of Fishery Hydrography, College of Fisheries Panangad for his constructive guidance and prompt advice throughout the course of my study. His broad minded and careful attention, inestimable suggestions and meticulous scrutiny of the manuscript helped me a lot in the preparation of the thesis. I am deeply obliged to him.

The other members of my advisory committee, Dr. Thressiamma James, Professor, Department of Aquaculture, Dr. J Rajashekharan Nair, Professor, Department of Fishery Biology and Sri. Mathew Sebastian, Assistant professor (Sel. Gr.), Department of Management Studies, have given useful suggestions during the study, and have gone through the manuscript meticulously. Their timely advice has helped me in improving quality of this thesis. I am greatly indebted to each one of them.

I am grateful to Dr. C.M. Nair, Dean, Dr. D.D. Namboodiri, Dr. K. K. Varma and Dr. K. S. Purushan, former Deans, College of Fisheries, for providing necessary facilities for my work.

I owe a great deal to Dr. C.J Cherian, Associate Professor (Retd.), Dept of Fishery Hydrography, who evinced a keen and genuine interest in my work and gave timely guidance during the course of this study.

I wish to express my gratitude to Dr. K.R Renjith, Guest Lecturer, College of Fisheries, Dr. K.V Jayachandran, Professor and Head of the Department of Fishery Biology, College of Fisheries, Dr. A.V. Saramma, Professor, School of Marine Science, Cochin University of Science and Technology, Dr. Aneykutty Joseph, Professor, School of Marine Science, Cochin University of Science and

Technology for their invaluable and timely help during the course of this work and during the preparation of this thesis.

I am extremely thankful to Smt. Manju K.G., Teaching assistant, Dept. of Fishing Technology, College of Fisheries for their encouragement in carrying out my study and research. I wish to thank Sri. Kunjumuhammed, Librarian and Sri Jaya Pradeep, Reference Assistant, College of Fisheries for their help during my study. The helps extended by Sri P.P Pushpakaran, Laboratory Assistant and Sri. George, Farm Supervisor, during the sample collection, was of great value.

My friends Jayasree, P.S., Seena Augustine, Sukham Monalisha Devi, Manjusha S, Anu, Navya have provided all the help and support during my M.F.Sc programme. I express my sincere thanks to them.

Finally, I am grateful to my family for their unfailing encouragement which gave me enough enthusiasm in carrying out this work.

Panangad

31-1-2009 **MAYA RAMACHANDRA**

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

INTRODUCTION

1. INTRODUCTION

The coastal wetlands in Kerala which is considered to possess rich renewable organic resource consist of a reticulate system of backwaters and canals (area of 3313 km²). The Cochin estuary, a part of Vembanad - Kol wetlands is the largest estuarine system in the south west coast of India. It lies parallel to the coastline with several islands and small arms with permanent openings to the Arabian Sea at Kochi (450m wide) and Azheekode. The region around Cochin barmouth is generally referred to as Cochin backwaters. With respect to the rich biodiversity and ecological values made Cochin estuary to be identified as a Ramsar Site (1214).

The tropical estuarine environment shows multitudinal features which characterize freshwater and sea water mixing and provides breeding ground for marine organisms. Cochin backwater supports diverse species of flora and fauna according to their tolerance for saline environment. Due to the tidal influence and the influence of land drainage, as well as monsoon rains, the hydrographical features of the prawn filtration fields are also typically estuarine (George, 1974).

The Cochin backwater system is the second largest shrimp resource zone in India, but this area naturally produces more than twice as much shrimp/unit area than the largest Hooghly-Matlah estuarine system (Stephen, 1985). There are 26,000 ha saline pokkali fields and a wide continental shelf embracing 39,139 km² in the aquatic resource map of Kerala (Anon, 2000; Purushan, 2000). The Cochin estuary and its adjoining low lying areas including pokkali fields serve as natural nursery grounds for a number of commercially important brackishwater fish and shrimp seeds like *Mugil cephalus* ,other mullets, *Chanos chanos, Lates calcarifer, Etroplus suratensis, Oreochromis*

mossambicus and shrimps like *Fenneropenaeus indicus, F. monodon, Metapenaeus dobsoni, M. monoceros* etc. The pokkali fields are unique in geographical features of Kerala producing enormous quantity of special variety of paddy and palatable shrimp and fish depending on seasons (Purushan, 2002).

The traditional culture fields fall into two categories: the seasonal fields and perennial fields. In seasonal fields, generally known as pokkali fields, paddy is grown during the monsoon months (June- September) when the backwater system is freshwater dominated. After the monsoon, rice is cultivated and when the water becomes brackish, the post larvae and juveniles of commercially important prawns are allowed to migrate into these fields in large numbers and they are trapped with the help of suitably located sluices. The shrimps take shelter in between the decaying paddy stalks and grow. The disintegrating paddy stalks release nutrients to the systems invigorating photosynthetic activity, periphyton production and live feed generation in addition to transforming itself as detritus. There is minimum interference by way of addition of fertilizers and artificial feeds. The synergistic effect of all these and the congenial conditions prevailing devolve to form a niche of forage organisms to the growing shrimps which attain marketable size within 3-4 months period. These shrimps are filtered during thakkams associated with lunar phase. A very long close meshed conical bag net (Erakkavala) is used for sluice gate filtration for effectively catching the shrimps (Purushan, 1996).

The perennial fields, where prawns are raised round the year are deeper than the seasonal paddy fields. The yields from these fields are generally higher than those from seasonal fields (George, 1974), because here prawns are cultured through out the year and they attain larger size. No additional expenditure is involved in the perennial

fields as in the preparation of seasonal fields for prawn culture after the harvest of paddy.

Of the 13000 ha in which shrimp farming is extended in Kerala, about 7000 ha pokkali fields are utilized for traditional shrimp filtration during summer season (Purushan, 2002). These fields are located in Trichur, Ernakulam, Kottayam, Alleppey districts centered around the backwater systems.

Of the catch of shrimps through traditional practice *M.dobsoni* (55-57%) dominates followed by *F.indicus* (36-42%), *M.monoceros*(3-6%) and *P.monodon* (0.7-1.0%). The extensive field areas or polders lying adjacent to the lake at the lower Kuttanad region (upstream region of the lake) are also used for trapping and growing fishes and palaemonid prawns but the catch mainly comprised of freshwater fishes (94%) mainly catfishes i.e. *Heteropneustes fossilis, Clarias batrachus, Ompok bimaculatus, Mystus malabaricus Wallago attu* and palaemonid prawns (7%) viz, *Macrobrachium rosenbergii and M. idella* (Kurup *et al.*, 1992).

Thus the pokkali fields are proved pre-eminent among the natures bounties to produce ample aquatic food items depending on seasons. Past records revealed that about 1.5 tonnes of shrimps and equal quantity of fishes/ha were realized from these fields during summer season in addition to their capacity to yield almost same measure of tasteful pokkali paddy during monsoon season. But the above trend could not be continued for long especially during 1980's, on account of the adverse effect of aquatic pollution and other associated factors (Purushan, 2002).

A comprehensive knowledge of natural fish food organism is an essential pre-requisite for successful prawn culture. The present study was undertaken with a view to find out the influence of

hydrographical parameters on the composition and seasonal variation of plankton population. Studies on the occurrence and abundance of such organism in relation to hydrographic conditions would be useful for evolving methods for improving the fishery potential of these prawn culture fields. This would generate necessary information for quantifying the requirements of supplementary feed in the field. Such studies may also be useful for obtaining optimum production in these prawn culture fields.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The prawn filtration field, in which the study was conducted, is connected with the southern part of the Cochin backwaters. Through the permanent openings at Azheekode and Cochin, seawater enters the backwater and associated canals and fields during high tides. Due to the tidal influence and the influence of land drainage, as well as monsoon rains, the hydrographical features of these waters are typically estuarine (George, 1974).

2.1 HYDROGRAPHICAL PARAMETERS

Cochin estuary is one of the intensively studied estuarine systems in India. The seasonal characteristics are well studied. The estuary exhibits partially mixed condition in postmonsoon season, a saltwedge in southwest monsoon season and well mixed condition in premonsoon season (Anon, 2004). Several workers have studied about the hydrography of Cochin backwaters (Balakrishnan, 1957; Ramamritham and Jayaraman, 1963; Cheriyan, 1967; Sankaranarayanan and Qasim, 1969; Qasim *et al.*, 1969; Qasim and Gopinathan, 1969; Josanto, 1971; Sreedharan and Salih, 1974; Balakrishnan and Shynamma, 1976; Varma *et al*., 2002; Vijayakumar, 2003; Haridevi *et al*., 2004; Renjith *et al*., 2004 and Anon, 2004).

The environmental conditions of prawn filtration ponds were explained by several authors (Balachandran *et al*.,1980; Sankaranarayanan *et al.*,1982; Gopinathan *et al*.,1982; Singh,1987; Mathew,1987; Gopalakrishnan *et al.*,1988; Jose *et al.*,1988; Joseph *et al*., 1988; Nair *et al.*,1988; Balasubramanian *et al.*,1995; Venketesan *et al.*,2001; Sudheer,2003 and Susheela *et al.*, 2006).

The hydrographical conditions of the Cochin backwater are greatly influenced by seawater intrusion and influx of river water

(Menon *et al*., 2000). Salinity is the major indicator of estuarine mixing. The hydrographical conditions of Vembanad Lake have a well defined seasonal pattern in salinity variations (Ramamritham and Jayaraman, 1963; Qasim and Gopinathan, 1969). Sankaranarayanan and Qasim (1967) reported that salinity values were maximum in premonsoon months in Cochin backwaters. Stratification was reported during monsoon at lower reaches of estuary because of salt water intrusion (Balakrishnan and Shynamma, 1976; Ramaraju *et al.*, 1979; Udayavarma *et al.*, 1981; Sankaranarayanan *et al.*, 1986; Joseph and Kurup, 1990). Varma *et al.* (2002) analysed long term daily variation of salinity at a station near Panangad Jetty and noticed that salinity range between 0 and 32‰ with a bimodal variation. Anon (2004) studied salinity variation in Panangad region of Vembanad Lake. During the southwest monsoon period (June-Sept) the salinity remains less due to the inflow of large amount of freshwater (George, 1958). An annual salinity range of 1-27‰ in seasonal and perennial prawn culture fields of Cochin estuarine system was observed by Gopinathan (1982) Sankaranarayanan *et al.* (1982); Singh (1987) and Venketasan *et al.* (2001). Sudheer (2003) found that the average salinity of an interior prawn filtration field in Cochin is around 14.3‰ during the study period. The study conducted by Susheela *et al.* (2006) in the same field revealed that the during pre-tsunami (2003-04) the salinity range was 3.0-27 ‰ while after the tsunami the salinity range varied from 12.0-26.0 ‰.

Vembanad Lake, being a tropical estuary, temperature variations are not as high as salinity. According to KunjuKrishna Pillai *et al.* (1975) temperature values range between 25°C and 33°C. Nair and Tranter (1971) have reported that the temperature does not vary much between pre and post monsoon. With the onset of monsoon, there was a decrease in surface temperature and a certain amount of uniformity was

maintained in temperature till the end of monsoon (Menon *et al.,* 1971, Kunjukrishnapillai *et al.,* 1975, Balakrishnan and Shynamma, 1976). Kumaran and Rao (1975) reported that monsoon rain and winter season caused a decrease in temperature unless there was a break in the monsoon and the temperature decreased from Nov- Jan due to the winter effect and then increased during next three months in the estuarine area between Narakkal and Aroor. Balakrishnan and Shynamma (1976) reported lowest values of temperature during July-August in Cochin harbour area. In the premonsoon period temperature was high at all depths. The variation in temperature in both surface and bottom waters of northern part of Vembanad Lake during different seasons were also related to the depth and location of stations (Bacha, 2000). Using daily temperature data for a long duration, Varma *et al.* (2002) observed a bimodal annual variation near Panangad Jetty.

Sankaranarayanan *et al.* (1982) found that temperature values were low during the south west monsoon in the culture field at Ramanthuruth. Singh (1987) reported that the temperature reached the peak during the pre- monsoon and showed a declining trend during monsoon months in seasonal and perennial fields. He observed that temperature values ranged between 24.5°C and 32.5°C. Nair *et al.* (1988) reported the annual variation in temperature in paddy-cum-prawn culture fields was less (~5°C) to affect the environment. Temperature was low during December-February and showed an increasing trend afterwards. This was followed by a decrease during monsoon months and again an increase during the later months. Susheela *et al.* (2006) observed a temperature range of 30-35°C after tsunami in an interior prawn filtration field in Cochin.

Turbidity is a measure of clarity of water. The greater the amount of suspended sediments in the water, murkier it appears and the higher

the measured turbidity. Anon (2004) found that turbidity values showed clear seasonal variation. During premonsoon, turbidity ranged between 0.9 and 15.5 NTU at surface with an average of 5.8 NTU and at the bottom, the range was from 1.4 to 12.7 NTU with an average of 7.3 NTU. During southwest monsoon period, it increased and ranged between 0.49 and 28.7 NTU (average 12.2 NTU) at surface and ranged between 0.56 and 36.9 NTU (average 16 NTU) at the bottom. During postmonsoon period, the surface and bottom values ranged between 0.1 and 13.3 NTU (average 3.4 NTU) and between 0.23 and 26.5 NTU (average 6.1 NTU) respectively.

pH is an important chemical factor affecting metabolism and other physiological processes of aquatic organisms. Sankaranarayanan and Qasim (1969) reported that pH exhibited considerable fluctuations at the surface of Cochin backwater. During the period of freshwater discharge the values at all depths were found to decrease reaching a minimum during July and August. It is interesting to note that clear stratification noticed in the case of salinity, temperature and oxygen was not observed with regard to the pH values. pH of the entire water column either decrease or increase simultaneously.

Sankaranarayanan *et al*. (1982) found that the pH values varied between7.0-8.2 in some tidal pools of Cochin. Higher values were recorded during the pre-monsoon season when the salinity was high. Mathew (1987) reported that there were no seasonal trends in variation of pH and it fluctuated from 6.0 to 9.2 in perennial fields from 6.7 to 8.2 in seasonal fields and from 6.1 to 8.3 in coconut grooves adjacent to Cochin backwater. A pH range of 6.5 to 9.0 is considered good for fish production in the culture ponds (Boyd, 1990; Venketesan *et al*. 2001). Balasubramanian *et al*. (1995) found that in ponds located at Vallarpadom Island, pH ranged between 7.0 and 8.0 in correlation with

changes in primary production. Susheela *et al*. (2006) found a pH range of 7.0-8.5 during pre tsunami (2003-2004) and 6.0-10.5 during post tsunami (2005) periods in an interior prawn filtration field in Cochin.

The variations in alkalinity in the Cochin backwater were less during the premonsoon months (Sanakaranarayanan and Qasim, 1969). Mathew (1987) reported high total alkalinity with wide fluctuations in some prawn culture fields around Cochin. The values ranged from 10-130 ppm in perennial fields, 22.5 – 111 ppm in seasonal fields and 24-185 ppm in Coconut grooves. He also observed that higher values were recorded during premonsoon and lower values during monsoon months. Susheela *et al*. (2006) carried out a study in an interior prawn filtration field and found that the total alkalinity was in the desirable range (25-75 ppm) during 2005 as against the minimum value of 15ppm during 2003-2004.

Seasonal variation in nutrients of Vembanad Lake was studied and found that during premonsoon period when the system was predominantly marine, the nutrient concentration was low and it was high during monsoon due to the influx of freshwater (Sankaranarayanan and Qasim, 1969; Reddy and Sankaranarayanan, 1972; Joseph 1974; Sreedharan and Salih, 1974; Pillai *et al*., 1980; Anirudhan and Nambisan 1990). Sreedharan and Salih (1974) found that phosphate values varied from 0.85 to 5.4 µg at/l. A phosphate concentration of 0-32 µg at/l was reported by Joseph and Pillai (1975).

The amount of nitrate was low (1.5-5.5 µg at/l) except for monsoon and during monsoon and it suddenly increased to 25-30 µg at/l (Sreedharan and Salih, 1974). Nitrate does not seem to be affected by the freshwater discharge and were mostly less than 1µ at/l (Sankaranarayanan and Qasim, 1969). Joseph and Pillai (1975) observed that nitrite range from 0-6 µg at/l. A negative correlation was found

between salinity and silicate in the Cochin estuary (Sankaranarayanan *et al*., 1984; Anirudhan *et al*., 1987; Anirudhan and Nambisan, 1990). Anon (2004) found a negative correlation between phosphate, silicate and nitrate with salinity indicating their terrestrial origin.

Sankaranarayanan *et al*. (1982) reported that inorganic phosphate values were high throughout the year in the tidal ponds of Ramanthuruth island and nitrate values varied between less than 1 and 15µg at/l. Nitrate value showed a general decrease during September - October period and the highest values were recorded during June - August. Nair *et al*. (1988) reported that nitrate values in the culture fields showed an increasing trend during monsoon months due to freshwater discharge. The low nitrate content during remaining period was due to less land drainage and high primary production. Phosphate values were found to vary between 0.97 and 19.69 µg at/l in the culture fields of Cochin (Panigrahi, 1993; Venketesan *et al*., 2001). The range of NO_3-N in water during premonsoon months was found between 0.03 and 7.43 µg at/l (Venketesan *et al*., 2001). Susheela *et al*. (2006) obtained a range of 20.5- 60.5 ppm for silicate in an interior prawn filtration pond.

Dissolved oxygen is an essential factor in the aquatic ecosystem and is an important indicator of water quality. The air - water interaction, respiration and photosynthetic processes influence dissolved oxygen status of aquatic ecosystems. Photosynthesis by phytoplankton is the primary source of oxygen (Hepher, 1963). The solubility of oxygen in water is mainly influenced by temperature and salinity (Weiss, 1970) and it decreases with increase in salinity and temperature. The lowest DO in Cochin backwater was recorded during monsoon (June-August) and highest during premonsoon season (Pillai *et al*., 1975). They observed an annual range from 1.1ml/l to 5.9 ml/l. Balakrishnan and

Shynamma (1976) observed DO values below saturation at all depth in all seasons in the Cochin harbour area, which could be due to the possible utilization for the decomposition of organic matter. Selvaraj *et al*. (2003) also found high dissolved oxygen during postmonsoon period and low values during premonsoon with a range of 3.29-4.93 ml/l.

Nair *et al.* (1988) reported that dissolved oxygen varied widely with tides in the paddy-cum-prawn culture fields. Seasonal fields, being shallow, showed low dissolved oxygen when compared with perennial fields. This could be attributed to the decomposition of organic matter present at the bottom.

Singh (1987) found that seasonal and perennial culture fields had low oxygen values during the pre-monsoon and the values increased with the onset of the monsoon. Dissolved oxygen values were high during the peak monsoon month (July).

Sankaranarayanan *et al.* (1982) observed high oxygen values (2-7ppm) during the pre-monsoon months in tidal ponds of Ramanthuruth island whereas low values (<4ppm) were observed during the southwest monsoon period. The values steadily increased in the following months.

2.2 BIOLOGICAL PARAMETERS

Cochin backwater is one of the estuarine areas in India, which has been subjected to extensive biological research work. The salinity gradient in the Cochin backwater support diverse flora and fauna according to their tolerance for saline environment (Menon *et al*., 2000). This tropical estuary, with high productivity acts as a nursery ground for many species of marine finfishes, molluscs and crustaceans.

Organic production of Cochin backwaters was studied by Qasim et al. (1969, 1973, 1979); Nair *et al*. (1975); Pillai *et al*. (1975); Gopinathan *et al*. (1984), Sreekumar and Joseph (1997); Renjith *et al.*

(2004), Anon (2004). The estimated gross production ranged from 272 to 293 gC/m^2/yr and net production was 193 gC/m^2/yr (Menon et al., 2000). Nair *et al*. (1975) reported that the rate of primary production in the Vembanad Lake was uniformly high, the maximum being 3 gC/m^2/day with average of 1.2 gC/m^2/day. It appears that primary production is not a limiting factor for secondary production in the estuary. The reason for not maintaining the conversion ratio between the primary, secondary and tertiary levels is possibly due to the interference of salinity (Menon *et al*., 2000). Primary production showed considerable seasonal variation, with postmonsoon season recording the peak period (Menon *et al*., 2000) and this might be due to optimum light intensity and effective utilization of nutrients. Estimation of photosynthetic pigments of flora of Cochin backwaters have brought about contrasting results. Nair *et al.* (1975) have estimated an overall range of 1.5-18 mg/m^3 for chlorophyll a. According to them premonsoon values were 2-3 times higher than that obtained in monsoon. Selvaraj *et al*. (2003) reported an annual mean of 6.64 mg /m^3. Though salinity controls the species composition and succession of phytoplankton, it has apparently no influence on primary production in the estuary (Qasim *et al*., 1972).

Paulinose *et al.* (1981) studied the primary productivity of prawn filtration ponds adjacent to Cochin backwaters and found that all the ponds were rich in primary production with values more than 70 µg at/l for chlorophyll a, but production was less during premonsoon months (January- May).

Mathew *et al.* (1988) reported primary production values of the range 1-30 gC/m^3/day for ponds in fish farm at Vyttila, near Cochin, while Jose *et al.* (1988) reported 1.1-8.1 gC/m^3/day for ponds in the same region.

Nair *et al.* (1988) found that prawn filtration fields in and around Cochin showed maximum chlorophyll a concentration during August-October and March. According to them the high concentration during August-October was due to the effect of land drainage bringing in nutrients during monsoon and the second peak during March was due to blue green algal bloom as a result of rapid regeneration of nutrients during this period. They also found that chlorophyll a content varied between 4.8 and 8.3 µg at/l in the seasonal fields located about 20 km north of Cochin harbour, near to Azheekode entrance, while perennial fields of same area showed chlorophyll concentration between 6.4 and 19.2 µg at/l during the study period.

Balasubramanian *et al.* (1995) carried out a study in two ponds of Vallarpadom Island which revealed the fact that the ponds were having high gross production between 5.68 $mgC/m^2/day$ and 6.21 $mgC/m^2/day$.

According to Venketesan *et al.* (2001) gross primary productivity was between 0.578 and 16.339 $gC/m^3/day$ in the ponds of Puthuvyppu and Valappu, during premonsoon months. He also observed that primary productivity was relatively more in Puthuvyppu ponds than in Valappu ponds. The reason for this high primary production in Puthuvyppu ponds was attributed to the relatively higher tidal influence observed at Puthuvyppu than at Valappu which brought more nutrients for the growth and multiplication of phytoplankton.

It is understood that salinity is the most important parameter that controls the phytoplankton diversity and succession (Menon *et al*., 2000). Of the various categories, nanoplankton comprising diatoms is relatively high through out the year (Qasim *et al*., 1974, Kumaran and Rao, 1985). They also found that around 70% of the total phytoplankton was contributed by *Skeletonema costatum*. Gopinathan (1975) had

inferred that proliferation of diatoms or biological spring fell during the monsoon months, when the diatom peaks coincide with low salinity and temperature associated with high concentration of nutrients.

According to Menon *et al*. (2000) the phytoplankton production in the Cochin estuary during premonsoon was high and fairly stable, with the dominant diatoms being *Chaetoceros*, *Coscinodiscus*, *Skeletonema*, *Pleurosigma* and *Nitzchia* and dinoflagellates of the genera *Peridinium*, *Gymnodinium* and *Ceratium*. During monsoon, flora was mostly fresh water species of the genera *Pledorina, Volvox*, *Pediastrum* and desmids. While during post monsoon gradually fresh water species disappear coinciding with the predominance of marine forms. Kumaran and Rao (1975) were of the opinion that most of the species recorded in the Cochin backwater were marine forms and the area near the barmouth was the most productive area. Sreekumar and Joseph (1995) estimated that periphytic algae of Cochin backwater were comprised of 66 species of Bacillariophyceae, 8 species of Chlorophyceae and 2 species of Cyanophyceae

Gopinathan (1972) found that temperature had no direct influence on phytoplankton production. About 120 species of phytoplankton were recorded by him. He also observed 2 peaks of abundance – one from May to July and the other from October to December.

Bopiah *et al*. (1982) studied the ecology of a tidal pond in estuarine enviornment of Karwar and found that abundance of phytoplankton occured during February i.e. during pre monsoon.

