CARBONDIOXIDE EQUILIBRIA AND NUTRIENT AVAILABILITY IN CULTURE ECOSYSTEM

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CERTIFICATE

This is to certify that this dissertation is a bonafide record of work carried out by Kum. ANNIE MATHEW under my supervision and that no part thereof has been presented before for any other degree.

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C O N T E N T S

PREFACE

Of all the compounds found on earth water is the most essential for the maintenance of life. Water is the fluid constituent of all living matter: plants use water for photo-synthesis, both plants and animals use it in metabolic activities, again the aquatic community finds food and shelter, make use of the gases dissolved in it, reproduce and sometimes care for the young ones usually without ever leaving the water. As the environmental medium water enters into, and maintains the integrity of the entire ecosystem and thus the effect of water is so all pervasive, that from one point of view it makes, more sense of think of aquatic species and the water surrounding them as elements of a single essentially conti-nuous system rather than as separate entities.

Man's interest in the study of waters around him is as old as himself. His studies extended to the treasures of food which grows in the water. As the need for protein increased, much more than what is being caught, he resorted to raise these organisms in impounded waters, which came to be known as AQUACULTURE. There is an increase in awareness of the benefit of mariculture as a means for increasing the fish production and providing employment in the recent years.

Unlike in other sophisticated countries, in India we depend mainly on natural source of water for raising the animals. Hence a sound knowledge about the conservative and non-conservative properties is very essential, for a proper management of our tide-fed farms. In natural water bodies the quality is mainly influenced by human interference by letting the agriculture and factory wastes into them. Most of these products have got direct influence on the fish production. Thus by measuring some of these easily measurable parametres periodically, the quality of the water bodies can be kept up and thereby increasing fish production. The various forms in which the different elements and compounds are present in water also has a very significant role to play in the management. When compared to the natural waters the cultured ponds contain more number of organisms for a standard volume of water. The fluctuation in the parameter like carbondioxide and oxygen has got a very good impact on water quality management. The other factors like temperature and pH has synergistic effect on these above mentioned factors.

Since chemical reactions in water bodies take place at phase discontinuities namely, the atmosphere - hydrosphere, Biosphere - hydrosphere and sediment - hydrosphere knowledge of the chemical make up of waters at the site is critical for significant study.

The life processes have long been known to be responsible for most dramatic compositional changes and in the regulation of the abundance of such elements as oxygen, nitrogen, phosphorous etc. The components of sea water enter into bio-chemical processes to such a degree that there concentrations are highly variable when compared to the total salinity. The distribution of the major components are to be accounted on physical and geo-chemical principles. The dissolved components are transported from place to place by advection and move from one place to another by eddy diffusion.

Because of fractionisation, the biologically active elements circulate than does water itself or its inactive solution. The principal source of the major components of the eco- system are carbonate, phosphate and nitrate ions. These major nutrients change on stoichometric basis as a result of biological activity. The exchange of chemical elements between the water and the biomass is a cyclic process. The two phases of the bio-chemical cycle is synthesis and re-generation. In upper layers the elements are withdrawn at a higher proportion when compared to re-generation which occurs at depths.

Water has an extraordinary capacity to hold substances in solution and enter into chemical reaction. A number of gases are found to be dissolved in natural waters namely hydrogen, oxygen, carbondioxide, ammonia etc. among which oxygen and carbondioxide occupies the prime position.

The importance of carbondioxide as a contributor to the fitness of natural waters depends essentially on three factors. In the first place it serves more or less, purely in the chemical sense, to buffer the environment against rapid shifts in alkalinity and acidity. A second contribution of carbondioxide pertains to regulating biological process in acquatic communities. The third and most important contribution is that it contains carbon, one of the versatile elements which facilitates the formation of various important biological compounds by tetravalent bonding.

The carbondioxide system is important for several reasons. It provides a better understanding of calcium carbonate precipitation from lagoons and other evaporated sea water bodies, as well as organic and inorganic precipitation associated with biological activities such as respiration, and photosynthesis and provide important information pertinent to the fauna and flora.

The carbondioxide content varies with locality and potential enrichment from industrial pollution. The global carbondioxide average is approximately 0.032% and is increasing progressively. The numerous and varied activities of carbondioxide in the aquatic eco system are made possible primarily by the high solubility in the natural waters. The solubility of carbondioxide is 200 times than that of oxygen and obeys normal solubility laws within the conditions of temperature and pressure.