Gopalakrishnan *et al.* (1988) studied about phytoplankton present in paddy cum prawn culture fields at four locations in and around Cochin backwaters. Total phytoplankton counts, in the seasonal and perennial fields in all the four areas showed maximum during

monsoon period. Highest average count of 4617 cells/l was observed at places fifteen km southeast of Cochin harbour entrance.

According to Nair *et al*. (1988) high concentration of phytoplankton was observed in seasonal fields in April (15380 cells/l) while phytoplankton concentration in perennial fields showed two peaks- one in May (7436 cells/l) and the other in September (5661 cells/l).

Balasubramanian *et al*. (1995) carried out a study in two adjoining culture ponds at Vallarpadom Island and found that phytoplankton was largely represented by diatoms, dinoflagellates and cyanophyceae.

A pioneering attempt of making a qualitative and quantitative study of zooplankton of the estuary was by George (1958) who enumerated the various groups existing in the estuary and attempted to correlate the seasonal fluctuations of the zooplankton population with changes in the salinity of water.

There are several reports on the seasonal and spatial changes of zooplankton of the Vembanad Lake and connected backwaters (Nair and Tranter, 1971; Menon *et al*., 1971; Haridas *et al.*, 1973; Wellershaus, 1974; Madhupratap, 1978).

Variations in the relative proportions of specific groups such as copepods, chaetognaths, hydromedusae, siphonophores, decapod larvae and cladocerans have been studied by various authors (Wellershaus, 1969, 1970; Abraham, 1970; Pillai, 1970, 1972; Srinivasan, 1972; Santhakumari and Vannucci, 1972; Mohammad and Rao, 1972; Pillai *et al.*, 1973; Pillai and Pillai, 1973; Sudheer, 2003 and Haridevi *et al*., 2004).

Menon *et al.* (1971) investigated the total biomass and faunal composition of the zooplankton in Cochin backwaters during January to December and found that three groups viz. copepods, decapod larvae and cladocerans dominated the total zooplankton. He observed that no single group continued to dominate the community though copepods were the major component of the community for most part of the year and abundance of cladocerans was noted only during the low salinity period.

Silas and Pillai (1975) stated that copepods, decapod larvae, cladocerans and cirripede larvae were the predominant components of zooplankton in the Cochin estuary. Of these copepods constituted 55-85% of the total zooplankton.

Distribution pattern of zooplankton in the Cochin backwater suggest that salinity is the major limiting factor controlling abundance (Menon *et al.*, 2000). All groups of zooplankton exhibited seasonal changes, according to the seasonal changes in salinity (Nair and Tranter, 1971, Haridas *et al.*, 1973, Wellershaus 1974, Madhupratap and Haridas, 1975, Rao *et al.* 1975, Madhupratap, 1978 and Silas and Pillai, 1975). About 90% of the common species occurring in the estuary registered their peak abundance during period of high salinity (Nair and Tranter, 1971; Rao *et al*., 1975). Zooplankton density falls during monsoon since the water becomes practically fresh and renders it unstable for the sustenance of zooplankton (Menon *et al*., 2000). Madhupratap and Haridas (1975) observed that the organisms that required high salinity conditions were eliminated during the monsoon and the organisms requiring low salinity conditions occupied the middle and upper reaches of the estuary.

Gopalakrishnan *et al.* (1988) studied about the zooplankton of some paddy-cum-prawn culture fields in and around Cochin and

reported that there was a scarcity of zooplankton in these fields. They also found that the seasonal culture fields had greater abundance of zooplankton compared to the perennial fields.

Jose *et al*. (1988) studied the zooplankton of a brackishwater fish farm in the area and reported that the zooplankton mainly composed of copepods with an average annual mean of 170 numbers/litre, which was 62.68% of the total plankton. The copepods were dominant during the high saline period from January to May (140-1021 numbers/l) whereas during the low saline phase from June to October their number was low and it ranged between12 and18 numbers/l.

Joseph (1988) reported that in the culture fields the zooplanktons were constituted mainly by copepods, rotifers and crustacean larvae.

Nair *et al*. (1988) studied four areas in and around Cochin and came to the conclusion that in general, in all the areas the zooplankton community was represented by one or two groups during the low salinity regime and the zooplankton increased as the salinity increased. The dominant groups in the zooplankton of the areas were copepods, amphipods, fish larvae and decapod larvae.

Materials and Methods

3. MATERIALS AND METHODS

The Vembanad Lake and connected backwaters around Cochin are well known for their role as a nursery ground for important fishery resources of this area. The fishery resource of any area is mainly dependent on the magnitude of primary and secondary productions which inturn are influenced by various physical, chemical and biological factors of water body (Pillai *et al*., 1975). These hydrographical parameters of a pond influence the composition and seasonal variation of the plankton population of that pond.

A perennial prawn filtration pond (Plate 1) having an area of 0.75 ha and 50 cm depth was selected near College of Fisheries, Panangad to study the influence of hydrographical parameters on the plankton population. The selected filtration pond is located adjacent to the southern part of Cochin estuary between Kumbalam and Panangad islands. The Panangad region of Vembanad Lake is about 10 km away from the barmouth which experiences a tidal range of 45 cm and 60 cm during premonsoon and postmonsoon respectively (Anon,2004). The south eastern part of the field has a canopy of mangrove vegetation and the north western border of the field adjoins the backwater. The selected culture field was very shallow and since the depth was below one meter, the vertical variations in hydrographical parameters were not considered (Sankaranarayanan *et al.,* 1982 and Nair *et al*., 1988).

The study was conducted from October, 2007 to July, 2008 for three prevailing seasons viz, postmonsoon (October-January), premonsoon (February-May) and monsoon (June-July). Two stations were selected in the pond, one adjacent to the sluice gate and the other away from the sluice gate. The data obtained for two stations were pooled to get an average picture. All the samples were collected during ebb tide to negate the possible tidal variation. Water samples were collected fortnightly for

the estimation of hydrographical parameters using a clean plastic bucket. Monthly averages were computed from the fortnightly data of the two stations and only monthly averages were reported. Monthly averages of meteorological parameters like maximum temperature, minimum temperature, rainfall and relative humidity were computed from the hourly data collected by the Automatic Weather Station (Plate 2).

3.1. METEOROLOGICAL PARAMETERS

Monthly mean values of meteorological parameters like maximum temperature, minimum temperature, rainfall and relative humidity were considered in the study. These values were computed from the hourly observation taken by an Automatic Weather Station (EMCON make), installed in the campus.

3.1.1 Maximum temperature

Maximum temperature is the highest air temperature attains by the air and usually occurs in the early afternoons.

3.1.2 Minimum temperature

Minimum temperature is the lowest air temperature attains by the air and usually occurs in the late nights or early mornings.

3.1.3 Rainfall

Daily total rainfall data was computed from the hourly rainfall data collected by the Automatic Weather Station.

3.1.4 Relative humidity

Relative humidity is the ratio of the actual amount of water vapour present in unit volume of air to the water holding capacity of the air at that particular temperature, expressed in percentage. Relative

humidity recorded by the AWS at 9.00 a.m and 6.00 p. m was taken for the analysis.

3.2 HYDROGRAPHICAL PARAMETERS

Hydrographical parameters of the pond like salinity, water temperature, turbidity, pH, total alkalinity, hardness, dissolved oxygen and nutrients were considered in the study.

3.2.1 Salinity

Salinity was determined by Knudsen-Mohr titration method (Grasshoff *et al*., 1983). The standardization of silver nitrate was done by using standard seawater obtained from I.A.P.S.O. Potassium dichromate was used as the indicator.

3.2.2 Water temperature

The surface water temperature was measured immediately after the sample collection by a precision thermometer.

3.2.3 Turbidity

Turbidity of the sample was read using a digital nephelo-turbidity meter (Systronics, 132) immediately after collection. Calibration of the instrument was done with standard formazin suspension prepared by mixing hydrazine sulphate and hexamethylene tetramine (APHA, 1998). The well mixed sample prepared by gentle agitation, was poured into the sample cell without air bubbles. The turbidity was read directly from the instrument display and was expressed in Nephelo Tubidimetric Unit (NTU).

3.2.4 pH

pH was determined within 15 minutes after sample collection using a digital pH meter (Systronics, MK VI). Each time, prior to the

analysis, the instrument was calibrated using buffer tablets of pH 4.0 and 9.2.

3.2.5 Total alkalinity

Total alkalinity was estimated by acidimetric titration method (Lenore *et al.,* 1998). The titration was carried out using standard hydrochloric acid and methyl orange was used as the indicator.

3.2.6 Hardness

The hardness of the sample was determined by using complexometric titration (APHA, 1995). The indicator employed was eriochrome black T.

3.2.7 Dissolved oxygen

Standard Winkler's method (Strickland and Parsons, 1972) was followed for the estimation of dissolved oxygen content of water samples. Surface water samples were collected insitu in 125 ml. clean oxygen bottles without trapping of air bubbles. Fixing of DO was done immediately after the sample collection by adding Winkler's reagents.

3.2.8 Nutrients

For the estimation of nutrients surface water samples collected were transferred into clean plastic bottles of 250 ml capacity. All these bottles were stored in an icebox with ice and subsequently kept in a freezer till analysis to prevent the loss of nutrients during storage. The nutrients like Nitrate-N, Nitrite-N, Phosphate-P and Silicate-Si were analysed in the laboratory following standard photometric methods (Grasshoff *et al.,* 1983) using UV-VIS spectrophotometer (JASCO, V-530). Phosphate and reactive Silicon were estimated by standard Molybdenum blue method. Nitrate was estimated by cadmium reduction followed by spectrophotometry (Grasshoff *et al.,* 1983). Nitrite was

estimated by photometric determination based on the reaction of nitrite with an aromatic amine leading to the formation of a diazonium compound which couples with a second aromatic amine to form an azo dye (Grasshoff *et al.,* 1983).

3.3 BIOLOGICAL PARAMETERS

3.3.1 Primary production

Primary production was estimated using Gaarder and Graan's light and dark bottle method. Three dissolved oxygen bottles, one dark and two light having a capacity of 125 ml, were filled with the water samples collected without trapping of air bubbles. Oxygen in one of the light bottles was fixed immediately. The second light and the dark bottles were incubated in water for 4 hours in identical conditions by keeping the water bottles in the water taken in a deep tray and kept adjacent to the sampling site. After the incubation period the bottles were taken out and the DO was fixed. The dissolved oxygen was determined titrimetrically using standard Winkler method (Strickland and Parsons, 1972). From the difference in dissolved oxygen content, gross primary productivity was calculated**.**

3.3.2 Chlorophyll-a

Chlorophyll was extracted by filtering about 1litre sample through 0.45µ GF/C filter paper and by keeping in 90% acetone at 4°C overnight. Estimation of chlorophyll-a was done by spectrophotometry (Strickland and Parsons, 1972).

3.3.3 Collection of phytoplankton and zooplankton

Phytoplankton and zooplankton were collected fortnightly from the culture field. Phytoplankton was collected by seiving 30 litres of water through a 55µm mesh bolting silk. The phytoplankton was

transferred to plastic bottles and preserved in 5% formalin. The standing crop of phytoplankton was collected using a Sedgwick rafter counting chamber and the number of cells per litre of water were estimated. All organisms were identified upto generic level.

For the zooplankton analysis, 50 litres of water were taken using a bucket and filtered through a conical plankton net made of 63µm mesh size. The plankton collected at the cod end of the net was transferred to plastic bottles and preserved in 5% formalin for analysis.

The preserved sample of zooplankton was made up to 50ml. in a measuring cylinder and stirred for uniform distribution. Soon after stirring one ml. subsample was transferred to a plankton counting chamber (Sedgwick rafter counting chamber) using a pipette and observed under a stereoscopic binocular zoom microscope for identification and counting. The animals were identified up to group level. Three subsamples of one ml. each were thus analysed and average number of each group per one litre of water (No./l) was calculated.

3.4 STATISTICAL ANALYSIS

The correlation coefficients (Snedecor and Cochran, 1968) were computed for studying the relationship between hydrographical parameters and also between hydrographical parameters and biological parameters.

The means of postmonsoon and premonsoon seasons for different hydrographical parameters were compared using student's t-test (Zar, J.H., 2003)

Plate 1 Automatic Weather Station Installed in the campus

Plate 2 Experimental Prawn Filtration Pond

RESULTS

4. RESULTS

4.1 METEOROLOGICAL PARAMETERS

The results of meteorological parameters are presented in Table 4.4 and the corresponding graphs are presented in Fig.4.3

4.1.1 Maximum temperature

The highest temperature recorded during the study period was 35.06ºC (February). During postmonsoon the maximum temperature recorded was 34.24ºC (December) which increased to 35.06ºC (February) during premonsoon and with the onset of south-west monsoon it again decreased to 32.82ºC (June).

4.1.2 Minimum temperature

The minimum temperature recorded during postmonsoon was 16.42ºC (December) and during premonsoon it increased to 19.15 ºC (March). During south west monsoon it further increased to 20.69ºC (July). The lowest temperature recorded during the study period was 16.42º C (December).

4.1.3 Total rainfall

The maximum rainfall was received in the month of June (156.15mm) while, there was no rain in January. Seasonal comparison of rainfall data had revealed that during postmonsoon the total rainfall received

was 86.5 mm. During premonsoon and monsoon the total amount of rainfall received were 138.42 mm and 288 mm respectively.

4.1.4 Relative Humidity

The comparison of relative humidities of three seasons, viz, postmonsoon premonsoon and monsoon had revealed that the high relative humidity was recorded in the monsoon period during morning and evening hours. Among the monsoon months, high relative humidities were recorded during morning hours. The premonsoon period like monsoon also recorded high relative humidities during morning hours than evening hours. But during postmonsoon period high relative humidities were recorded during evening hours.

4.2 RESULTS OF HYDROGRAPHICAL PARAMETERS AND BIOLOGICAL PARAMETERS

The results of monthly variation of hydrographical parameters and biological parameters and their corresponding graphs are presented in Table 4.1 and Fig.4.1 respectively. The seasonal variation of hydrographical parameters and biological parameters are presented in Table 4.2. Fig.4.2 represents the graphs for seasonal variation of hydrographical parameters and biological parameters.

4.2.1 Salinity

Salinity of the prawn filtration pond ranged between 0.36 ‰ and 26.24 ‰ during the study period. The minimum was recorded in October while maximum was recorded in January. The average salinity during post

monsoon was 15.54 ‰, which decreased to 13.75‰ during premonsoon. With the onset of monsoon salinity further decreased to 5.85 ‰ due to rainfall and land run off.

4.2.2 Water temperature

The average water temperature during post monsoon period was 27.82 ^{0}C which increased to 29.72 ^{0}C during premonsoon. But it decreased to 28.5 ^{0}C during the south west monsoon period. In the culture field water temperature varied between 31.5 ^{0}C and 26.5 ^{0}C. Maximum was recorded during May and the minimum during January.

4.2.3 Turbidity

Turbidity ranged between 9.3 NTU and 35.26 NTU. The maximum was recorded in July, while the minimum was recorded in November. During postmonsoon the turbidity was 17.3 NTU which increased to 21.19 NTU during premonsoon and with the onset of monsoon; water became more turbid (25.02 NTU).

4.2.4 pH

pH increased from 7.74 during postmonsoon to 7.97 during premonsoon and with the onset of monsoon pH again decreased to 6.99. The pH ranged between 7.03 and 8.3. The maximum pH was recorded in May while the minimum value was recorded in July.

4.2.5 Total Alkalinity

The highest alkalinity of 212.5 mg$CaCO_3$/l was recorded in January, February and May, while the lowest value of 50 mg$CaCO_3$/l was recorded in October. During the postmonsoon period the average alkalinity value was 140.91 mg$CaCO_3$/l which increased to 182.81 mg$CaCO_3$/l during premonsoon. But with the onset of monsoon it again decreased to 162.5 mg$CaCO_3$/l.

4.2.6 Total Hardness

The total hardness ranged between 41.25 mg$CaCO_3$/l and 776.25 mg$CaCO_3$/l. Maximum hardness was recorded in February while the minimum was recorded in October. Hardness increased from 533.95 mg$CaCO_3$/l during postmonsoon to 623.44 mg$CaCO_3$/l during premonsoon. But with the onset of monsoon hardness showed a sudden decrease to 225 mg$CaCO_3$/l.

4.2.7 Nitrate-nitrogen

During postmonsoon the estimated nitrate value was 5.24µg at/l which decreased to 3.77µg at/l during the premonsoon season. But with the onset of monsoon it again increased to 5.09µg at/l. Nitrate value ranged between 12.12µg at/l and 3.05µg at/l during the study period. The maximum value was recorded in October, while the minimum value was recorded in March.

4.2.8 Phosphate- phosphorus

The Phosphate value ranged between 8.21µg at/l and 3.05 µg at/l during the study period. Highest value was recorded in April while, the lowest value was recorded in November. The estimated phosphate value during postmonsoon period was 6.1µg at/l and during premonsoon it was 6.44µg at/l. But the phosphate- phosphorus decreased to 5.46 µg at/l during monsoon.

4.2.9 Silicate- silicon

Silicate varied from 39.67µg at/l during postmonsoon period to 14.61µg at/l during premonsoon period. The silicate content showed a sudden decrease (8.6 µg at/l) in the south west monsoon period. Silicate ranged between 72.63µg at/l and 4.81µg at/l. The highest value was recorded in January while the lowest value was recorded in October.

4.2.10 Nitrite- Nitrogen

Nitrite value ranged between 2.39µg at/l and 0.398µg at/l. The maximum value was recorded in February and the minimum value was recorded in October. During postmonsoon the estimated nitrite content was 1.07µg at/l and during premonsoon it was 1.29µg at/l. During the monsoon the estimated nitrite value was 1.16 µg at/l.

4.2.10 Dissolved Oxygen

The maximum dissolved oxygen was estimated in June and the minimum was in December. Dissolved oxygen ranged between 9.6 mg/l and 2.13 mg/l. During postmonsoon the estimated dissolved oxygen was

3.81 mg/l which increased to 5.86 mg/l during premonsoon. With the onset of monsoon dissolved oxygen further increased to 8.6 mg/l.

4.2.11 Primary Productivity

Primary productivity ranged between 3449.3 mgC/m^3/day and 358.9 mgC/m^3/day. The maximum value was recorded in May while the minimum value was recorded in November. The primary productivity value increased from 824.75 mgC/m^3/day during postmonsoon to 2615.17 mgC/m^3/day during premonsoon and decreased to 1922.07 mgC/m^3/day during southwest monsoon

4.2.12 Chlorophyll

The chlorophyll value increased from 9.22 mg/m^3 during postmonsoon to 20.43 mg/m^3 during premonsoon and during monsoon the estimated chlorophyll value further increased to 45.2 mg/m^3. The chlorophyll value ranged between 46.85 mg/m^3 and 3.3 mg/m^3. The maximum value was recorded in June while the minimum value was recorded in October.

4.2.13 Total Phytoplankton

The total phytoplankton values ranged between 2000 cells/l and 7932 cells/l. The maximum value was recorded in June and the minimum value was recorded in October. The phytoplankton counts increased from 4320 cells/l during postmonsoon to 6161cells/l during premonsoon and it further increased to 7751cells/l during monsoon.

4.2.14 Zooplankton

Table 4.3 represents the counts of total zooplankton and the different groups collected during the study period.

The total zooplankton ranged between 9 No. /l and 37 No. /l during the study period. The maximum value was recorded in July and the minimum value was recorded in November and May. During postmonsoon season an average of 13.3 No. /l was estimated which increased to 21 no. /l during premonsoon season and with the onset of monsoon it further increased to 25.5 No. /l.

The major groups of zooplankton collected from the culture field during the study period were copepods, crustacean larvae, nematodes, tintinids, veliger larvae of molluscs, rotifers, fish eggs, polychaete larvae, urochordates and cladocerans.

Considering the frequency of occurence and abundance, groups such as copepods, crustacean larvae, tintinids, veliger larvae, nematodes and rotifers were treated as individual groups, while the groups constituting less than 0.5% in total were included under the category of ‘others’. Crustacean larvae and copepods were collected through out the study period with considerable variation in quantity in different months.

Copepods were the most predominant group of zooplankton (85 No. /l), which contributed 43.8% of the total zooplankton during the study period. The copepods exhibited maximum abundance in July (25 No. /l) while they contributed only 3 No. /l in October.

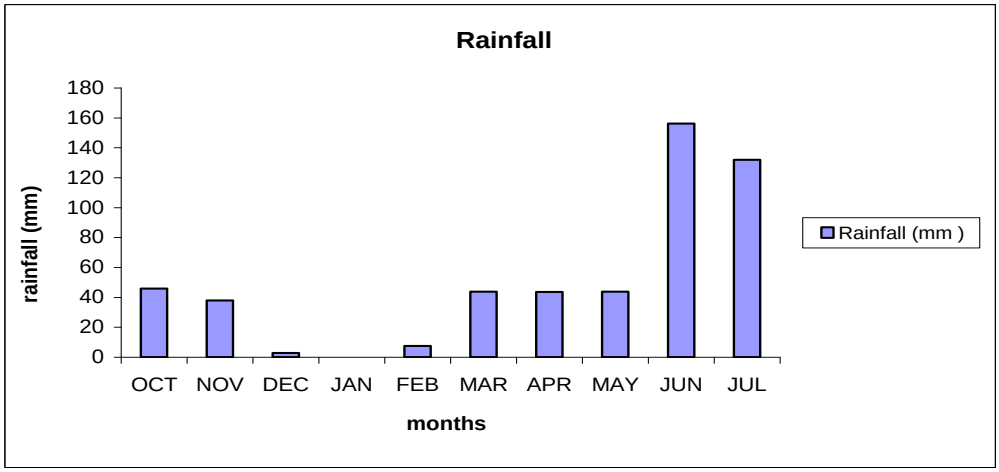
Crustacean larvae occupied the second position (46 No. /l) in abundance during the study period, contributing 23.7 % of the total

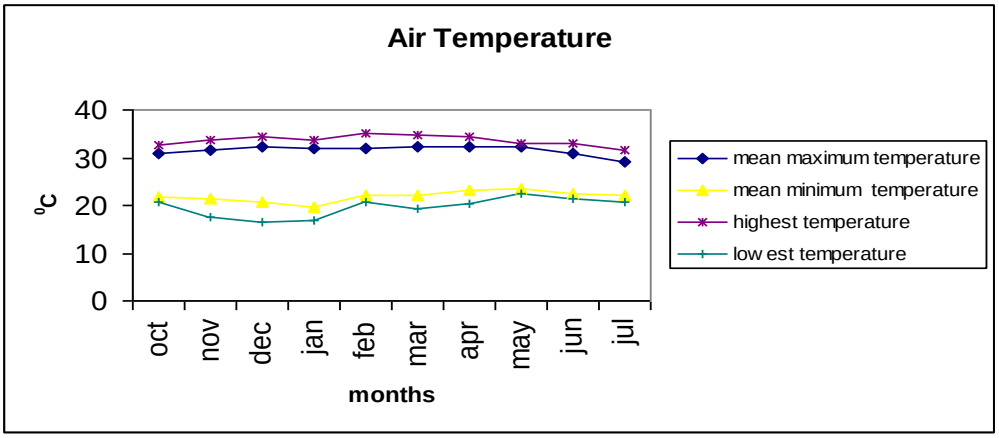
zooplankton. They exhibited maximum abundance in July (10 No. /l), while only 2 No. /l was recorded in December and May. As mentioned earlier, copepods were present throughout the study period.

Tintinids contributed 13.92% (27 No. /l) to the total zooplankton, with maximum abundance in April (14 No. /l). They were absent in the culture field in October, November, December, May and July. Nematodes were maximum in February (11 No. /l) and contributed 10.8% (21 No. /l) to the total zooplankton. They were present in the culture field during December, February, March and April. Veliger larvae contributed 3.09 % (6 No. /l) to the total zooplankton and was present in the culture field only during December, January and February, while rotifers were present in October and July. Rotifers contributed only 1.55% (3 No. /l) to the total zooplankton.

Table 4.1Monthly variation of meteorological parameters

Parameters	Months									
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Mean Maximum temperature (º C)	30.94	31.5	32.19	32.08	32.07	32.17	32..36	32.13	30.8	29.17
Highest Temperature(º C)	32.57	33.78	34.24	33.78	35.06	34.89	34.29	33.01	32.82	31.49
Mean Minimum temperature (º C)	21.8	21.45	20.79	19.57	22.2	22.18	23.27	23.34	22.53	22.16
Lowest temperature (º C)	20.79	17.55	16.42	16.69	20.79	19.15	20.4	22.34	21.35	20.69
Total Rainfall (mm)	45.9	37.9	2.7	0	7.38	43.74	43.56	43.74	156.15	131.85
Relative Humidity (%)										
9.00 a.m.	77.59	74.33	71.32	73.5	79.68	88.65	96.28	91.73	97.17	97.28
6.00 p.m.	82.91	78.45	74.02	68.37	73.93	85.28	93.75	88.45	94.58	97.35





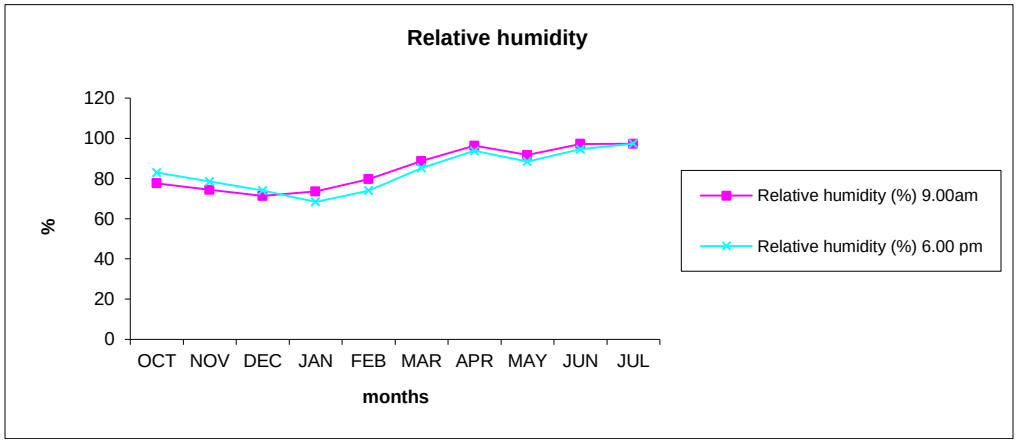


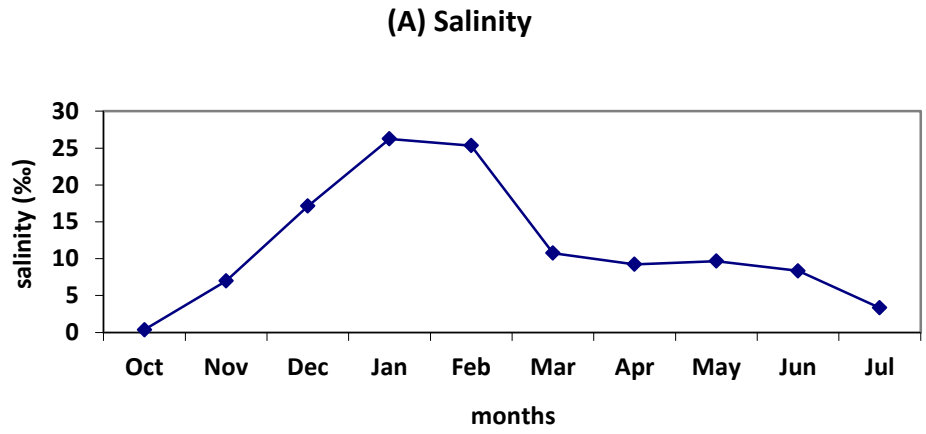
Fig.4.1 Monthly variation of meteorological parameters

Table.4.2 monthly variation of hydrographical parameters and biological parameters

Parameters	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Salinity (ppt)	0.36	6.97	17.13	26.24	25.33	10.75	9.24	9.68	8.35	3.34
Water temperature (º C)	30	28.5	28	26.5	28.88	28.5	30	31.5	31.03	26.88
Turbidity (N.T.U)	22.15	9.3	19.13	17.5	27.53	13.68	19.43	24.1	14.78	35.26
pH	7.03	7.65	7.73	8.14	8.27	7.7	7.6	8.3	7.2	6.78
Alkalinity ($mgCaCO_3$/l)	50	75	150	212.5	212.5	168.75	137.5	212.5	162.5	162.5
Hardness ($mgCaCO_3$/l)	41.25	560	728.33	621.5	776.25	708.13	538.13	471.25	320	130
$NO_{3\text{-}N}$ (µg at/l)	12.12	3.56	3.99	3.57	4.23	3.053	4.83	3.53	4.36	5.81
$PO_{4\text{-}P}$ (µg at/l)	3.87	3.05	7.37	7.79	5.11	7.69	8.21	4.78	5.34	5.58
$Sio_{4\text{-}Si}$ (µg at/l)	4.81	37.31	20.5	72.63	26.32	9.69	39.18	38.65	36.19	57.41
$NO_{2\text{-}N}$ (µg at/l)	0.398	0.87	1.32	1.32	2.39	0.13	1.09	0.95	0.93	1.39
Dissolved Oxygen (mg/l)	7.4	3.8	2.13	3.28	5	4.6	6.65	7.2	9.6	7.6
Primary productivity (mg C/m^3/day)	1575	358.9	1041.5	520	1725	3173.75	2112.8	3449.3	2158.13	1686
Chlorophyl l (mg/ m^3	3.3	6.2	15.4	9.05	11.63	21.88	13.58	33.85	46.85	43.55
Phytoplank-ton counts (cells/l)	2000	3735	5930	4565	5391	5940	5528	7247	7932	7570

Table.4. Monthly variation of Zooplankton (No. /1) in the culture field

Months	Crustacean larvae	Copepods	Tintinids	Nematodes	Veliger larvae	Rotifers	Others	Total zooplankton
Oct	3	3	0	0	0	2	2	10
Nov	3	6	0	0	0	0	0	9
Dec	2	12	0	4	2	0	0	20
Jan	5	6	2	0	1	0	0	14
Feb	4	6	4	11	3	0	1	29
Mar	7	7	6	4	0	0	0	24
Apr	3	9	14	2	0	0	0	28
May	2	6	0	0	0	0	1	9
Jun	7	5	1	0	0	0	1	14
Jul	10	25	0	0	0	1	1	37
Total	46	85	27	21	6	3	6	194
Percentage (%)	23.7	43.8	13.92	10.8	3.09	1.55	3.09	



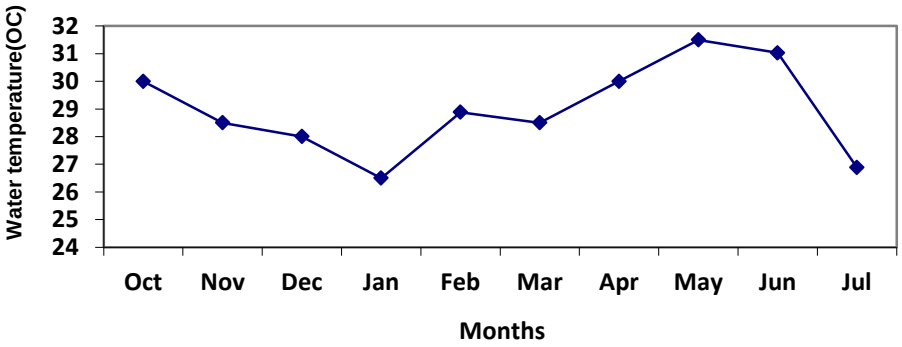
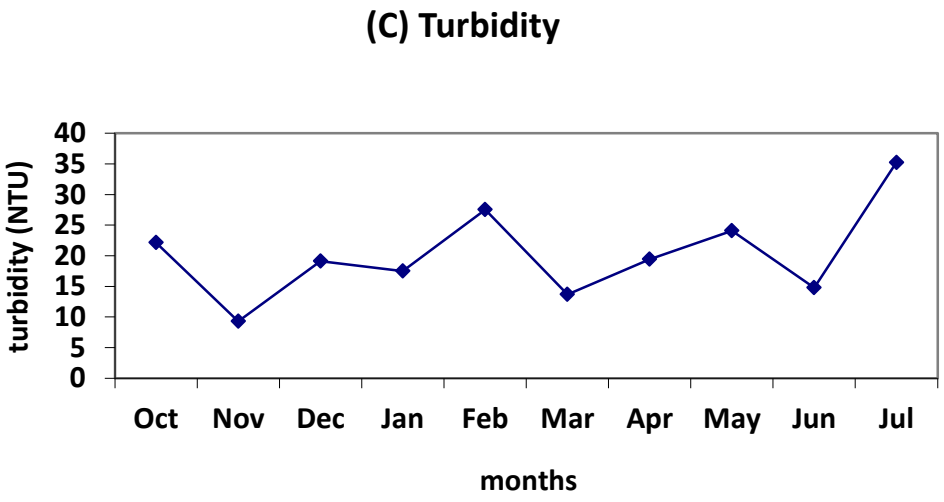


Fig.4.2. Monthly variation of hydrographical parameters and biological parameters



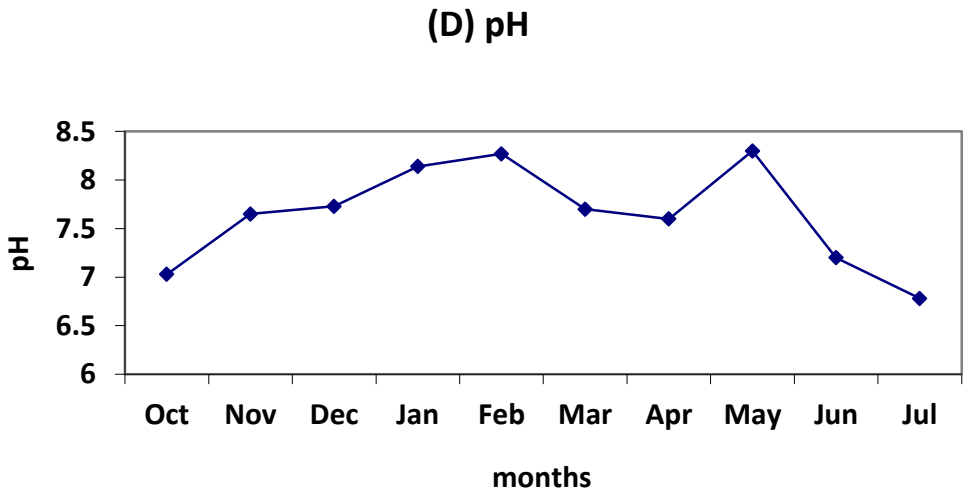
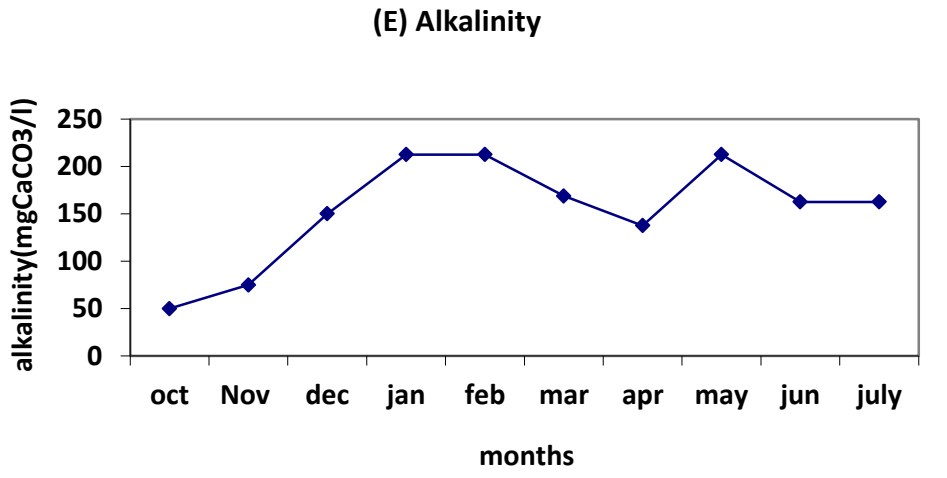


Fig.4.2. (contd.) Monthly variation of hydrographical parameters and biological parameters



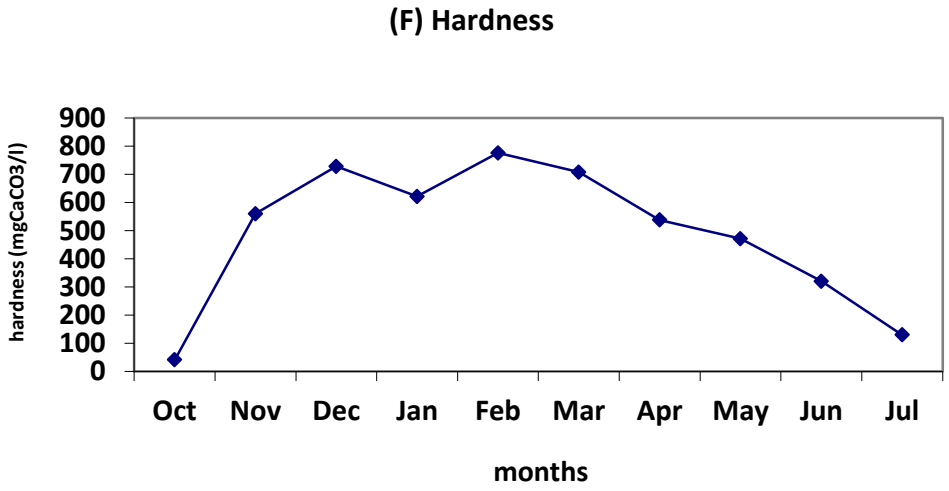
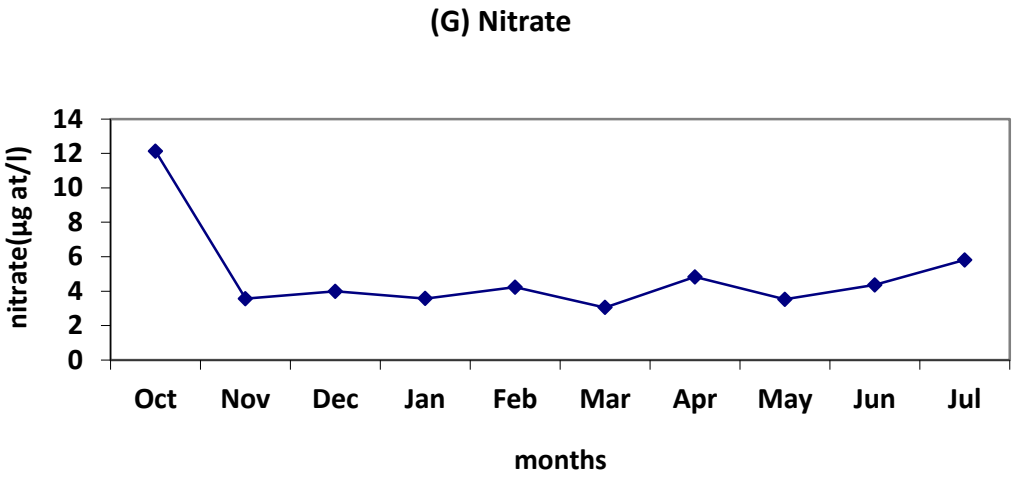


Fig.4.2. (contd.) Monthly variation of hydrographical parameters and bioogical parameters



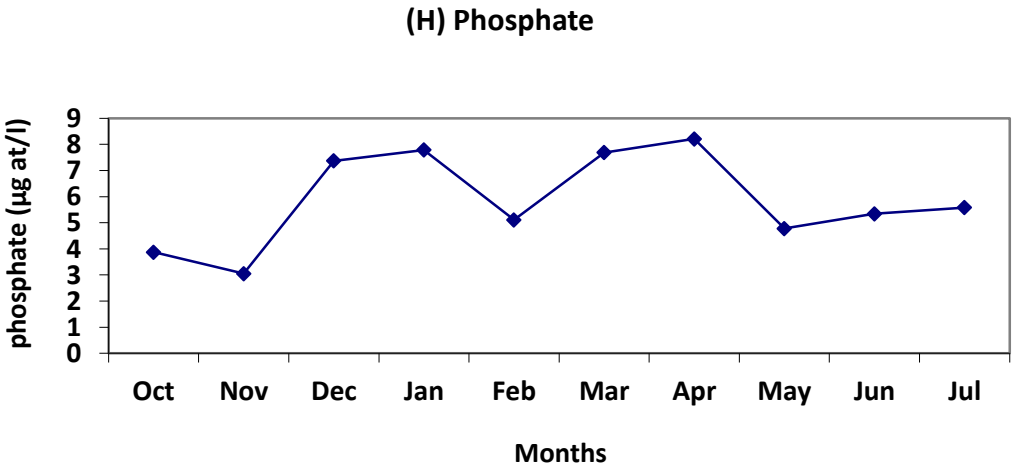
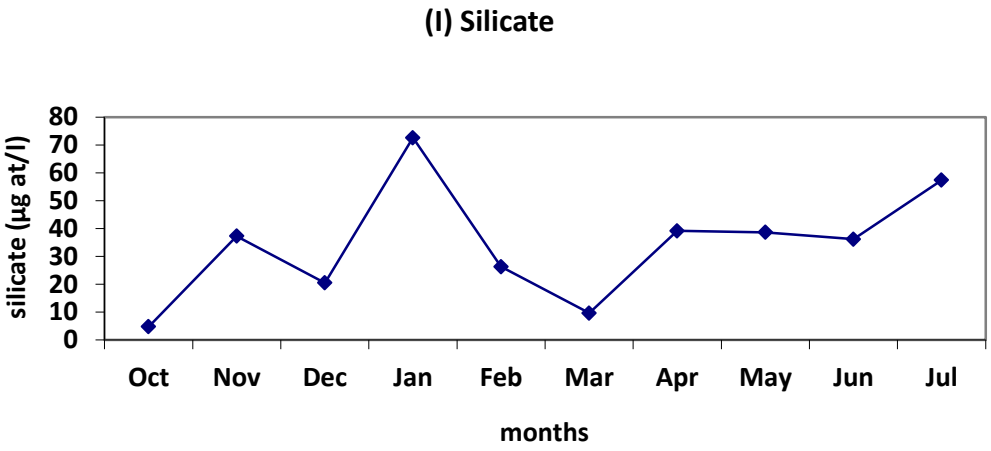


Fig. 1.2. (contd.) Monthly variation of hydrographical parameters and biological parameters



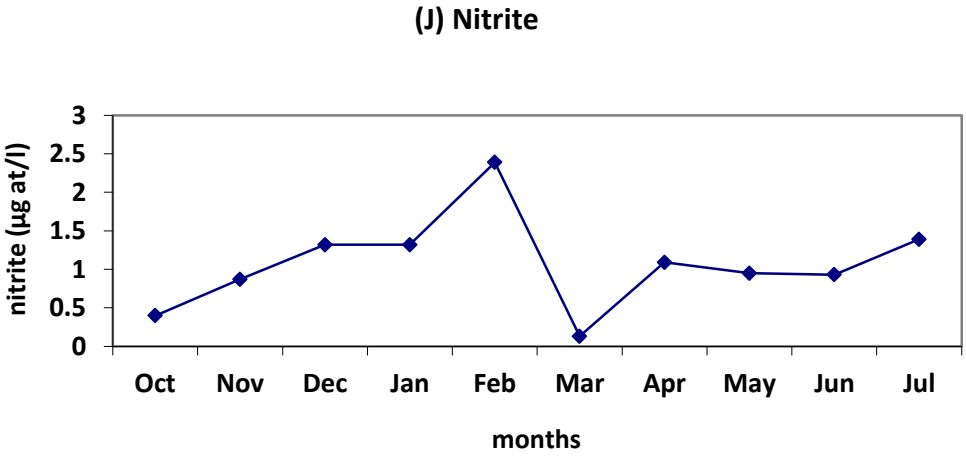
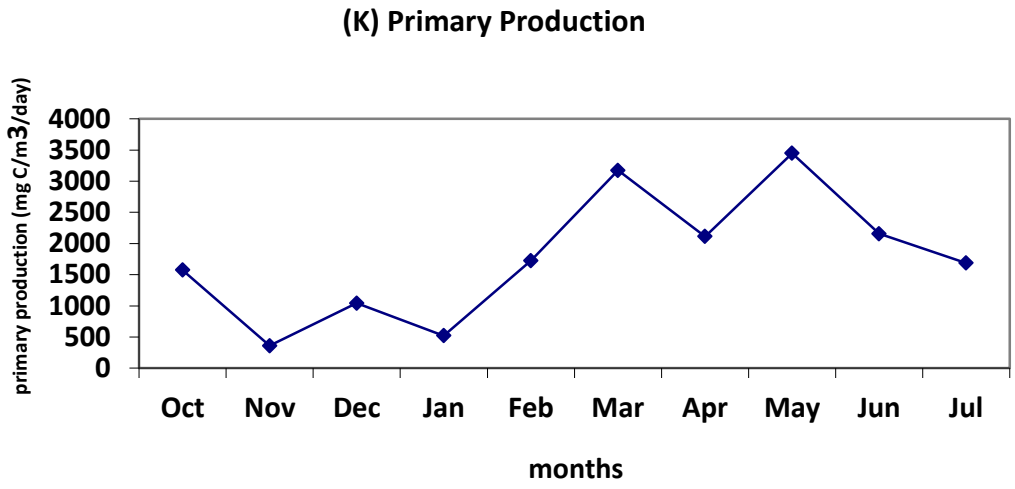


Fig. 2.2. (contd.) Monthly variation of hydrographical parameters and bioogical parameters



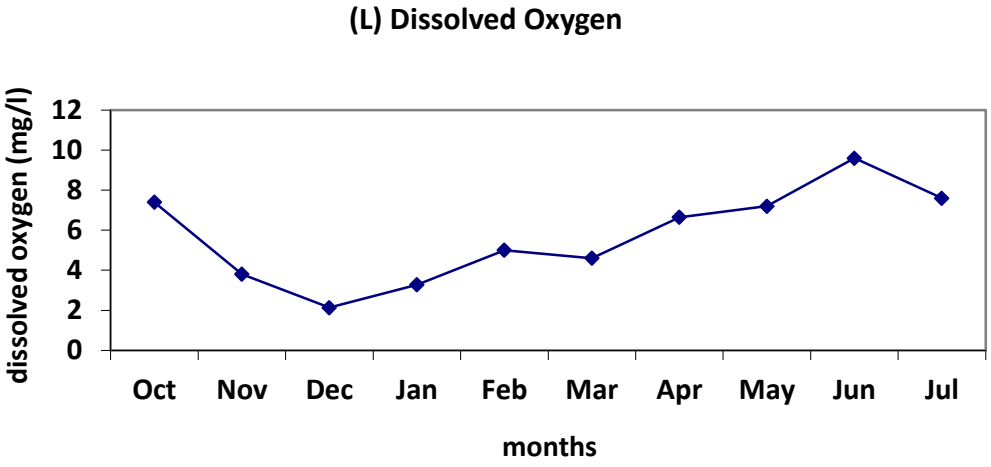
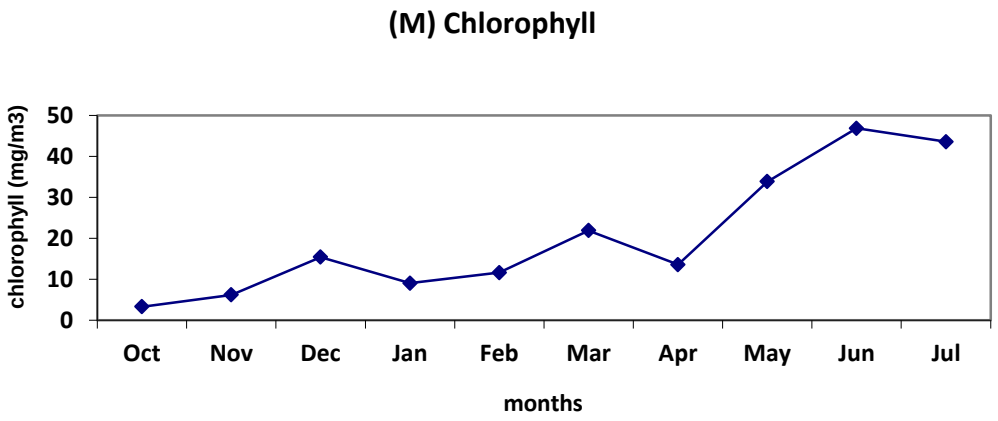


Fig. 4.2. (contd.) Monthly variation of hydrographical parameters and biological parameters



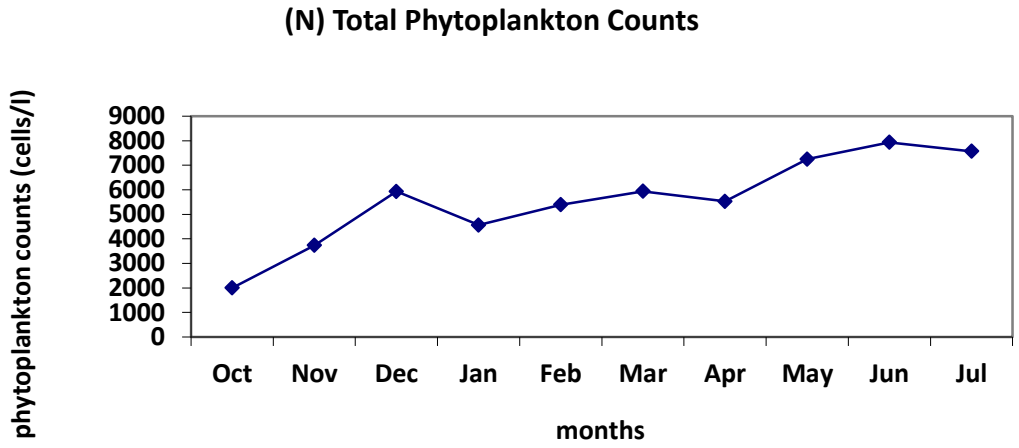


Fig.4.2. (contd) Monthly variation of hydrographical parameters and biological parameters

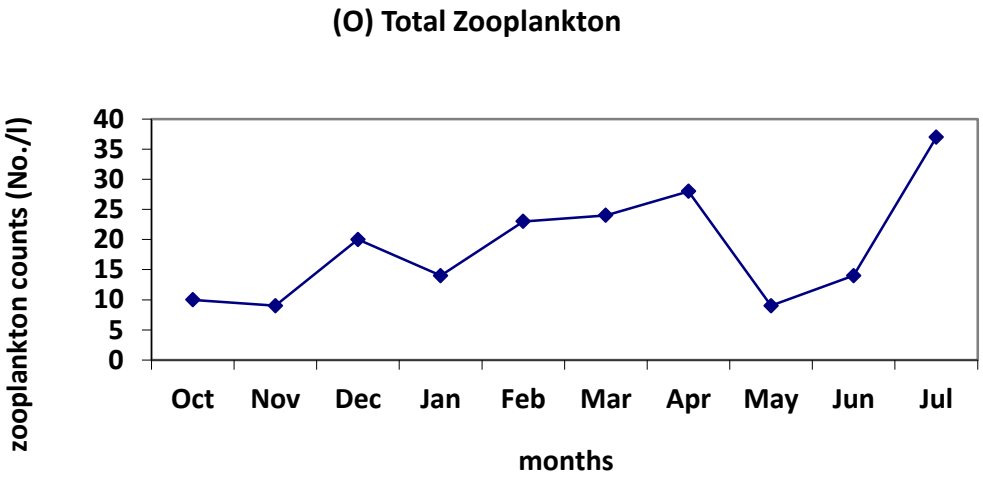


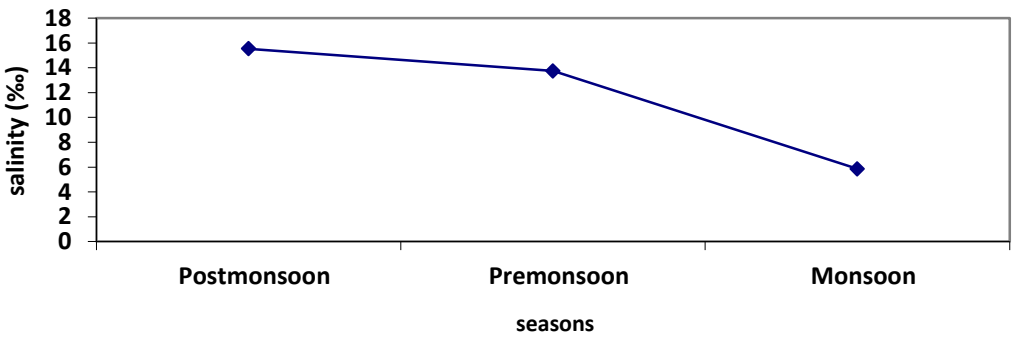
Fig. 4.2. (contd) Monthly variation of hydrographical parameters and biological parameters

Table 4.3. Seasonal variation of hydrographical and biological parameters

Parameters	Postmonsoon	Premonsoon	Monsoon
Salinity (ppt)	15.54	13.75	5.85
Water temperature (° C)	27.82	29.72	28.5
Turbidity (N.T.U)	17.3	21.17	25.02
pH	7.74	7.97	6.99
Alkalinity (mg $CaCO_3$/l)	140.91	182.81	162.5
Hardness (mg $CaCO_3$/l)	533.95	623.44	225
$NO_{3\text{-}N}$ (µg at/l)	5.24	3.77	5.09
$PO_{4\text{-}P}$ (µg at/l)	6.10	6.44	5.46
$Sio_{4\text{-}Si}$ (µg at/l)	39.67	28.46	8.6
$NO_{2\text{-}N}$ (µg at/l)	1.07	1.29	1.16
Dissolved Oxygen (mg/l)	3.81	5.86	8.6
Primary productivity (mg C/m^3/day)	824.75	2615.2	1922.1
Chloro-Phyl l (mg/ m^3	9.22	20.2	45.2
Phyto Plank-ton counts (cells/l)	4320	6161	7751
Total zoo-plankton (No./l	14	21	25

Note- Figures in the table represent the average values in the three seasons

(A) Salinity



(B) Water Temperature

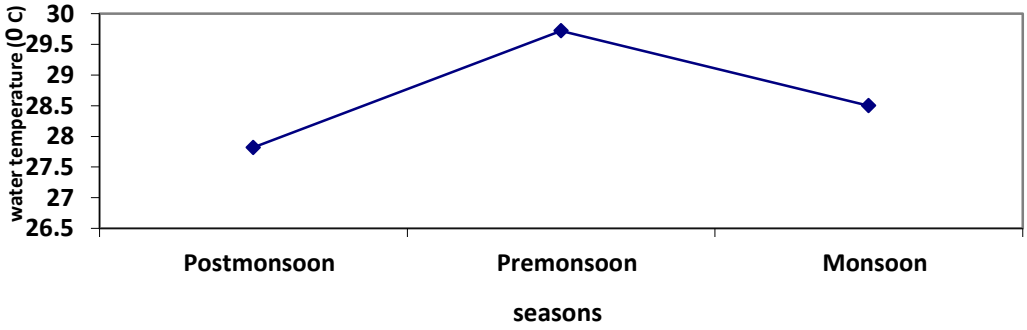
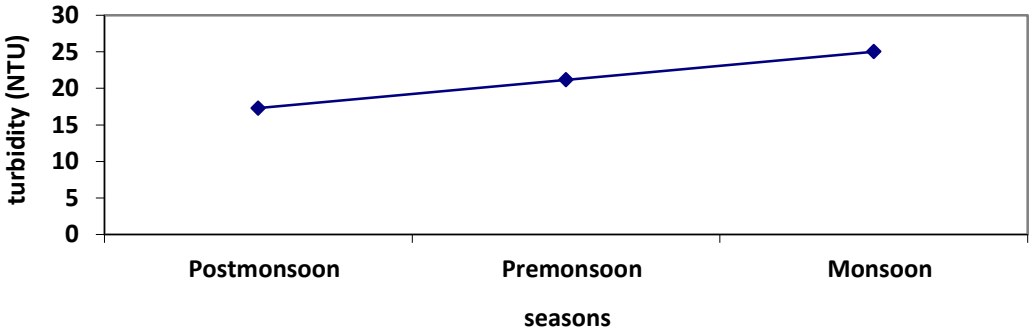


Fig.4.2. Seasonal variation of hydrographical parameters and biological parameters

(C) Turbidity



(D)pH

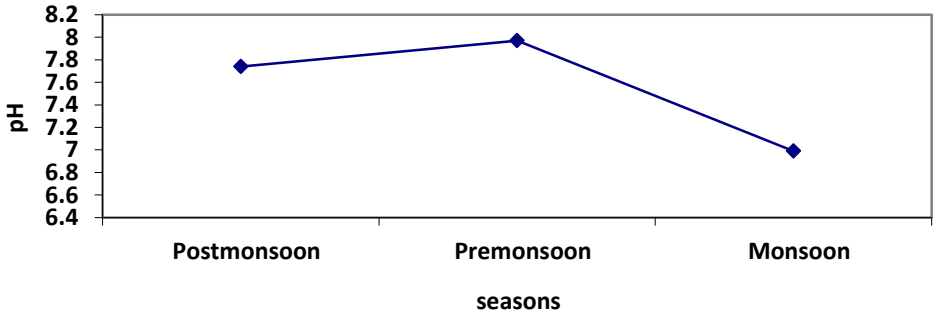
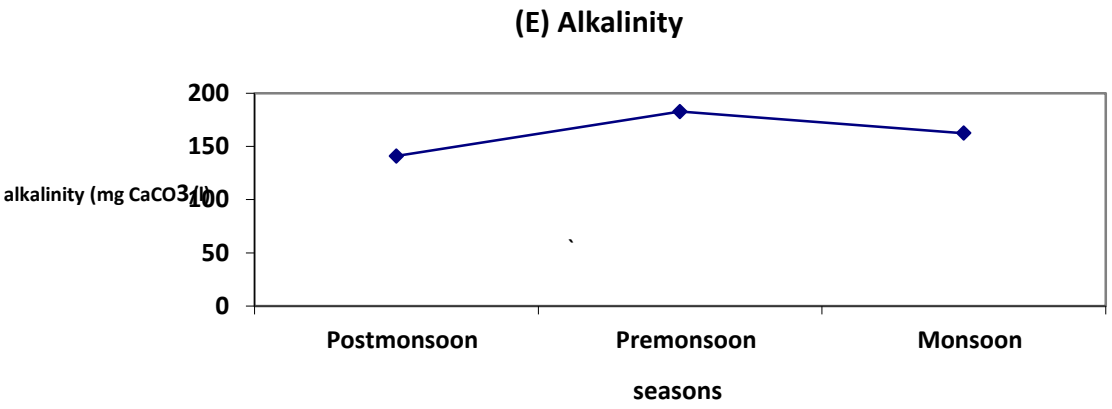


Fig. 4.2. (contd.) Seasonal variation of hydrographical parameters and biological parameters



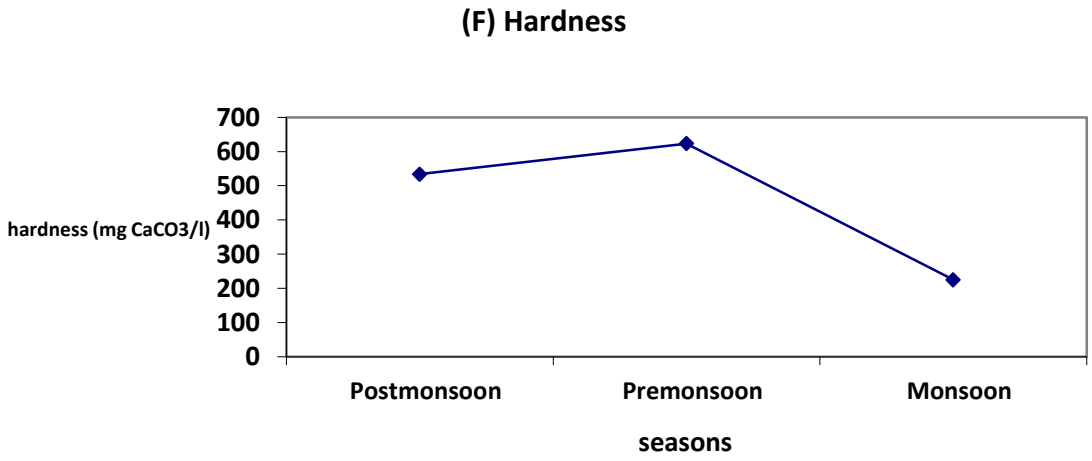
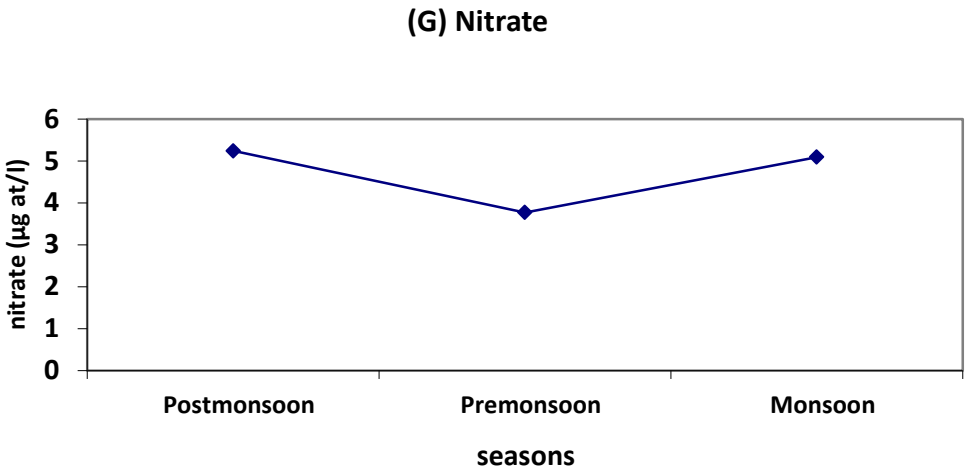


Fig. 4.2. (contd.) Seasonal variation of hydrographical parameters and biological parameters



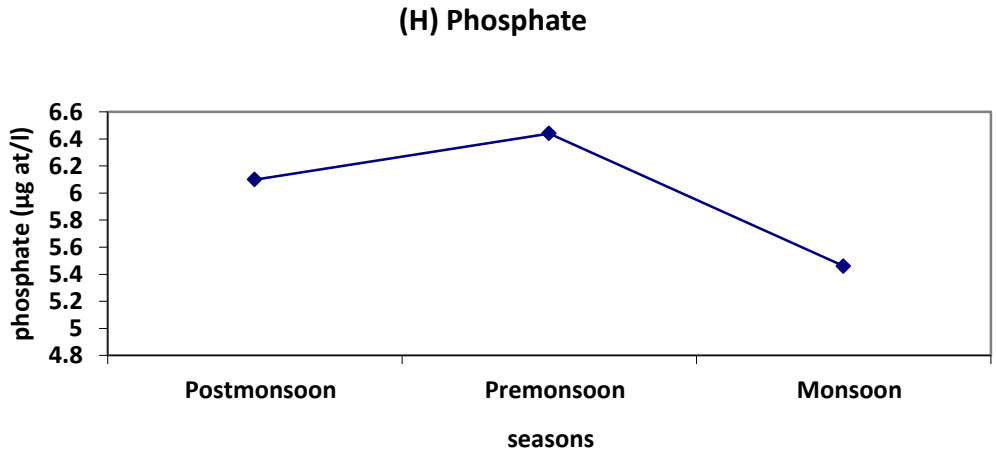
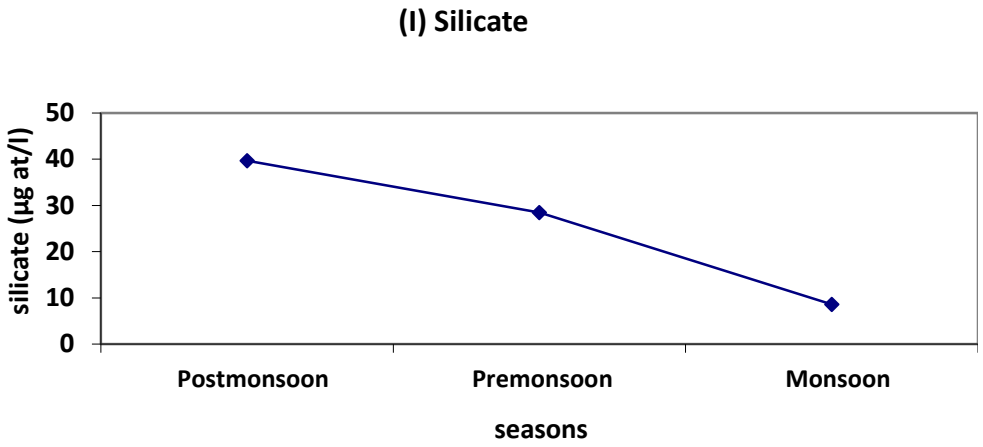


Fig. 4.2. (contd.) Seasonal variation of hydrographical parameters and biological parameters



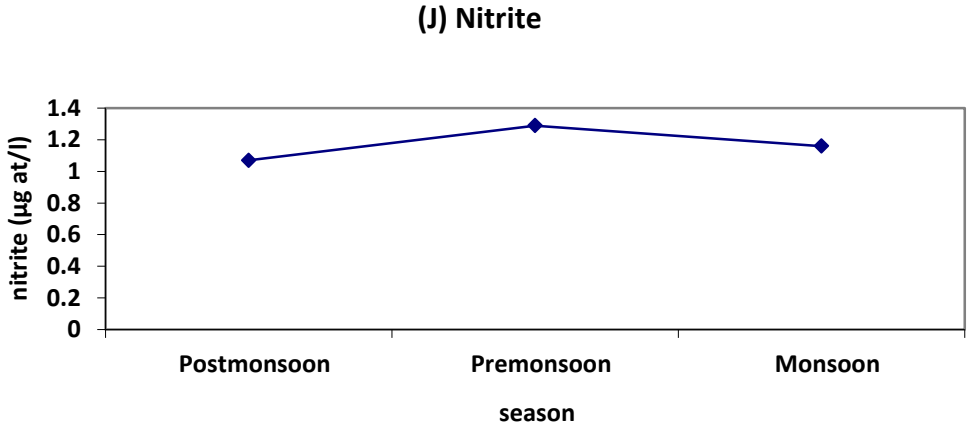
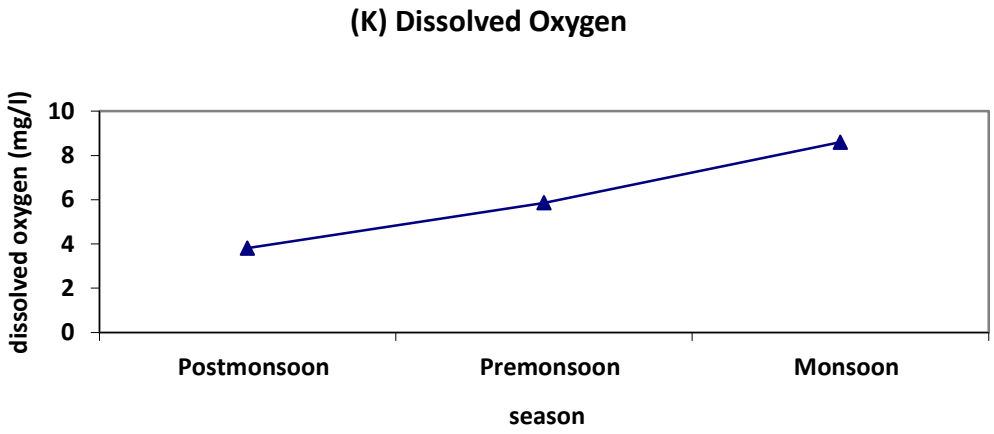


Fig.4.2. (contd.) Seasonal variation of hydrographical parameters and biological parameters



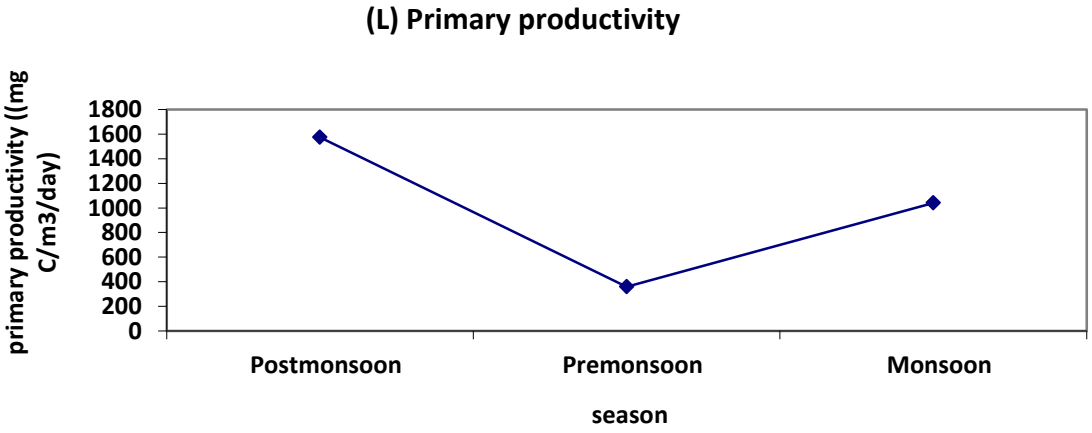
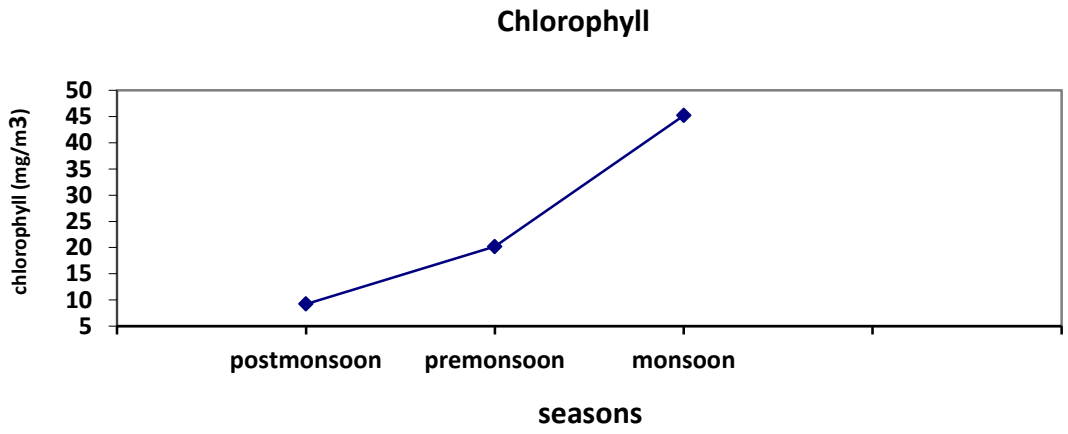


Fig.4.2 (contd.) Seasonal variation of hydrographical parameters and biological parameters



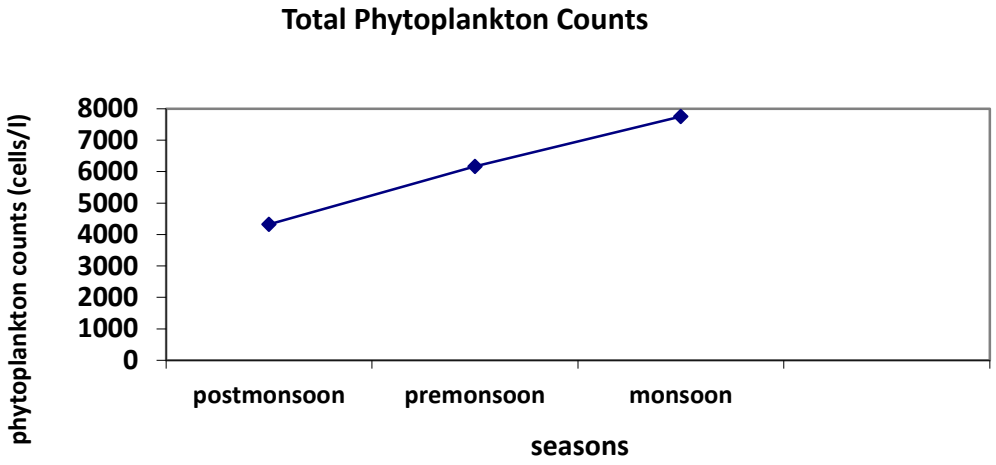


Fig.4.2. (contd.) Seasonal variation of hydrographical parameters and biological parameters

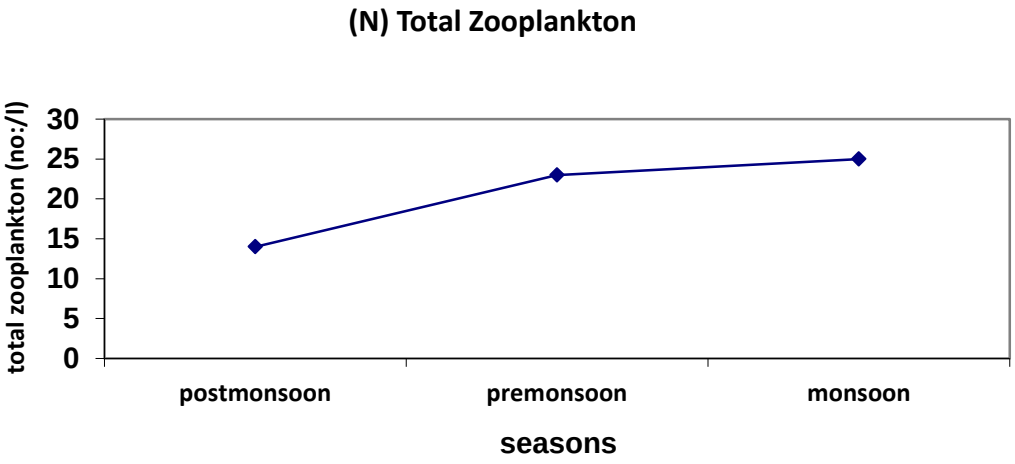


Fig.4.2. (contd.) Seasonal variation of hydrographical parameters and biological Parameters

Table 4.5.Percentage composition of zooplankton in different seasons

Zooplankton groups	Postmonsoon	Premonsoon	Monsoon
Copepods	50.9	31.1	58.82
Crustacean larvae	24.5	17.78	33.33
Tintinids	3.7	26.67	1.96
Nematodes	7.55	18.89	0
Veliger larvae	5.66	3.33	0
Rotifer	3.77	0	1.96
Others	3.7	2.22	3.92

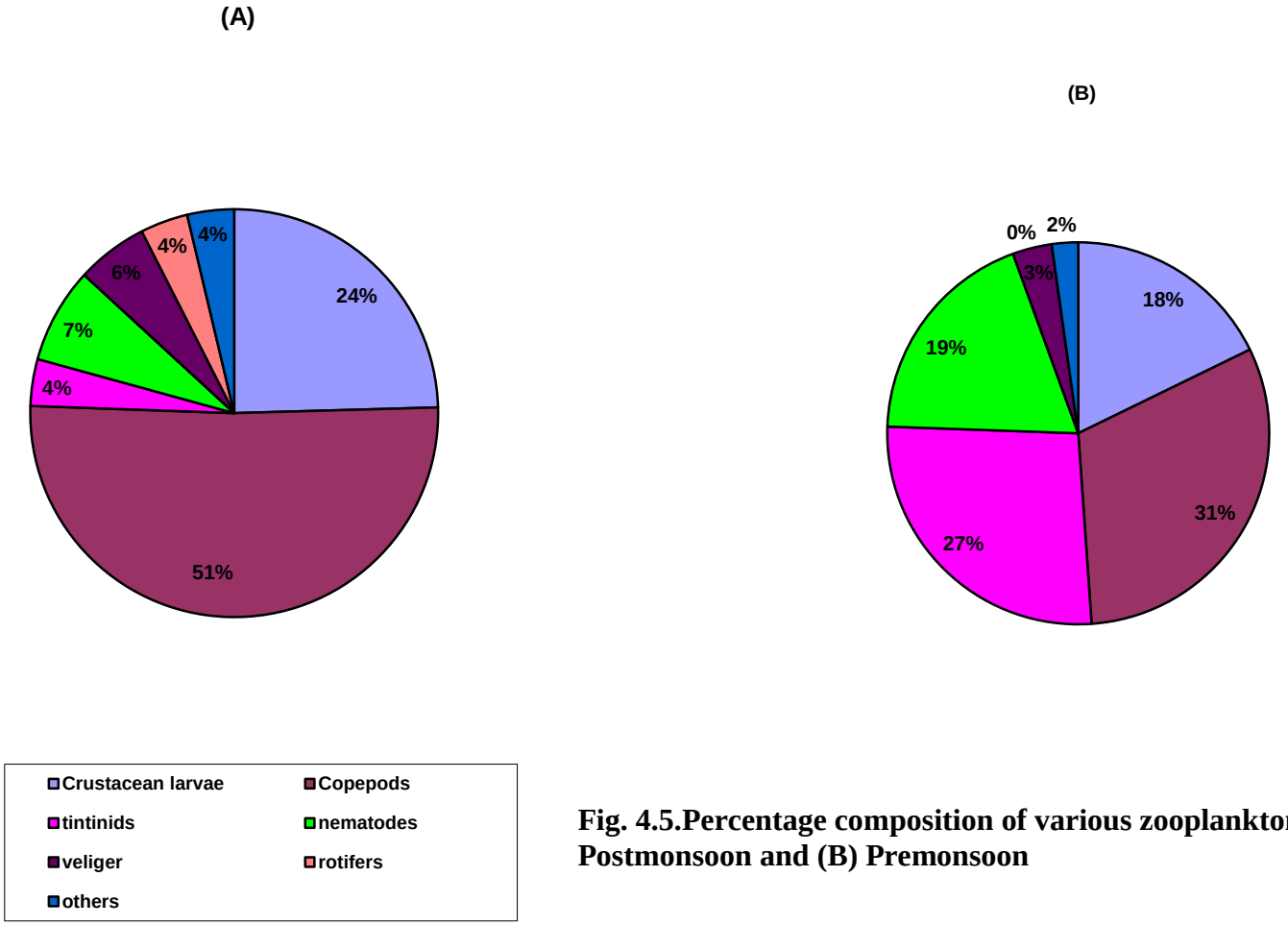


Fig. 4.5.Percentage composition of various zooplankton groups in (A) Postmonsoon and (B) Premonsoon

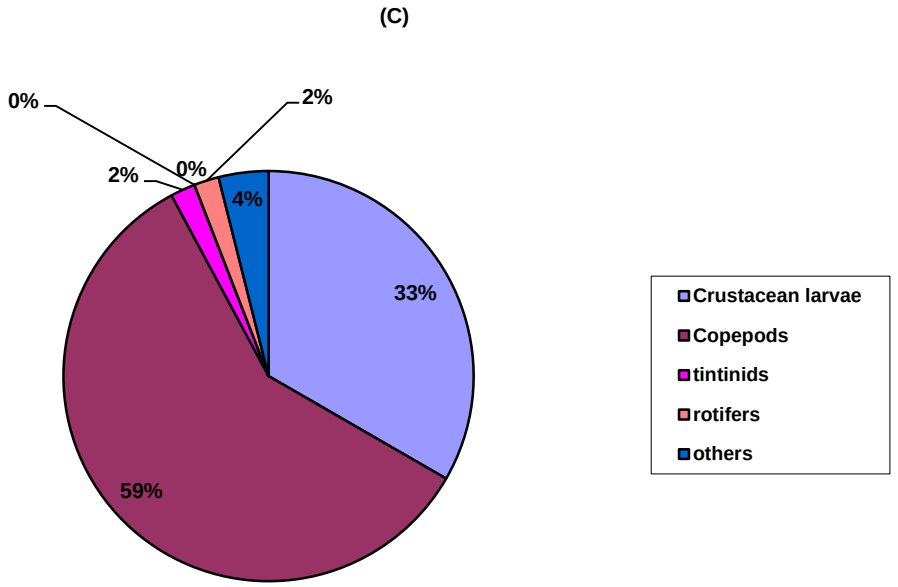


Figure 4.4. (contd) Percentage composition of zooplankton (C) Monsoon

4.3 STATISTICAL ANALYSIS

4.3.1 Student's t-Test

The mean values of hydrographical parameters for premonsoon and postmonsoon periods were statistically compared using student's t- test. The results are presented in Table 4.5.

Statistical analysis showed that there is no significant ($p = 0.606$) difference between the mean values of the two seasons. The mean salinity for postmonsoon was 15.54‰ with a standard error of 3.15. The corresponding figures for premonsoon period were 13.75‰ and 1.87.

It is evident from the statistical analysis that there is significant ($p= 0.004$) decrease in water temperature during postmonsoon period when compared to premonsoon period. The mean temperature during postmonsoon was 27.82 ºC, while that for premonsoon period was 29.72 ºC.

The mean turbidity for postmonsoon period was 17.30 NTU with a standard error of 2.46. During premonsoon period the mean turbidity was 21.17 NTU with a standard error 1.70. From the statistical analysis it is clear that there is no significant ($p = 0.193$) difference between the two means.

In the case of pH, statistical analysis showed that there is no significant ($p=0$) difference in pH from postmonsoon period to premonsoon period. The mean pH during postmonsoon period was 7.74 with a standard error of 0.14. The corresponding figures for premonsoon period were 7.97 and 0.91.

The mean alkalinity during postmonsoon period was 140.91 mgCaCO3/l with a standard error of 22.18. It was increased to 182.81 mgCaCO3/l with a standard error of 10.14 during the premonsoon period. However, the increase was statistically not significant (p= 0.107).

The mean hardness during postmonsoon period was 533.95 mgCaCO3/l with a standard error of 77.03. This was increased to 623.44 mgCaCO3/l with a standard error of 37.17 during premonsoon period. Statistical analysis did not reveal any significant (p=0.260) change in hardness from postmonsoon to premonsoon period.

The statistical analysis for nutrients like nitrate, phosphate, silicate and nitrite revealed that there was no significant (p> 0.025) difference between the mean estimated nutrient values during the two seasons.

The mean nitrate during postmonsoon period was 5.24 µg at/l with a standard error of 1.54. This was decreased to 3.77 µg at/l with a standard error of 0.17 during premonsoon. In the case of nitrite, the corresponding figures for the two seasons were 1.07 ± 0.13 and 1.29 ± 0.19µg at/l.

The estimated mean phosphate for postmonsoon period was 6.10 µg at/l with a standard error of 1.53 which changed to a mean value of 6.44 µg at/l during premonsoon period with a standard error of 0.75.

The estimated silicate during postmonsoon period was 39.67 µg at/l with a standard error of 12.07 which decreased to 28.46 µg at/l during premonsoon period with a standard error of 3.52.

Statistical analysis for dissolved oxygen showed significant (p = 0.024) decrease during postmonsoon period when compared to premonsoon period. The mean value for postmonsoon period was 3.81mg/l with a

standard error of 0.58. The corresponding figures for the premonsoon period were 5.86 mg/l and 0.61.

4.3.2 Correlation

4.3.2.1 Correlation between hydrographical parameters

Salinity showed highly significant positive correlation with pH (r = 0.694), alkalinity (r = 0.604) hardness (r = 0.728) and nitrite (r = 0.497). But showed highly significant negative correlation with dissolved oxygen (r = -0.593).

A negative correlation was observed between temperature and silicate (r = -0.357) which was significant at 5% level.

pH showed positive correlation with alkalinity (r = 0.553) and hardness (r = 0.676). The correlations were significant at 5% level.

A significant positive correlation was observed between alkalinity and hardness (r = 0.375).

No intercorrelation was observed between nutrients.

Dissolved oxygen showed highly significant negative correlation with hardness (r = -0.612) but only a significant negative correlation with pH (r = -0.428).

The correlation coefficient between dissolved oxygen and temperature (r = 0.440) was significant at 1% level.

4.3.2.2 Correlation with hydrographical parameters and biological parameters

Primary production showed highly significant positive correlation with temperature (r = 0.479) but only significant positive correlation with dissolved oxygen (r = 0.399).

The correlation coefficient between chlorophyll and salinity was negatively significant (r = -0.387) at 5% level, while the correlation between dissolved oxygen and chlorophyll (r = 0.453) was positively significant at 1% level.

The total phytoplankton count showed significant positive correlation with dissolved oxygen (r = 0.358). A significant negative correlation was observed between total phytoplankton and nitrate (r = -0.362)

The correlation coefficient of total zooplankton with temperature (r = -0.409) and pH (r = -0.378) was significant at 5% level.

Table 4.6 Analysis of hydrographical parameters using t-test

(A) Salinity (‰)

Season	Sample Size	Mean	S.D.	S. E.	t	P value
Postmonsoon	11	15.54	10.46	3.15	0.522	0.606 (NS)
Premonsoon	16	13.75	7.47	1.87		

(B)Water Temperature (ºC)

Season	Sample Size	Mean	S.D.	S.E.	t	P value
Postmonsoon	11	27.82	1.54	0.46	-3.169*	.004
Premonsoon	16	29.72	1.53	0.38		

(C)Turbidity (N.T.U)

Season	Sample Size	Mean	S.D.	S. E.	t	P value
Postmonsoon	11	17.30	8.17	2.46	-1.338	0.193 (NS)
Premonsoon	16	21.17	6.81	1.70		

Table 4.6. (contd.) Analysis of hydrographical parameters using t- test

(D) pH

Season	Sample Size	Mean	S.D.	S. E.	t	P value
Postmonsoon	11	7.74	0.47	0.14	-1.426	0.166 (NS)
Premonsoon	16	7.97	0.37	0.91		

(E) Alkalinity ($mgCaCO_3/l$)

Season	Sample Size	Mean	S.D.	S. E.	t	P value
Postmonsoon	11	140.91	73.55	22.18	-1.719	0.107 (NS)
Premonsoon	16	182.81	40.54	10.14		

(F) Hardness ($mgCaCO_3/l$)

Season	Sample Size	Mean	S.D.	S.E.	t	P value
Postmonsoon	11	533.95	255.49	77.03	-1.151	0.260 (NS)
Premonsoon	16	623.44	148.69	37.17		

Table 4.6. (contd.) Analysis of hydrographical parameters using t- test

G) Nitrate (µg at/l)

Season	Sample Size	Mean	S. D.	S. E.	t	P value
Postmonsoon	11	5.24	5.11	1.54	0.947	0.365 (NS)
Premonsoon	16	3.77	0.66	0.17		

(H)Nitrite (µg at/l)

Season	Sample Size	Mean	S.D.	S. E.	t	P value
Postmonsoon	11	1.07	0.43	0.13	-0.861	0.397 (NS)
Premonsoon	16	1.29	0.77	0.19		

(I) Phosphate (µg at/l)

Season	Sample Size	Mean	S. D.	S. E.	t	P value
Postmonsoon	11	6.10	5.08	1.53	-0.222	0.826 (NS)
Premonsoon	16	6.44	2.98	0.75		

Table 4.6. (contd.) Analysis of hydrographical parameters using t- test

(J) Silicate (µg at/l)

Season	Sample Size	Mean	S.D.	S.E.	t	P value
Postmonsoon	11	39.67	40.02	12.07	0.892	0.390 (NS)
Premonsoon	16	28.46	14.07	3.52		

(K) Dissolved Oxygen (mg/l)

Season	Sample Size	Mean	S. D.	S. E.	t	P value
Postmonsoon	11	3.81	1.91	0.58	-2.340*	0.024
Premonsoon	16	5.86	2.44	0.61		

NS- Statistically not significant ($p > 0.025$)

* - Statistically significant ($p < 0.025$)

Table 4.7 Correlation between hydrographical parameters

Parameters	Salinity	Water Temperature	Turbidity	pH	Alkalinity	Hardness	Nitrate	Nitrite	Phosphate	Silicate	Dissolved oxygen
Salinity	1	-0.341*	-0.060	0.694**	0.604**	0.728**	-0.315	0.497**	0.121	0.185	-0.593**
Water Temperature		1	-0.044	0.100	-0.170	-0.078	0.039	-0.163	-0.051	-0.357*	0.440**
Turbidity			1	-0.111	0.118	-0.333	0.149	0.325	0.076	0.138	0.062
pH				1	0.553**	0.676**	-0.443**	0.286	-0.011	-0.043	-0.428*
Alkalinity					1	0.373*	-0.386*	0.330	0.005	0.287	-0.160
Hardness						1	-0.465**	-0.344*	0.164	-0.093	-0.612**
Nitrate							1	-0.220	-0.130	-0.117	0.159
Nitrite								1	0.133	0.164	-0.012
Phosphate									1	0.219	-0.096
Silicate										1	-0.023
Dissolved Oxygen											1

* Significant at 5 % level (two tailed)

** Significant at 1 % level (two tailed)

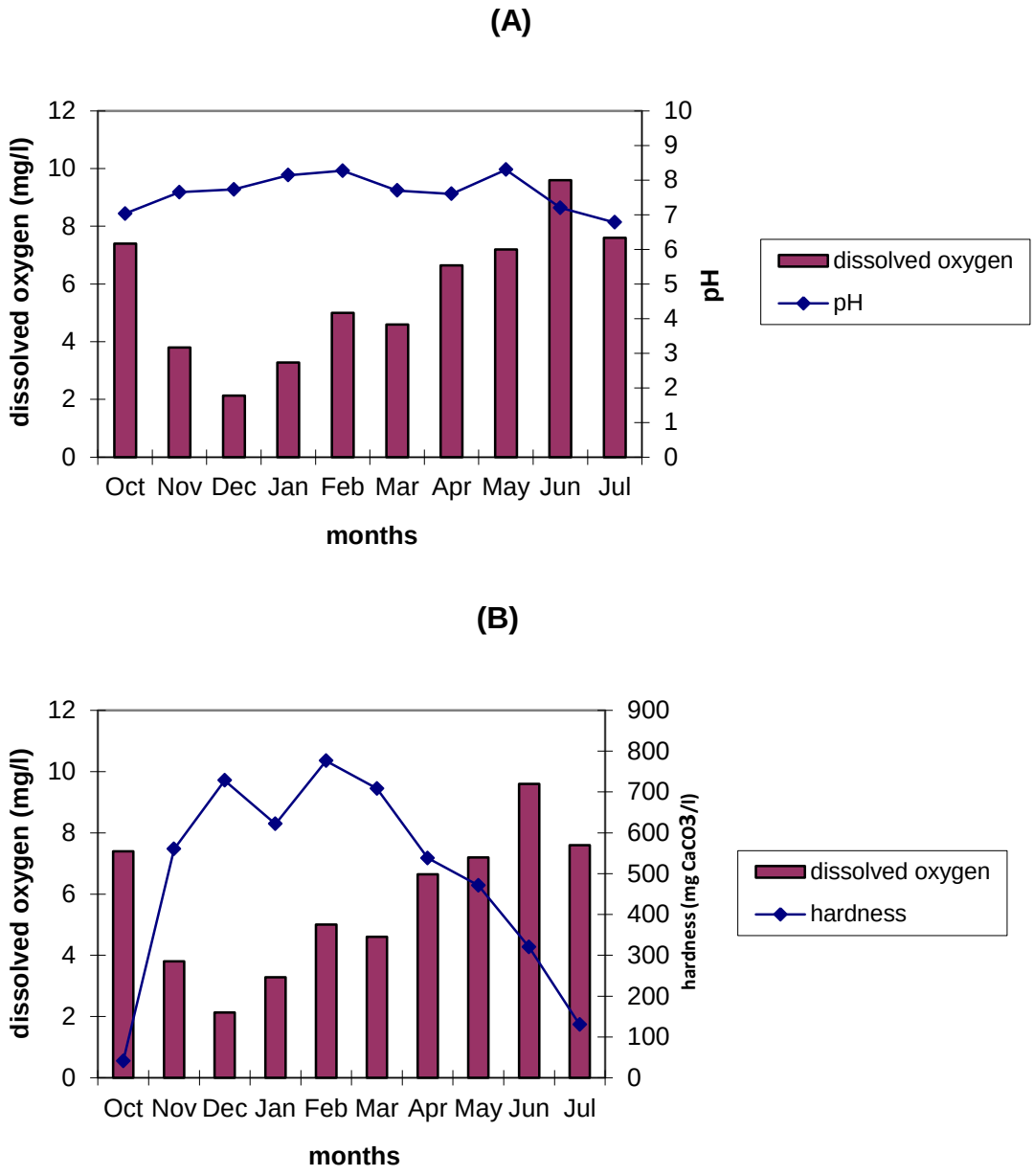


Figure4.7.Monthly variation of hydrographical parameters

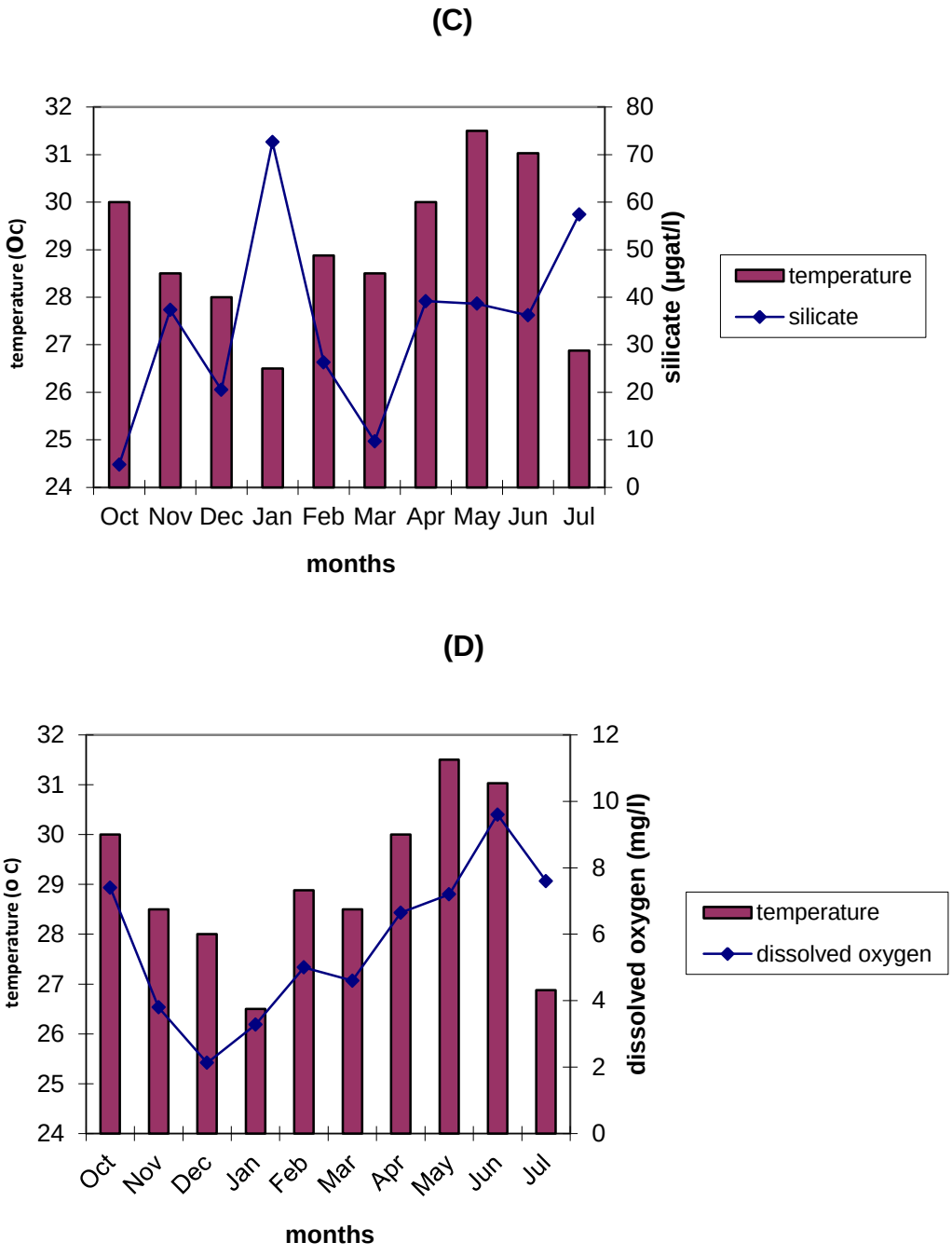
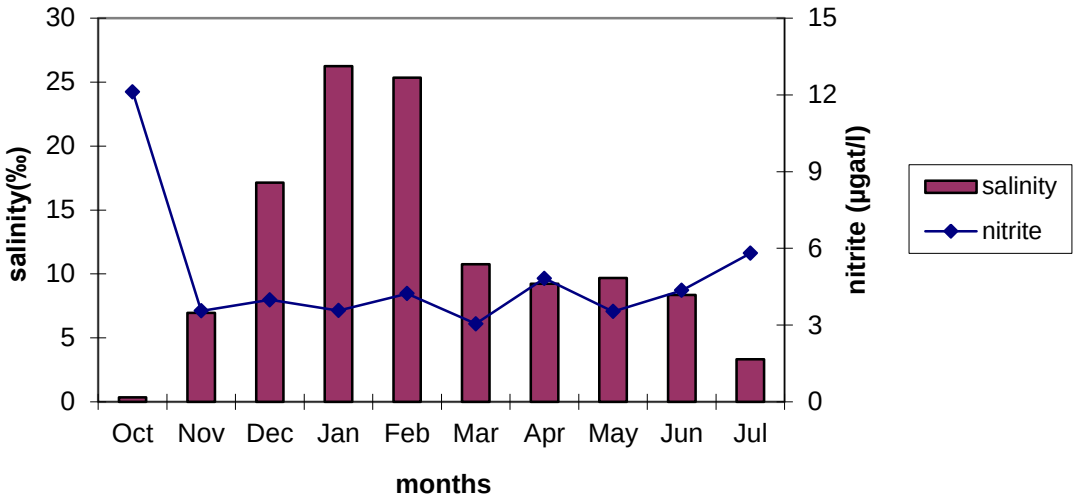


Figure 4.7.(contd) Monthly variation of hydrographical parameters

(E)



(F)

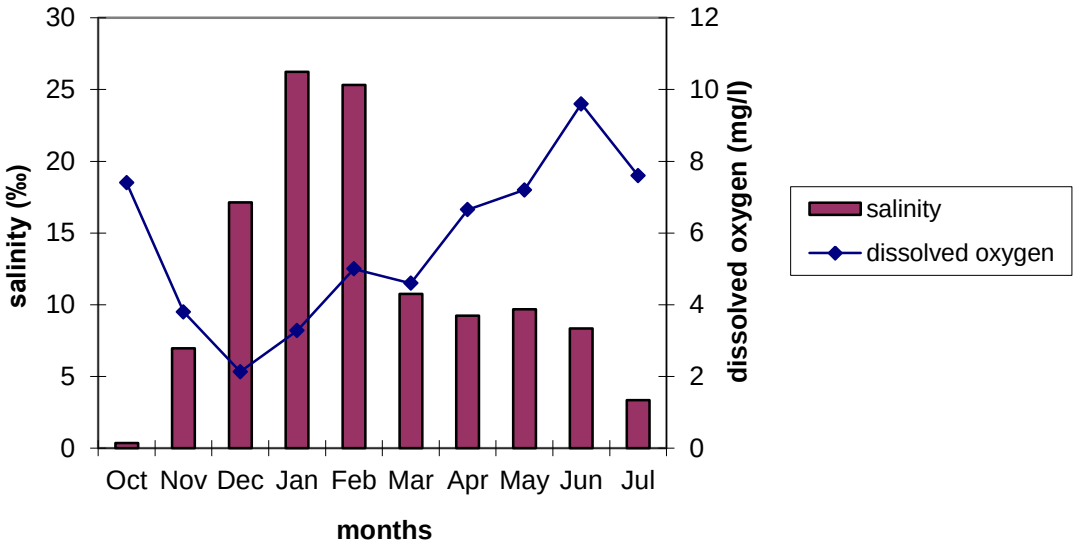
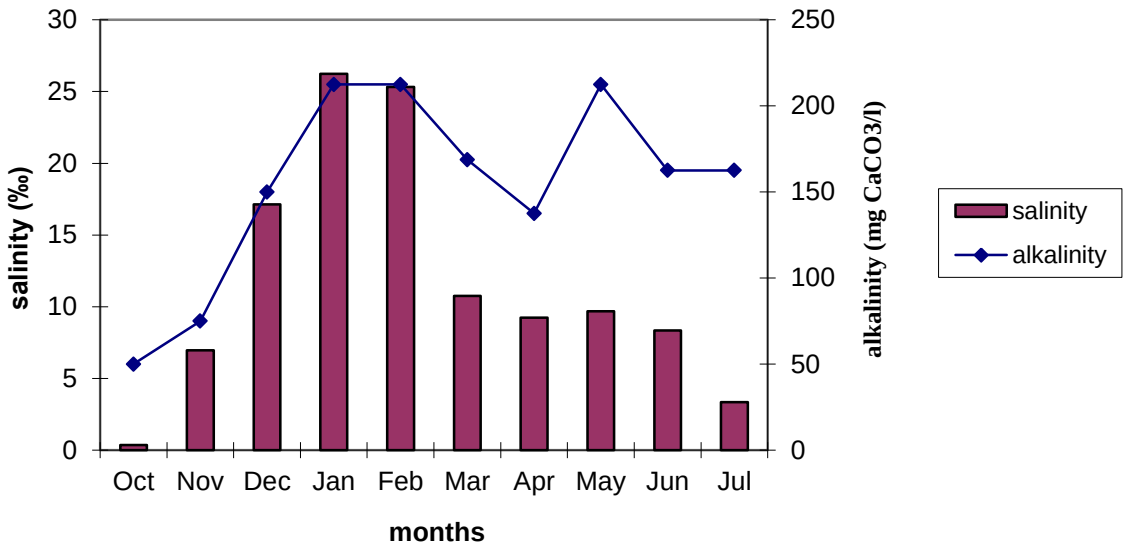


Figure 4.7.(contd) Monthly variation of hydrographical parameters

(G)



(H)

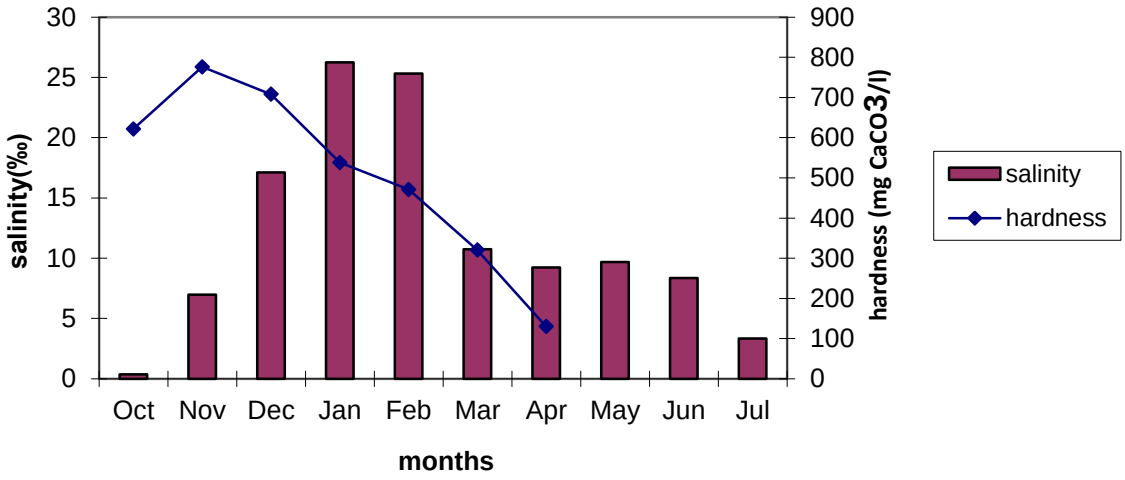
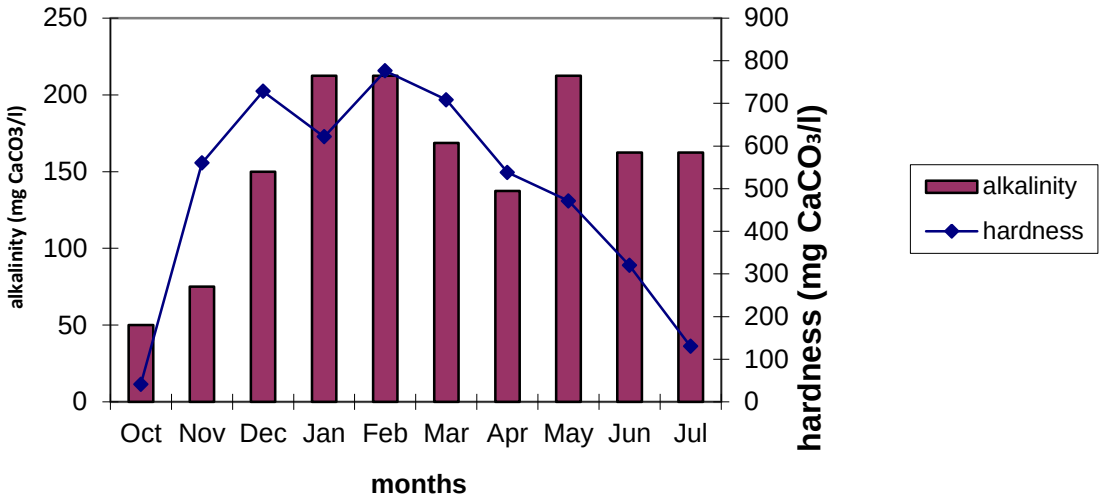


Figure 3.7(contd) Monthly variation of hydrographical parameters

(I)



(J)

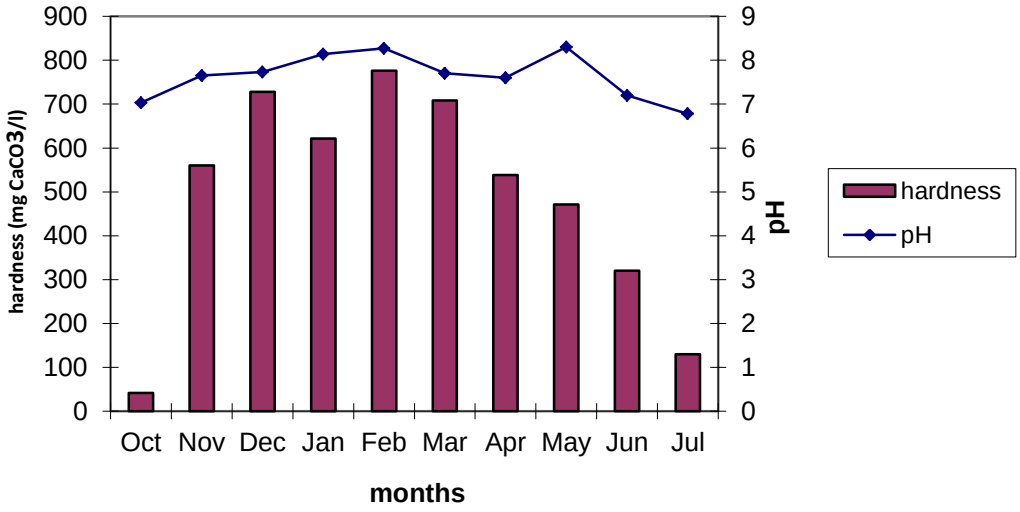


Figure 4.7. (contd.) Monthly variation of hydrographical parameters

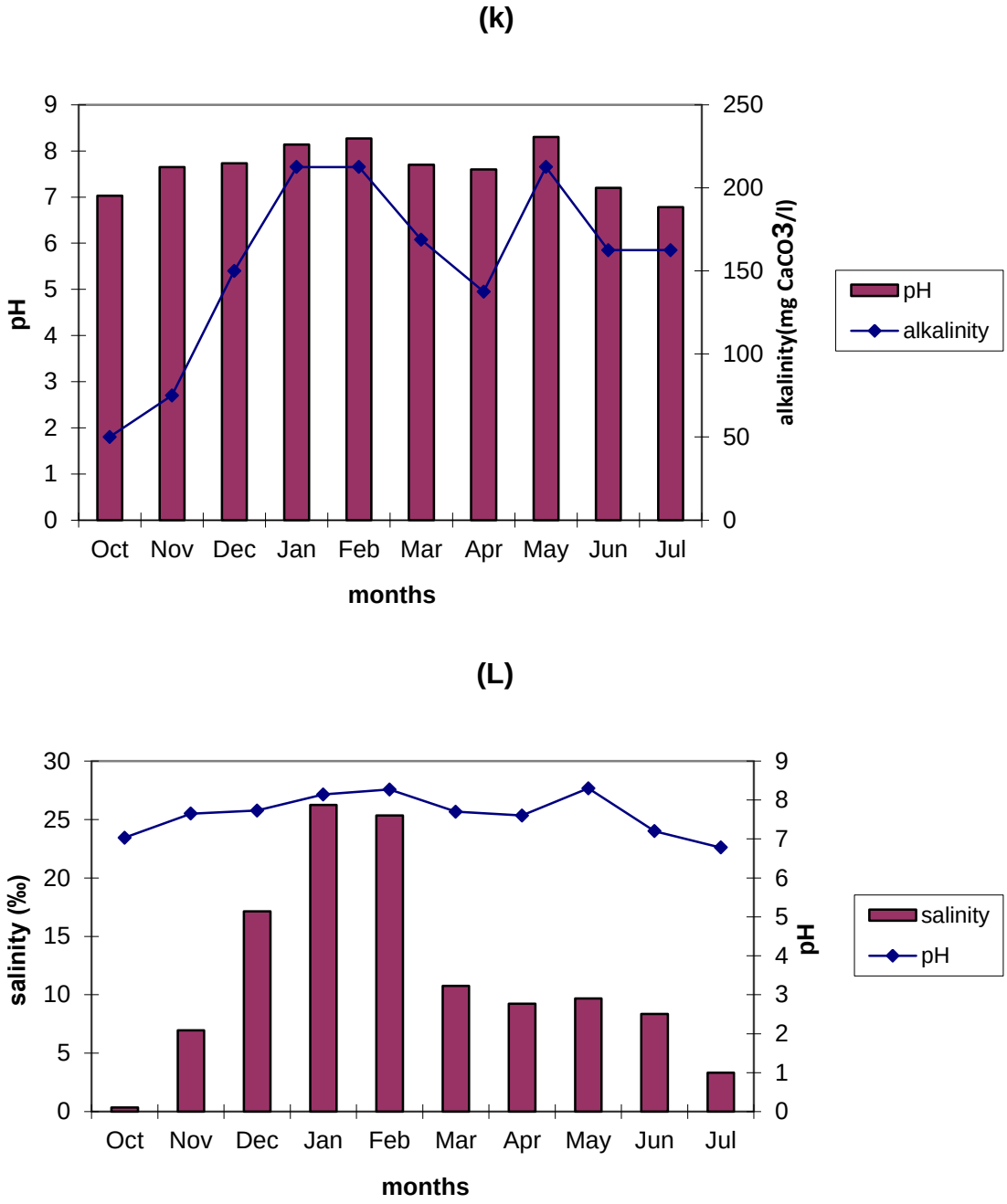


Figure 4.7.(contd.) Monthly variation of hydrographical parameters

Table4.8.Correlation between hydrographical parameters and biological parameters

Parameters	Primary production	Chlorophyll	Total Phytoplankton counts	Total zooplankton
Salinity	-0.312	-0.387*	-0.198	-0.128
Temperature	0.479**	0.145	0.154	-0.409*
Turbidity	0.008	0.254	0.205	0.391*
pH	0.051	-0.250	-0.102	-0.378*
Alkalinity	0.134	0.145	0.369*	0.045
Hardness	-0.103	-0.394*	-0.085	-0.084
Nitrate	0.211	-0.024	-0.362*	-0.013
Nitrite	-0.134	-0.078	0.070	0.288
Phosphate	-0.142	-0.087	0.057	0.215
Silicate	-0.250	-0.013	0.033	0.031
Dissolved Oxygen	0.399*	0.453**	0.358*	0.034

* Significant at 5 % level (two tailed)

** Significant at 1 % level (two tailed)

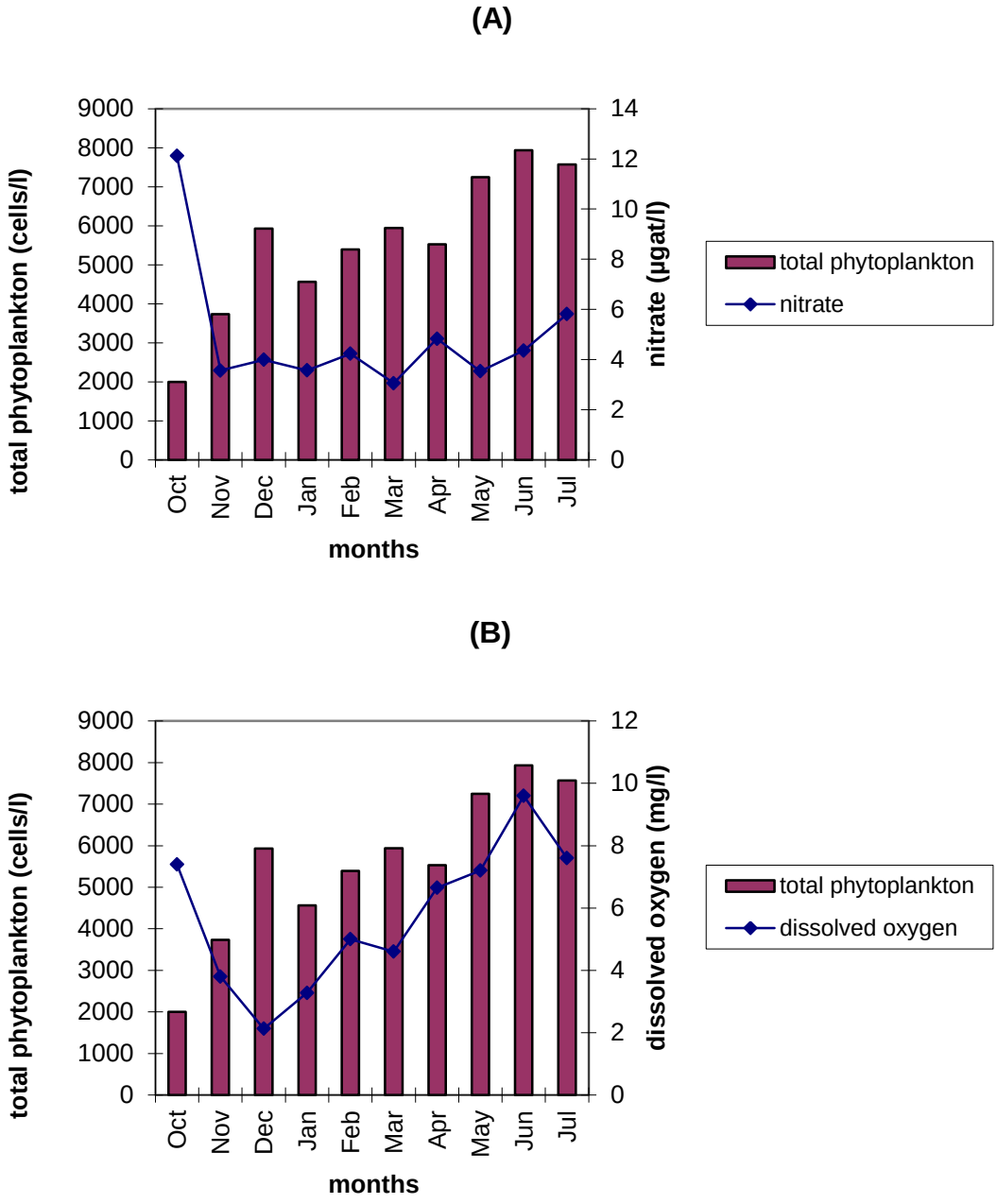


Fig.4.8.Monthly variation of hydrographical and biological parameters

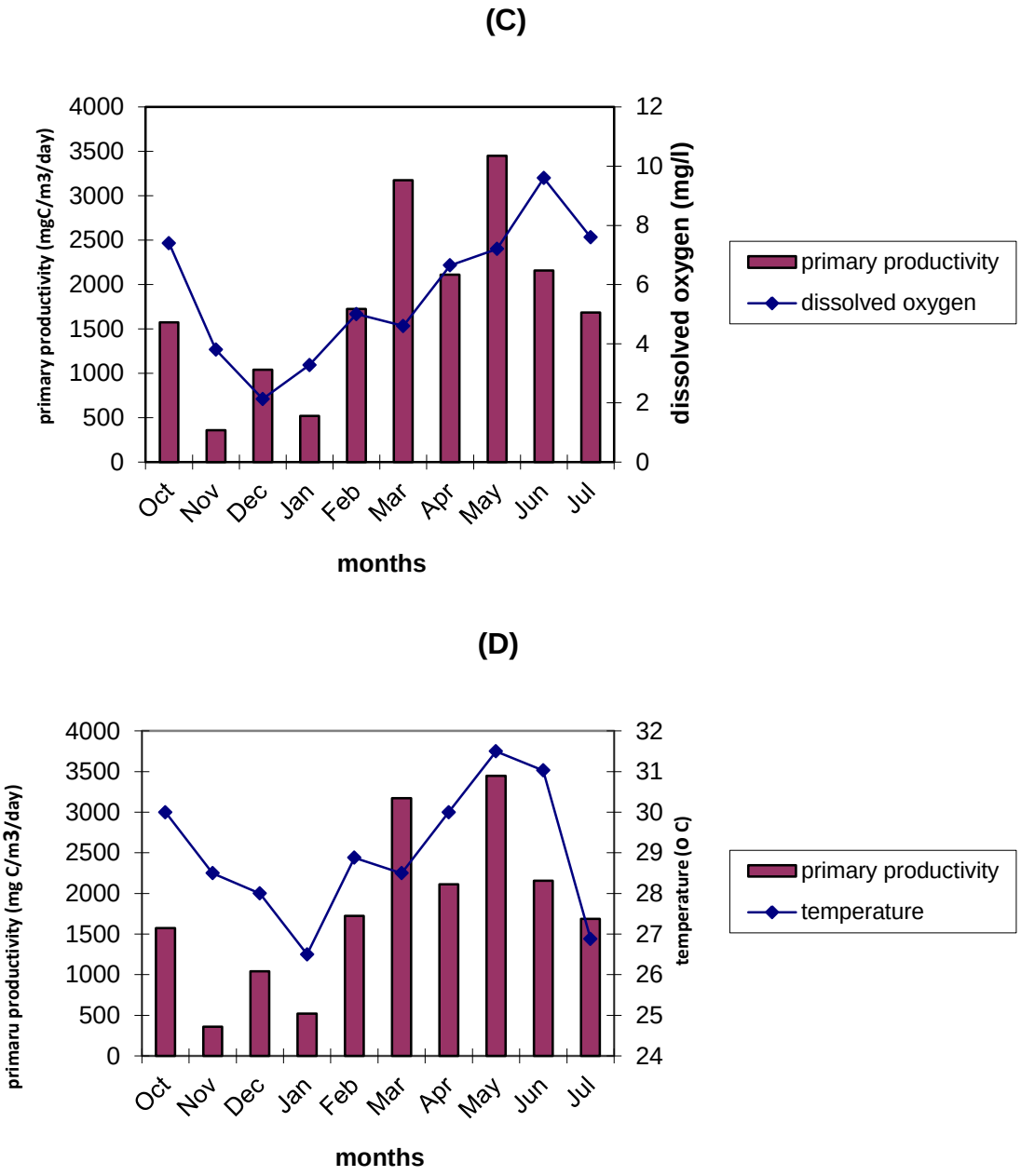


Fig. 4.8. (contd.) Monthly variatiion of hydrographical and biological parameters

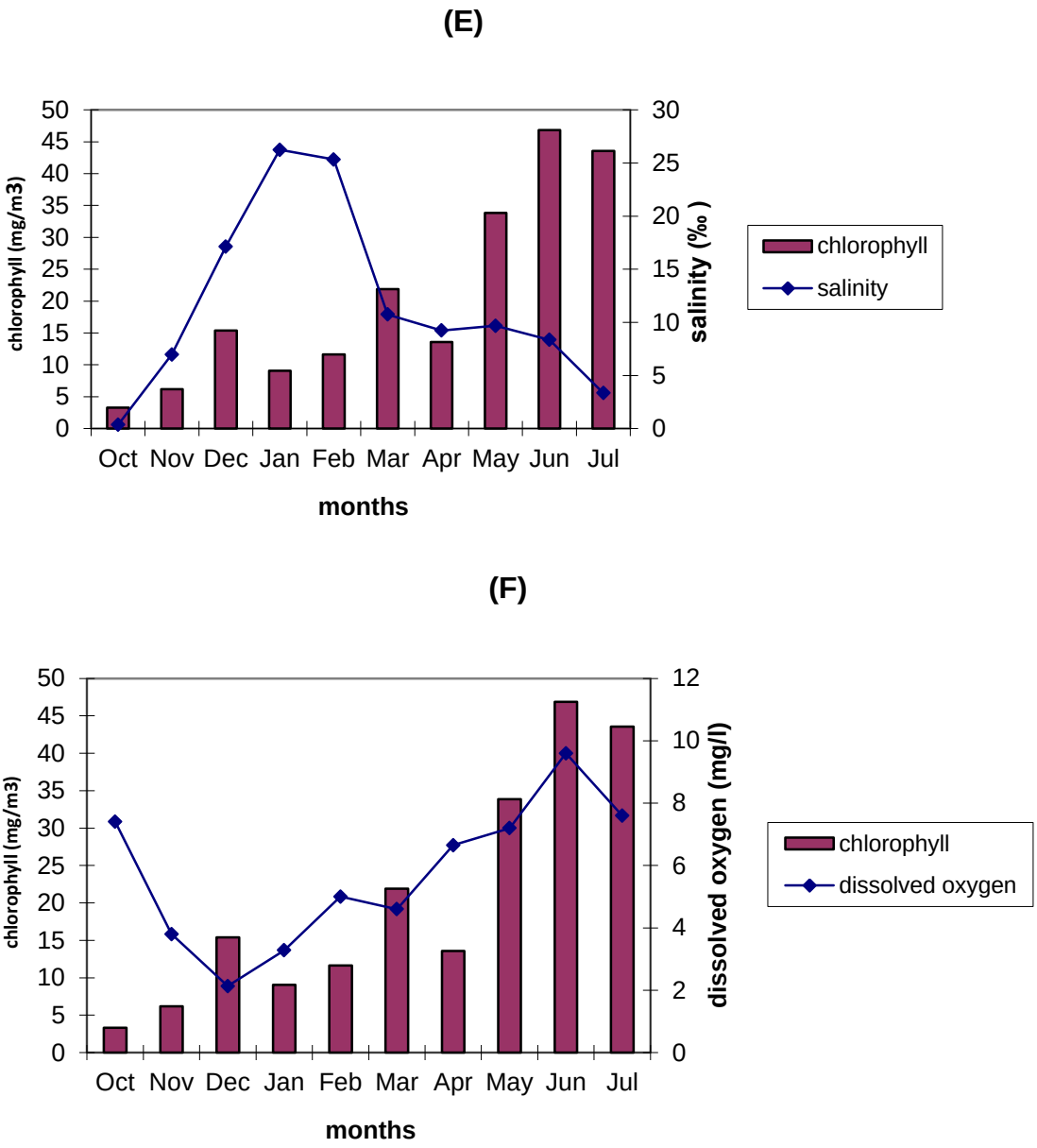


Fig. 4.8. (contd.) Monthly variatiion of hydrographical and biological parameters

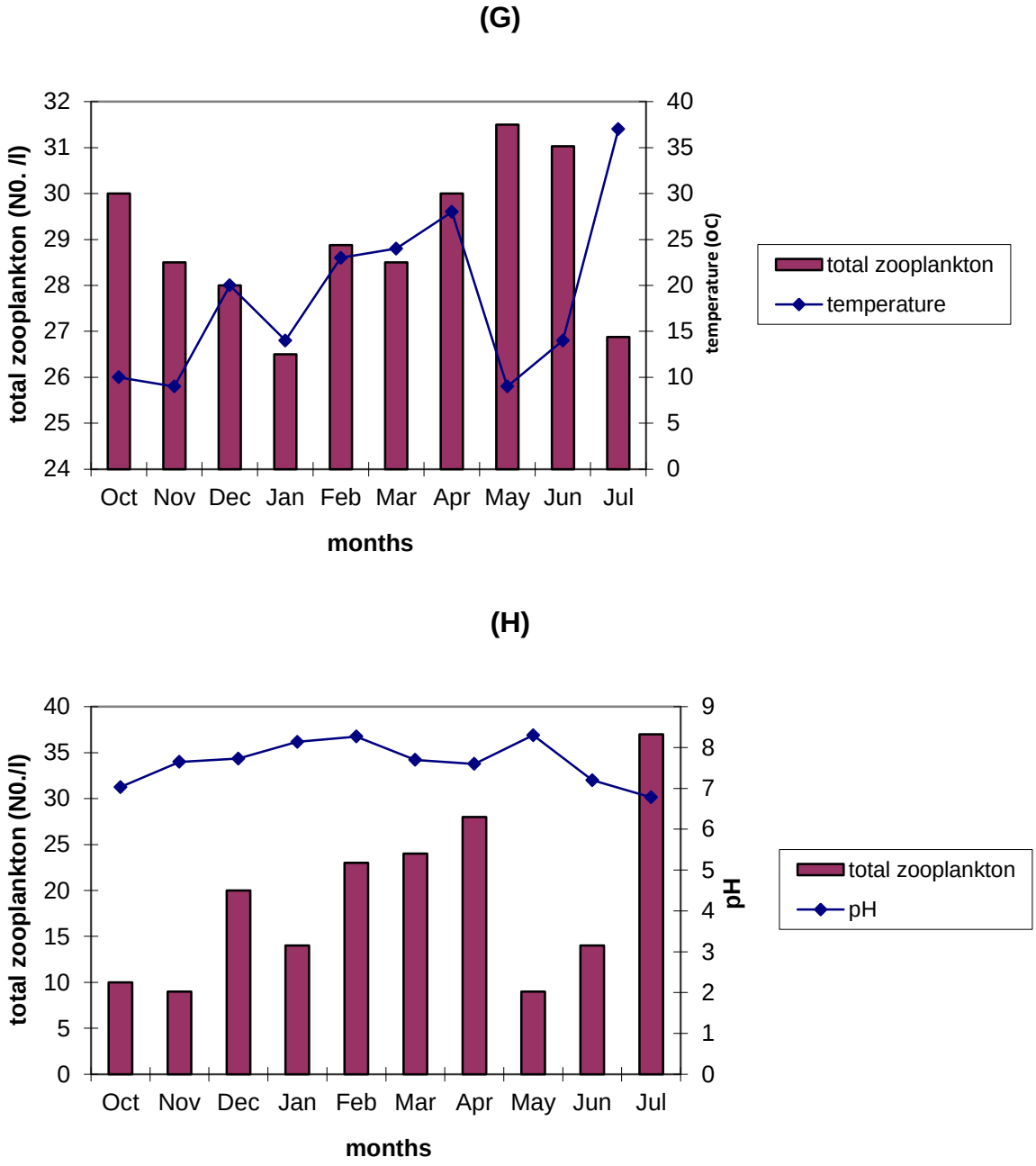


Fig. 4.8. (contd.) Monthly variatiion of hydrographical and biological parameters

DISCUSSION

5. DISCUSSION

5.1 HYDROGRAPHIC PARAMETERS

In the present study salinity values ranged from those of near marine condition (26.24‰) in January to almost freshwater condition (0.36 ‰) in October (Table 4.2). Varma *et al.* (2002) on analyzing long term daily changes in Panangad near to the present sampling site noticed salinity range between 0‰ and 32 ‰, similar to the present study. An annual salinity range of 1‰-27‰ in seasonal and perennial prawn culture fields of Cochin estuarine system was observed by Gopinathan (1982), Sankaranarayanan *et al.*(1982), Singh (1987) and Susheela *et al.* (2006). Similar values were also reported by Anon (2004) in a study conducted in the Panangad region of the Vembanad Lake. The maximum salinity was recorded in January when there was no rainfall (Table 4.4). During south west monsoon season minimum average salinity was recorded due to rainfall (285mm) and runoff. This agrees with the case reported by George (1958); Balakrishnan and Shynamma (1976); Ramaraju *et al.* (1979); Udayavarma *et al.* 1981; Sankaranarayanan *et al.* (1986); Joseph and Kurup (1990) and Anon (2004). Sankaranarayanan and Qasim (1967) reported maximum salinity in premonsooon season, but in the present study postmonsoon recorded highest average salinity of 15.54‰ season when compared to premonsoon season (Table 4.3). This might be due to less rainfall recorded in the postmonsoon season (86.5mm). During premonsoon season the amount of rainfall recorded was 138.42mm (Table 4.3 and Fig.4.3) and it might be the reason for less salinity compared to postmonsoon. Student's t- test showed no significant decrease of salinity in premonsoon compared to postmonsoon.

Salinity showed positive significant correlation with pH, alkalinity and hardness (Table 4.7 and Fig. 4.7) which indicates that increase in salinity resulted in a corresponding increase in pH, alkalinity and hardness. This might be due to the increase in the amount of dissolved salts.

Water temperature (Table 4.2, Fig. 4.2) did not show any wide fluctuation in the prawn filtration pond as reported by Kunjukrishna Pillai *et al.* (1975), Nair *et al.* (1975) and Nair *et al.* (1988). Singh (1987) observed that temperature ranged between 24.5ºC and 32.5ºC similar to the present study. The minimum water temperature was recorded in January and July which is similar to the trend reported by Kumaran and Rao (1975) in the estuarine area between Narakkal and Aroor. The low values observed during this period could be attributed to the winter effect and southwest monsoon as reported by Kumaran and Rao (1975) in the area between Narakkal and Aroor. Sakaranarayanan *et al.* (1982) also reported similar values from the tidal ponds of Ramanthuruth island (Cochin). Nair et al. (1988) reported similar trends in paddy-cum-prawn culture fields of Cochin area. There was a gradual increase in water temperature from February and highest value was recorded during May (Table 4.2 and Fig. 4.2). This might be due to the warm weather and maximum solar radiation during this period (Silas and Pillai, 1975).

Mean temperature value of postmonsoon season was less compared to the mean temperature of premonsoon season (Table 4.6). The peak values recorded in the premonsoon season (Table 4.3, Fig. 4.3) started showing a declining trend with the onset of monsoon (Table 1.2, Fig 1.2). Gopalakrishnan *et al.* (1982), Sankaranarayanan *et al.* (1982) and Nair *et al.* (1988) reported similar values in water temperature in

culture fields of Cochin area. Varma *et al.* (2002) and Haridevi *et al.* (2003) also reported similar trends in the Panangad region.

Mean turbidity of postmonsoon and premonsoon (Table 4.6 and Fig 4.6) did not show significant seasonal variation. But maximum average turbidity was reported in southwest monsoon season (July) as reported by Anon (2004) and Renjith (2006). The maximum average turbidity during monsoon period might be due to runoff (Anon, 2004) and churning up of the bottom of the pond due to low depth.

pH (Table 4.2, Fig.4.2) was minimum during July as reported by Sankaranarayanan and Qasim (1969). The pH range obtained was similar to the result obtained by Sankaranarayanan *et al*. (1982) in some tidal pools of Cochin. Mathew *et al.* (1987) and Susheela *et al.* (2006) also observed similar trends in perennial prawn culture fields adjacent to Cochin backwaters. According to Boyd (1990) and Venketesan *et al.* (2001) the range obtained is suitable for fish culture. The highest pH was recorded in premonsoon (Table 4.3, Fig.4.3) and this agrees with Sankaranarayanan *et al.* (1982). The lowest pH was obtained in the southwest monsoon and similar case was reported by Sankaranarayanan and Qasim (1969). From the t-test (Table 4.6), it is clear that eventhough pH increased during premonsoon when compared to postmonsoon the increase was not significant statistically.

pH showed highly significant positive correlation (Table 4.7 and Fig.4.7) with salinity as mentioned by Sankaranarayanan *et al.* (1982). Also a correlation was obtained between pH and primary production which agrees with the report of Balasubramanian *et al.* (1995).

Mathew *et al.* (1988) reported that total alkalinity was high with wide fluctuation in some prawn culture fields around Cochin. A similar situation was noticed in the present study (Table 4.2, Fig.4.2). But the range obtained in the present study was higher than the range reported

by Mathew *et al.* (1988). The alkalinity values, obtained during premonsoon season (Table 4.3, Fig.4.3) were less and this agrees with the findings of Sankaranarayanan and Qasim (1969) about Cochin backwaters.

The total hardness range reported by Baticados *et al.* (1986) and Ignasius (1995) were high when compared to the total hardness (41.25 to 776.25 mg $CaCO_3$/l) range obtained in the present study (Table4.2, Fig.4.2). The mean hardness and alkalinity during postmonsoon did not show any significant increase when compared to premonsoon. Alkalinity and hardness showed significant correlation with each other. Also alkalinity and hardness showed correlation (Table4.7, Fig.4.7) with pH, indicating that the latter increased with an increase in the former. This might be due to the presence of calcium and magnesium carbonate.

Nutrient concentrations didnot show any wide fluctuations in the current study (Table 4.2 and Fig.4.2). Nitrate concentration (Table 4.2 and Fig. 4.2) range obtained in the present study was similar to the range obtained by Sankaranarayanan *et al.* (1982).

Joseph and Pillai (1975) found that phosphate ranged between 0µg at/l and 32 µg at/l in the Cochin backwaters. Also Panigrahi (1993) and Venketesan *et al.* (2001) observed that phosphate values ranged between 0.97 and 19.69 µg at/l in the culture fields of Cochin. The range obtained in the present study was well within this range.

A nitrite concentration range of 0.13 µg at/l to 2.39µg at/l was obtained in the current study and this is within the range of 0-6µg at/l as reported by Joseph and Pillai (1975).

In the case of silicate, the range obtained was between 4.81 µg at/l and 72.63 µg at/l. But the result obtained by Susheela *et al.* (2006) was between 20.5 µg at/l and 60.5 µg at/l in an interior prawn filtration field in Cochin.

From the t-test analysis (Table 4.6), no seasonal variation between postmonsoon and premonsoon seasons was found in the case of any of the nutrients. Also nutrients didnot show any significant correlations with any of the parameters. From all this it is clear that some other process influence the nutrients. Bonnani *et al*, (1992) reported that sediments in shallow coastal waters are known to be important sites for the accumulation of organic matter and the subsequent remineralisation and recycling of nutrients. Hence the process might be internal loading. The perennial ponds like estuaries have water column of low depth, thus the nutrients get deposited in the sediments resulting in effective recycling of nutrients irrespective of seasons and other parameters.

In general the dissolved oxygen (Table4.2, Fig.4.2) values remained high through out the study period and this might be due to the perennial nature of the field where there is less organic decomposition as reported by Nair *et al.* (1988). Singh (1987) found that seasonal and perennial prawn culture fields had less dissolved oxygen values during premonsoon season and the values increased with the onset of monsoon. This is similar to the result obtained in the present study (Table4.3, Fig.4.3).

Low dissolved oxygen values were obtained in postmonsoon seasons when compared to the high dissolved oxygen values obtained during monsoon in the current case. But Selvaraj *et al.* (2003) reported high dissolved oxygen values during postmonsoon period. The mean dissolved oxygen of postmonsoon was significantly higher than the mean dissolved oxygen of premonsoon.

Dissolved Oxygen values showed a negative significant correlation with salinity (Table 4.7 and Fig.4.7). This agrees with findings of Weiss (1970) who mentioned that solubility of oxygen in

water is mainly influenced by temperature and salinity and it decreases with increase in salinity and temperature. But in the present study temperature showed a positive correlation with dissolved oxygen.

According to Hepher (1963) photosynthesis by phytoplankton is the primary source of oxygen. The present study agrees with this report, where a positive significant correlation was obtained between dissolved oxygen and primary production. Similarly, positive significant correlation was obtained between chlorophyll and dissolved oxygen and total phytoplankton count and dissolved oxygen.

5.2 BIOLOGICAL PARAMETERS

The primary production range obtained in the present study was well within the range (Table 4.2 and Table 4.2) reported by Nair *et al.* (1975), Mathew *et al.* (1988), Jose *et al.* (1988), Anon (2004) and Renjith *et al.* (2004). The primary production showed considerable seasonal variation with premonsoon recording the peak period against the case reported by Paulinose *et al.* (1981) and Menon *et al.* (2000). This might be due to the optimum light intensity during premonsoon and also due to effective nutrient recycling.

The primary production range obtained in premonsoon season (Table 4.2, Fig. 4.2) agrees with the range obtained by Venketesan *et al.* (2001).

From the estimation of chlorophyll values (Table4.2, Fig.4.2), it is clear that the range is relatively higher than the range reported by Nair *et al.* (1975), Paulinose *et al.* (1981) , Selvaraj *et al.* (2003) and Nair *et al.* (1988).

Chlorophyll content was maximum during monsoon season (July). This agrees with the findings of Paulinose *et al.* (1988).

Primary production and chlorophyll showed significant correlation with dissolved oxygen indicating that increase in dissolved oxygen was due to photosynthesis. A negative significant correlation was observed between chlorophyll and salinity. But the correlation between salinity and primary production was not significant which indicates that salinity has apparently no influence on primary production in the pond (Qasim *et al.* 1972).

The highest total phytoplankton count (Table 4.3, Fig.4.3) was estimated in monsoon which agreed with the earlier findings (Gopinathan *et al.* 1975 and Gopalakrishnan *et al.* 1988). But Bopiah *et al.* (1982) obtained maximum count during premonsoon season. The maximum count of 7932 cells/l obtained in the present study agrees with the count obtained by Nair *et al. (*1988). But he obtained maximum count in the month of May, while in the present study maximum count was recorded in June.

Temperature didnot have any direct influence on phytoplankton production in the present study and this agrees with the observation of Gopinathan (1972). No significant correlation (Table 4.8, Fig.4.8) was observed between total phytoplankton count and salinity which disagrees with the report of Menon *et al.* (2000). But a positive correlation was observed between dissolved oxygen and phytoplankton indicating that dissolved oxygen concentration increased with increase in phytoplankton count.

A negative significant correlation was observed between total phytoplankton count and nitrate. This might be due to the utilisation of nitrate for phytoplankton growth.

Sankaranarayanan *et al*. (1982) and Gopalakrishnan *et al*. (1988) reported that zooplankton of the culture fields are limited in quality and quantity. The present observation generally agrees with these findings

(Table 4.3). Also the total number of zooplankton collected during the study period was only 190 No. /l and this agrees with the report of Gopalakrishnan *et al*. (1988) who stated that in general seasonal culture fields had greater abundance of zooplankton compared to perennial fields. The total zooplankton was more during premonsoon months (February, March, April and May) and was less during monsoon months in the present study (Table 4.2 and Fig.4.2) which agrees with the report of Haridas *et al*. (1973), Silas and Pillai (1975) and Nair *et al*. (1988). But there was not much decrease in the total zooplankton in the monsoon months. This might be due to the replacement of saline tolerant ones with non tolerant ones.

The total zooplankton (Table 4.8 and Fig. 4.8) abundance didnot show any significant correlation with hydrographic parameters except with temperature and pH. Renjith (2006) also reported that total zooplankton was negatively correlated with temperature. This negative correlation might be due to the diurnal vertical migration of zooplankton. Eventhough salinity is considered as the master factor in the estuarine environment, its variations were not reflected in the abundance of zooplankton. This might be due to the replacement of the organisms of high salinity period (premonsoon) with freshwater organisms during the southwest monsoon as observed by Pillai *et al.* (1973). According to Silas and Pillai (1975) salinity acts on zooplankton in a different way affecting nature and type of fauna and not on the biomass of zooplankton as a whole. Wellershaus (1974) also observed that there is no linear correlation excisting between zooplankton abundance and salinity of Cochin backwaters. The present observation agrees with these findings. Copepods and crustacean larvae were the dominant groups and were present through out the study period in varying numbers.

Copepods dominated the zooplankton in abundance in the present study and were present through out the study period in varying intensities. The report of Menon *et al.* (1971), Silas and Pillai (1975), Jose *et al.* (1988), Joseph *et al.* (1988), Nair *et al.* (1988), Haridevi *et al.* (2003), Anon (2004) and Renjith (2006) agrees with this. The seasonal variations were not pronounced in copepod abundance in the present study. Copepods constituted 50.9%, 31.1% and 58.82% in postmonsoon, premonsoon and southwest monsoon respectively. Jose *et al.* (1988) has reported that the maximum zooplankton was recorded during the high saline period from January to May. But in the present study, the maximum number was recorded in July (Table4.4).This might be due to the occurence of cyclopoids of freshwater origin.

The crustacean larvae occupied second position in abundance. They dominated the culture field in all the three seasons. They constituted 24.5%, 17.78% and 33.33% during postmonsoon, premonsoon and monsoon respectively. This agrees with the report of Antony (1991), who observed high abundance of crustacean larvae in the Cochin harbour area during the onset of the monsoon and attributed the increase to the sudden change in salinity, which triggered the spawning of the decapods. Nair and Tranter (1971), Menon *et al.* (1971), Silas and Pillai (1975) and Antony (1991) have studied the distribution of crustacean larvae in the Cochin backwaters. According to their observations brachyuran larvae occur throughout the year while copepod larvae were more during November-April.

Tintinids were observed during high saline period and their number deceases with decrease in salinity. They are generally marine in origin and found during high saline period. Tintinids constituted only 3.7% in postmonsoon while they constituted 26.67% in premonsoon. In monsoon they constituted 1.96%. In premonsoon, eventhough average

salinity was low the individual months had comparitively high salinity when compared to postmonsoon and hence tintinids dominated during premonsoon.

Nematodes though benthic in nature were observed in the plankton in the present study (Table4.3). They showed high abundance in February. They were either absent or very few in other months. They constituted 5.66% and 3.33% (Fig 4.5) during postmonsoon and premonsoon respectively. They were completely absent during monsoon.

Veliger larvae of gastropods and lamellibranchs were observed in the culture field during December, January and February. They constituted 5.66% and 3.33% during postmonsoon and premonsoon respectively and were absent during monsoon. This agrees with the observation of George (1958) and Nair and Tranter (1971). On the other hand, Silas and Pillai (1975) recorded their maximum during the post-monsoon period from the Cochin backwater.

Rotifers were present in October and July, when salinity was less. They constituted 3.77% and 1.96% during postmonsoon and premonsoon respectively.

The total zooplankton had not shown significant correlation with the nutrient concentration in the present study. It is well known that nutrients do not have direct relation with zooplankton, but they influence them indirectly by influencing the primary production. Zooplankton grazes upon the phytoplankton whose abundance is dependent on the availability of nutrients. Studies have shown that the availability of food in the form of phytoplankton for the zooplankton was never a limiting factor in the Cochin backwaters (Madhupratap and Haridas, 1975).

In brief, it can be explained that during the present study no significant influence of hydrographical parameters on biological parameters was observed.

SUMMARY

6. SUMMARY

1. The present study was carried out to find out the influence of hydrographical parameters on the plankton population in a prawn filtration pond.
2. Fortnightly sampling was carried out for the analysis of hydrographical parameters and biological parameters from October, 2007 to July, 2008.Hydrographical parameters like salinity, water temperature, turbidity, pH, total hardness, total alkalinity, nitrate, phosphate, silicate, nitrite and dissolved oxygen were studied. Biological parameters like primary productivity, chlorophyll-a, total phytoplankton and zooplankton were studied. Phytoplankton and zooplankton were collected using 55µm and 63µm mesh respectively.
3. Monthly averages of meteorological parameters like maximum temperature, minimum temperature rainfall and relative humidity were computed from hourly data collected by an Automatic Weather Station.
4. To study the relationship between hydrographical and biological parameters, linear correlation coefficients were worked out.
5. Salinity ranged from near marine (26.24‰) to almost freshwater (0.36‰). The average salinity during southwest monsoon was 5.85. Among the three seasons, postmonsoon recorded the highest average salinity. Alkalinity, hardness and pH increased with increase in salinity due to increase in the amount of dissolved salts.
6. Water temperature did not show wide fluctuation. The minimum water temperature was recorded in January and July due to winter effect and south west monsoon respectively. The peak

values recorded during premonsoon started showing declining trend with the onset of monsoon.

7. The average turbidity was highest during southwest monsoon due to runoff and churning up of the bottom of the pond due to low depth.
8. Highest average pH was recorded in postmonsoon.
9. The total alkalinity values showed wide fluctuation. Average alkalinity during southwest monsoon was less.
10. Total hardness value ranged between 41.25 mg $CaCO_3$/l to 776.25 mg $CaCO_3$/l. Alkalinity and hardness showed correlation with pH indicating the presence of calcium and magnesium.
11. Nutrients did not show any seasonal variation. Also any significant correlation was obtained with any of the parameters. Internal loading and effective recycling of nutrients might be responsible for the lack of correlation and seasonal variation.
12. Dissolved oxygen values were high through out the study period due to the perennial nature of the pond and high primary production. The average dissolved oxygen during southwest monsoon was high as salinity was less.
13. The mean primary production values for premonsoon season was high due to optimum light intensity and effective nutrient recycling.
14. The average chlorophyll was highest during monsoon season. Chlorophyll and salinity showed no correlation indicating the presence of euryhaline organisms in the pond.
15. The mean phytoplankton count was high in monsoon .Dissolved oxygen and total phytoplankton increased simultaneously.

16. The total zooplankton was limited in quantity and quality. The total zooplankton was maximum in premonsoon months. But no decrease was seen during monsoon indicating the replacement of organisms of high salinity period with freshwater organisms during southwest monsoon. Also showed correlation with temperature inidicating the phenomenon of diurnal vertical migration.
17. Major groups of zooplankton collected were copepods, crustacean larvae, tintinids, nematodes, rotifers and veliger larvae of mollusks.
18. Copepods dominated the zooplankton. They were maximum during southwest monsoon.
19. However seasonal variations were not pronounced in the present study area.
20. .Crustacean larvae occupied the second position and were present in all the three seasons *viz.* pre-, post- and monsoon season.
21. Tintinnids and nematodes were observed during the saline period and their number decreased with decreasing salinity. Rotifers were recorded during low saline period only. Veliger larvae were recorded during December, January and February.
22. In brief, no significant correlations were observed between hydrographical and biological parameters

REFERENCES

7. REFERENCES

Abraham, S. 1970. On the occurrence and seasonal distribution of *Acartia plumosa* T. Scott (Copepoda: Calanoida) a new record from the West Coast of India. *Curr. Sci.* **39**: 115-116

Anirudhan, T.S., Balchand, A.N., Nair, S.M. and Nambisan, P.N.K. 1987. Distribution pattern of salinity and silicon and their inter- relationship in Cochin backwaters. *Proceedings of the National Seminar on Estuarine Management, June 4-5, 1987* (ed. Balakrishnan Nair, N.). State Committee on Science, Technology and Environment, Government of Kerala, Trivandrum, pp. 26-31

Anirudhan, T.S. and Nambisan, P.N.K. 1990. Distribution of salinity and silicon in Cochin estuary. *Indian J. Mar. Sci*. **19**: 137-139

Anon. 2000. Report of the expert committee for fisheries management studies, Kerala, submitted to Government of Kerala by Balakrishnan Nair (Chairman, Expert Committee). p.213

Anon. 2004. Studies on circulation and mixing and their influence on productivity of Panangad region of Vembanad Lake. Dept. of Fishery Hydrography, College of Fisheries Panangad. p.142.

Antony, M. 1991. A study on the fluctuation of zooplankton in the estuarine waters at Cochin during May-September, 1991. M.Sc. thesis, Central Marine Fisheries Research Institute, Cochin, p. 95

A.P.H.A. 1998. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, Washington D.C, p. 181

Batcha, S.M.A. 2000. Studies on surface and bottom water temperature distribution of a tropical estuary during different seasonal periods. *J. Env. Poll.* **7**: 143-148

Balakrishnan, A. 1957. Variation of salinity and temperature in Ernakulam Channel. *Bull. Cent. Res. Univ. Kerala* **5**: 7-9

Balakrishnan, K.P. and Shynamma, C.S. 1976. Diel variations in hydrographic conditions during different seasons in the Cochin harbour (Cochin Backwater). *Indian J. Mar. Sci.* **5**: 190-195

Balasubramanian, T., Viswakumar, M. and Venugopal, P. 1995. Ecological evaluation of two-prawn culture fields in the Cochin Backwater based on pre-monsoon diurnal observations. *J. Mar. biol. Ass. India.* **37**: 212-220

Baticados, M.C.L., Coloso, R.M., Ouremdez, R.O. 1986. Studies on the chronic soft shell syndrome in the tiger prawn, *Penaeus monodon* (Fabracious), from brackish water ponds. *Aquaculture* **56**: 271-285

Bonnani, P., Caprioli, R., Ghiara, E., Mignuzzi, C., Orlandi, C., Paganin, G. and Monti, A. 1992. Sediment and interstitial water chemistry of the Orbetello Lagoon (Grosseto, Italy); nutrient diffusion across the sediment water interface. *Hydrobiologia* 553-568

Bopiah, B.A. and Neelakantan, B. 1982. Ecology of a tidal pond in an estuarine environment, Karwar. *Mahasagar* **15**: 29-36

Boyd, C.E. 1990. *Water quality in ponds for* Aquaculture. Albama agricultural Experiment Station, Auburn University, p.480

Cheryian, P.V. 1967. Hydrographical studies in and around the Cochin harbour. *Bull. Dep. Mar. biol. Oceanogr. Univ. Kerala*. **3**: 9-17

George, K.V. 1974. Some aspects of prawn culture in the seasonal and perennial fields of Vypeen Isalnd. *Indain J. Fish.* **21**:1-19

George, M.J. 1958. Observations on the plankton of the Cochin backwaters. *Indian J. Fish.* **5**: 375-401

Gopalakrishnan, T.C., Lalithambika Devi, C.B., Aravindakshan, P.N., Nair, K.K.C. and Krishnankutty, M. 1988. Phytoplankton and zooplankton of some paddy-cum-prawn culture fields in and around Cochin. *Mahasagar* **21**: 85-94

Gopinathan, C.P. 1972. Seasonal abundance of phytoplankton in the Cochin backwater. *J. Mar. biol. Ass. India* **14:** 568-577

Gopinathan, C.P. 1975. Studies on the estuarine diatoms of India. *Bull.Dept.Mar.Sci.Univ.Cochin* **7**: 995-1004

Gopinathan, C.P., Nair, P.V.R. and Nair, A.K.K. 1984.Quantitative ecology of phytoplankton in the Cochin backwater. *Indian J.Fish*. **31**: 325-336

Gopinathan, C. P., Nair, P.V.R., Pillai, K.K.V., Pillai, P.P., Kumaran, M.V. and Balachandran, V.K. 1982. Environmental characteristics of the seasonal and perennial prawn culture fields in the estuarine system of Cochin. *Proceedings of the Symposium on Coastal Aquaculture, January 12-18, 1980* (eds. Silas, E.G., Rao, P.V., Nair, P.V.R., Algarswami, K., Jacob, T., George, K.C., Rengarajan, K., Pillai, P.P., Mathew, K.J., Pillai, V.K. and Ponniah, A.G.). Marine Biological Association of India, Cochin, **1**: 369-382

Grasshoff, K., Ehrhardt, M. and Kremling, K. 1983. *Methods of Sea Water Analysis.* Second Edition. Verlag Chemie, Weinhein, p. 419

Haridas, P., Madhupratap, M. and Rao, T.S.S. 1973. Salinity, temperature, oxygen and zooplankton biomass of the backwaters of Cochin to Alleppey. *Indian J. Mar. Sci.* **2**: 94-102

Haridevi, C.K., Houlath, K.K., Varma, K.K., Renjith, K.R., Vijayakumar, C.T. and Prabha Joseph (late) 2004. Seasonal variation of zooplankton in related to Hydrographic parameters in the Panangad region of Vembanad Lake. *Proceedings of the national seminar on new frontiers in Marine Bioscience Research, January 22-23,* 2004. (eds. Abidi, S. A. H., Ravindran, M., Venkatesan, R. and Vijayakumaran, M.) National Institute of Ocean Technology, Chennai, pp.501-511.

Hepher, B. 1963. Ten years of research in fishpond fertilization in Israel. II. Fertilizer dose and frequency of fertilization. *Bamidgeh.* **15**: 78-92

Ignasius, C.A.1995. Ecological productivity studies of prawn farms in central Kerala. Ph.D Thesis, Central Marine Fisheries Research Institute. p.361

Josanto, V. 1971. The bottom salinity characteristics and the factors that influence the salt water penetration in the Vembanad Lake. *Bull. Dept. Mar. biol. Oceanogr. Univ. Cochin* **5**: 1-16

Jose, S., Mathew, P.M., Jose, M.M. and Mrithunjayan, P.S. 1988. Zooplankton and macrobenthos in a brackishwater fish farm in the southwest coast of India. *Proceedings of the first Indian fisheries forum*, 1987 (ed. Mohan Joseph, M.). Asian Fisheries Society Indian Branch, Mangalore, pp.147-150

Joseph, A. 1988. Secondary production in brackishwater culture ponds. M.F.Sc. thesis, Kerala Agricultural University, Thrissur, p. 143

Joseph, P.S. 1974. Nutrient distribution in the Cochin harbour and in its vicinity. *Indian J. Mar. Sci.* **3**: 28-32

Joseph, J. and Kurup. P.G. 1990. Stratification and salinity distribution in Cochin Estuary, Southwest coast of India. *Indian J. Mar. Sci*.**19**:27-31

Joseph, K.J. and Kunjukrishna Pillai, V. 1975. Seasonal and spatial distribution of phytoplankters in the Cochin backwater. *Bull. Dept. Mar. Sci. Univ. Cochin*. **7**: 171-180

Kumaran, S. and Rao, T.S.S. 1975. Phytoplankton distribution and abundance in the Cochin backwater during 1971-1972. Third all India symposium on estuarine ecology, Cochin-1975. *Bull. Dept. Mar. Sci. Univ. Cochin* **7**: 791-79

Kunjukrishna Pillai, V., Joseph, K.J. and Kesavan Nair, A.K. 1975. The plankton production in the Vembanad lake and adjacent waters in relation to environmental parameters. Third all India symposium on estuarine ecology, Cochin-1975. *Bull. Dept. Mar. Sci. Univ. Cochin* **7**: 137-150

Kurup, B.M., Sebastian, M.J, Sankaran, T.M. and Rabindranath, P. 1992. Exploited fishery resources of the Vembanad Lake: fishery based on pokkali fields and polders. *Fish. Tech.* **29**: 21-26

Lenore, S.C., Arnold, E.G. and Andrew, D.E. 1998. *Standard Methods for the Examination of Water and Wastewater*. Twentieth Edition. American Public Health Association, Washington, p.1085

Madhupratap, M. 1978. Studies on the ecology of zooplankton of Cochin backwaters. *Mahasagar* **11**: 45-56

Madhupratap, M. and Haridas, P. 1975. Composition and variations in the abundance of zooplankton of backwaters from Cochin to Alleppey. *Indian J. Mar. Sci.* **4**: 77-85

Mathew,P.M., Jose, M.M. and Mrithunjayan, P.S. 1988. Polyculture of brackishwater fishes in Vyttila fish farm, Kerala. *Proceedings of the first Indian fisheries forum*, 1987 (ed. Mohan Joseph, M.). Asian Fisheries Society Indian Branch, Mangalore, pp. 131-134.

Menon,N.N., Balchand, A.N. and Menon, N.R. 2000. Hydrobiology of Cochin backwater system- a review. *Hydrobiologia* **430**: 149-183

Menon, N.R., Venugopal, P. and Goswami, S.C. 1971. Total biomass and faunistic composition of the zooplankton in the Cochin backwater. *J. Mar. biol. Ass. India* **13**: 220-225

Mohammed, K.H. and Rao, V.P. 1972. Estuarine phase in the life history of the commercial prawns of the West Coast of India. *J. Mar. biol. Ass. India* **13**: 149-161

Nair, K.K.C., Sankaranarayanan, V.N., Gopalakrishnan, T.C., Balasubramanian, T., Lalithambika Devi, C.B., Aravindakshan, P.N. and Krishnankutty, M. 1988. Environmental conditions of some paddy-cum-prawn culture fields of Cochin backwaters, South West Coast of India. *Indian J. Mar. Sci.* **17**: 24-30

Nair, P.V.R., Joseph, K.J, Balachandran, V.K. and Pillai, V.K.1975. A study on the primary production in the Vembanad Lake. *Bull. Dept. Mar. Sci. Univ. Cochin*. **7**: 161-170

Nair, K.K.C. and Tranter, D.J. 1971. Zooplankton distribution along salinity gradient in the Cochin backwater before and after the monsoon. *J. Mar. biol. Ass. Indi.* **13**: 203-210

Panigrahi, A. 1993. Influence of different types of soil on the water quality in culture ponds. M.Sc. Thesis, Cochin University of Science and Technology, Cochin, p.120

Paulinose, V.T., Balasubramanian, T., Aravindakshan, P.N., Gopala Menon, P and Krishnanankutty, M.1981. Some aspects of prawn ecology in Cochin backwaters. *Mahasagar* **14**: 123-133

Pillai, P.P. 1970. *Pseudodiaptomus jonesi*, a new calanoid copepod from Indian waters. *Curr. Sci.* **39**: 78-80

Pillai, P.P. 1972. Studies on the estuarine copepods of India. *J. Mar. biol. Ass. India* **13**: 162-172

Pillai, P.P. and Pillai, M.A. 1973. Tidal influence on the diel variations of zooplankton with special reference to copepods in the Cochin Backwater. *J. Mar. biol. Ass. India* **15**: 411-417

Pillai, P.P., Qasim, S.Z. and Nair, A.K.K. 1973. Copepod component of zooplankton in a tropical estuary. *Indian J. Mar. Sci.* **2**: 38-46

Purushan, K.S. 1996. Sustainable shrimp production from culture systems in Kerala- an improved farming practise.

Purushan, K.S. 2000. The potential of aquaculture in Kerala. *Seafood export Journal* **31**: 13-19

Purushan, K.S. 2002. Wetland ecosystem development and management in relation to Pokkali area. *Wetland conservation and management of Kerala* (eds. M.Jayakumar, Dr. Kamalakshan Kokkal, Dr. P.N.Premachandran, Dr. Bijukumar) p 47-55

Qasim, S.Z. 1973. Productivity of backwaters and estuaries. *Ecol.Stud.* **3**: 145-154

Qasim, S.Z. 1979. Primary production in some tropical environments. *Marine Production Mechanisms*, IBP. **20**: 31-69

Qasim, S.Z., Bhattathiri, P.M.A. and Devassy, V.P. 1972. Influence of salinity on the rate of photosynthesis and abundance of some tropical phytoplankton. *Mar.Biol*. **12**: 200-206

Qasim, S.Z. and Gopinathan, C.K. 1969. Tidal cycle and the environmental features of Cochin backwater. *Proc. Indian Acad. Sci.* **67**: 336-348

Qasim, S.Z., Sumitra Vijayaraghavan., Joseph, K.J. and Balachandran, V.K. 1974. Contribution of microplankton and nanoplankton in the waters of a tropical estuary. *Indian. J. Mar. Sci*. **3**: 146-149

Qasim, S.Z., Wellershaus, S., Bhattathiri, P.M.A. and Abidi, S.A.H. 1969. Organic Production in a Tropical estuary. *Proc. Indian Acad. Sci.* **69**: 51-94

Ramamirtham, C.P. and Jayaraman, R. 1963. Some aspects of the hydrographical conditions of the backwaters around Willingdon Island (Cochin). *J. Mar. biol. Ass. India.* **5**: 170-177

Ramaraju,V.S., Udayavarma, P. and Abraham Pylee. 1979. Hdrographical characteristics and tidal prism at the Cochin harbour mouth. *Indian J. Mar. Sci.* **8**: 78-84

Rao, T.S.S., Madhupratap, M. and Haridas, P. 1975. Distribution of zooplankton in space and time in a tropical estuary. *Bull. Dept. Mar. Sci. Univ. Cochin.* **7**: 695-704

Reddy, C.V.G. and Sankaranarayanan, V.N. 1972. Phosphate regenerative activity in the muds of a tropical estuary. *Indian J. Mar. Sci.* **1**: 57-60

Renjiith,K.R. 2006. Chemodynamics and ecohydrology of a tropical estuary. Ph.D Thesis, Cochin University of Science and Technology, Cochin, p. 398

Renjith,K.R., Varma, K.K., Haridevi, C.K., Houlath, K.H., Vijayakumar, C.T. and Prabha Joseph. 2004. Primary production and fishery potential of the Panangad region of Cochin estuarine system. *J.Mar.Biol.Ass.India* **46**:126-132

Sankaranarayan, V.N., Joseph, T. Vijayalakshmy, K.V. and Balachandran, K.K., 1984.A typical behaviour of dissolved silicon in the Cochin Backwater and Periyar River. *Indian J. Mar. Sci.***13**:60-63

Sankaranarayanan, V. N., Kumaran, S., Balasubramanian, T., Stephen, R. and Panampunnayil, S.U. 1982. Studies on the environmental conditions of tidal ponds in the Ramanthuruth Isalnd (Cochin). *Proceedings of the Symposium on Coastal Aquaculture, January 12-18, 1980* (eds. Silas, E.G., Rao, P.V., Nair, P.V.R., Algarswami, K., Jacob, T., George, K.C., Rengarajan, K., Pillai, P.P., Mathew, K.J., Pillai, V.K. and Ponniah, A.G.). Marine Biological Association of India, Cochin. **1**: 362-368

Sankaranarayanan, V.N. and Qasim, S.Z. 1967. The influence of some hydrographical factors on the fisheries of Cochin area. *Proceedings of symposium on Indian Ocean, March, 1967.* National Institute of Sciences India, pp. 846-853

Sankaranarayanan, V.N. and Qasim, S.Z. 1969. Nutrients of the Cochin backwater in relation to environmental characteristics. *Mar. Biol.* **2**: 236-247

Sankaranarayanan, V.N., Udaya Varma, P., Balakrishnan, K.K., Pylee, A. and Joseph, T. 1986. Estuarine characteristics of the lower reaches of river Periyar (Cochin Backwater). *Indian J. Mar. Sci.* **15**: 166-170

Santhakumari, V. and Vannucci, M. 1972. Monsoonal fluctuations in the distribution of the hydromedusae in the Cochin backwater, 1968-1969. *J. Mar. biol. Ass. India* **13**: 211-219

Selvaraj, G.S.D., Thomas, V.J. and Khambadkar, C.R.2003. Seasonal variation of phytoplankton and productivity in the surf zone and backwater at Cochin. *J. Mar. biol. Ass. India* **45:** 9-19

Silas, E.G. and Pillai, P.P. 1975. Dynamics of zooplankton in a tropical estuary with a review on the plankton fauna of the environment. *Bull. Dept. Mar. biol. Oceanogr. Univ. Cochin* **7**: 329-335

Singh, D. 1987. Comparative studies on the ecology of bottom macrofauna in seasonal and perennial fishponds and in the adjacent backwaters. M.Sc. thesis, Central Marine Fisheries Research Institute, Cochin, p. 122

Snedecor, G.M. and Cochran, W.G. 1968. *Statistical Methods.* Sixth edition. Oxford and IBH publishing company, New Delhi, p. 593

Sreedharan, M. and Mohammed Salih, K.Y. 1974. Distribution characteristics of nutrients in the estuarine complex of Cochin. *Indian J. Mar. Sci.* **3**: 125-130

Sreekumar, R. and Joseph, K.J. 1995. Periphyton colonization in Cochin estuary. *Phykos* **34**: 83-89

Sreekumar,R and Joseph, K.J. 1997.Contribution of periphytic algae to the bioproductivity in Cochin estuary. *J. Mar. Biol. Ass. India* **39**: 13-19

Srinivasan, M. 1972. Biology of chaetognaths of the estuarine waters of India. *J. Mar. biol. Ass. India* 13: 173-181

Stephen, D. 1985. Imperatives for the future development of shrimp culture in the Cochin backwater system (Kerala, India). Ph.D Thesis, University of Hawaii, p. 220

Strickland, J.D.H. and Parsons, T.R. 1972. *A Practical Handbook of* S*eawater* A*nalysis*. Third edition. Fisheries Research Board of Canada, p.311

Sudheer.2003. Community changes in zooplankton and macrobenthos of a prawn filtration field in relation to hydrographical conditions. M.F.Sc. thesis, KAU, Thrissur, p.124

Susheela Jose, Shyama, S., Dinesh, K. and Mohan, M.V. 2006. Impact of tsunami on the ecology, species composition and production in an interior prawn filtration field in kochi. *Fish. Technol.* **43**: 118-203

Udayavarma, P., Abraham Pylee and Ramaraju, V.S. 1981. Tidal influence on the seasonal variation in current data and salinity around Willingdon Island. *Mahasagar*. **14**: 225-237

Varma, K.K., Cherian, C.J., Mrithunjayan, P.S., Raman, N.N. and Prabha Joseph 2002. Characteristics of temperature and salinity fluctuations in a south Indian estuary. A study of Vembanad Lake, a monsoon-influenced estuary. *Earth. Sys. Monitor* **12**: 9-1

Venketesan, V., Prema, D. and Selvaraj, G.S.D. 2001. Sediment and water characteristics of selected prawn farming sites at Cochin during premonsoon months. *J. Mar. biol. Ass. India.* **43:** 41-48

Vijayakumar, C.T. 2003. Studies on temporal and spatial variations of circulation and hydrographic characteristics of Pananagad region of the Vembanad Lake, M.F.Sc. thesis, KAU, Thrissur, p.118

Weiss, R.F.1970. *Deep Sea Res*., **17**, 721

Wellershaus, S. 1969. On the taxonomy of planktonic Copepoda in the Cochin Backwater (A South Indian Estuary). *Veroeff. Inst. Meeresforsch Bremerhaven* **11:** 245-286

Wellershaus, S. 1970. On the taxonomy of some copepods in Cochin backwater (A South Indian Estuary). *Ibid.* **12**: 463-490

Wellershaus, S. 1974. Seasonal changes in the zooplankton population in the Cochin backwater (A South Indian estuary). *Hydrobiol. Bull.* **8:** 213-223

Zar, J.H. 2003. *Biostatistical Analysis*. Fourth edition. Pearson Education. p. 122-126

INFLUENCE OF HYDROGRAPHICAL PARAMETERS ON THE COMPOSITION AND SEASONAL VARIATION OF THE PLANKTON POPULATION

IN A PRAWN FILTRATION POND

By

MAYA RAMACHANDRAN, B.F.Sc.

THESIS

Submitted in partial fulfillment of the requirement for the degree

MASTER OF FISHERIES SCIENCE

Faculty of Fisheries

Kerala Agricultural University

2009

DEPARTMENT OF FISHERY HYDROGRAPHY

COLLEGE OF FISHERIES

PANANGAD, COCHI

ABSTRACT

The present study was carried out in the prawn filtration pond located in the campus to study the influence of hydrographical parameters on the plankton population. Fortnightly samples were collected for the analysis of hydrographical parameters like salinity, water temperature, turbidity, pH, total alkalinity, total hardness, nitrate, phosphate, nitrite, silicate and dissolved oxygen. Samples for biological parameters like primary production, chlorophyll, phytoplankton and zooplankton also were collected fortnightly.

Salinity increased with increase in alkalinity, hardness and pH. Highest average for salinity and pH occurred in postmonsoon. The peak temperatures were recorded during premonsoon which started showing declining trend with the onset of monsoon. But turbidity was highest during southwest monsoon due to runoff and churning up of the pond bottom due to low depth. Alkalinity and hardness showed correlation with pH indicating the presence of calcium and magnesium. Nutrients were effectively recycled in the pond due to shallow depth. This resulted in the absence of significant variation between postmonsoon and premonsoon. Throughout the study period due to the perennial nature of the pond and high primary production, dissolved oxygen values were high. Primary production values were high in premonsoon due to high light intensity and effective nutrient recycling. Chlorophyll and salinity showed correlation and might be due to the presence of euryhaline phytoplanktons in the pond. Total phytoplankton count was high in monsoon.

The total zooplankton was limited in quantity and quality. The total zooplankton was maximum in premonsoon months. But no decrease was

seen during monsoon. Major groups encountered were copepods, crustacean larvae, tintinids, nematodes, rotifers and veliger larvae. Copepods dominated the zooplankton and maximum number was collected during southwest monsoon. Crustacean larvae occupied the second position and were present in all the three seasons. Tintinids and nematodes were observed in high saline period and their number decreased with decrease in salinity. Rotifers were recorded during low saline period only. Veliger larvae were recorded during December, January and February.

Total zooplankton did not show any significant correlation with hydrographical parameters except temperature and pH.