The weak carbonic acid formed by the reaction between water and carbondioxide reacts with lime stone to form soluble calcium bicarbonate. The solution of bicarbonate remain stable only in the presence of certain amount of free or "equilibrium carbondioxide". The free carbondioxide represents the carbondioxide in carbonic acid plus that in the simple solution. Thus in establishing the water quality criteria of cultured water, acidity and alkalinity are of importance. The productivity of an aquatic eco system is reduced, if the pH goes below five, and the yield becomes less. The discharge of acid waste into the water containing bicarbonate alkalinity will result in the formation of free carbondioxide may be liberated which may become toxic to the fish.

There is generally a trend to maintain constant pH in sea and the adjacent water which can be extended by the buffering capacity of sea water with respect to dissolved carbondioxide. It has been inferred that the increase in carbondioxide must be counter-balanced by the other process that tend to increase the pH and the total alkalinity so that the net balance result in a fairly constant pH. Thus it can be inferred as said above that the studies of productivity in terms of nutrient content and availability can be remarkably facilitated by a side by side study of pH and carbondioxide content. The nutrient assimilation during photosynthesis will have a close relationship with carbondioxide since the latter is a material requisite for photosynthesis. Nitrogen is central to all eco systems because of its role in the synthesis and maintenance of protein, which along with carbohydrates and fats is a major constituent of all living substances. In ecological thinking, phosphorus is often considered the most critical factor in the maintenance of the biogeo-chemical cycles. The extreme importance stems from the fact that phosphorus is vitally necessary in the energy transfer system of the cell and that it occurs in very small amounts. Thus a deficiency of any of the nutrient in turn could lead to inhibition of phytoplankton increase resulting ultimately in decreased productivity.

The culture ponds are usually affected by tidal flow and land influx precipitation and run off during heavy monsoon. The availability of nutrients is invariably a limiting factor for phytoplankton growth and subsequently to the other animals in different trophic levels and thus the investigation on nutrient contents and their variation is of paramount importance. Moreover in brackish water ponds mainly fed by tides, which will induce large changes in the eco system, studies over a particular period of time especially the diurnal variation will be of remarkable significance.

This study is one of the pioneering works on the carbondioxide equilibria in relation to the nutrient availability in the brackish water culture ponds at Cochin.

I wish to express my sincere gratitude to my guide Mr. C.P. Ramamritham for his constant encouragement and guidance to complete this work.

I am greatly indebted to our director Dr. E.G. Silas and thank him for all the encouragement given to me during my study.

I also wish to express my thanks to the authorities of MPCL for providing the Yamaha motor boat for the collection and the Officer-in-Charge, State Fisheries Department for permitting the collection of water sample from their ponds.

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I wish to thank Mr. Nandakumar for his timely help.

INTRODUCTION

A few elements notably the halogens and a number of non-metallic oxides and organic substances when dissolved in water to form compounds, which when dissociated decreases the hydrogen ion concentration. Such compounds are called acids. In the natural water by far the most important of such oxides is carbondioxide which when dissolve produces a small amount of Carbonic acid a fairly weak acid.

The numerous and varied activities of carbondioxide in the aquatic ecosystem are made possible primarily by the high solubility of the gas in natural waters. The solubility of Carbondioxide is 200 times than that of oxygen and obeys normal solubility laws within the condition of temperature and pressure.

The solubility of Carbondioxide in water depends on temperature salinity and is directly proportional to the partial pressure of the gas. When Carbondioxide in the solution contain unhydrated carbondioxide is at about the same concentration by volume as in the atmosphere. (HUTCHINSON, 1957), (STUMM & MORGAN, 1970).

$$CO_2 \text{ (air)} \rightleftharpoons CO_2 \text{ (dissolved)} + H_2O$$

The carbondioxide of water hydrates by slow reaction

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

This reaction predominates at a pH less than 8. Carbonic acid being a fairly weak acid dissociates rapidly in comparison to hydration reaction.

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \rightleftharpoons H^+ + CO_3^{--}$$

The bicarbonate and carbonate thus formed dissociates after the equilibria is established.

$$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$$

$$H_2CO_3 \rightleftharpoons H_2O + CO_2$$

$$CO_3^{--} + H_2O \rightleftharpoons HCO_3^- + OH^-$$

Several workers have done work on the availability of total carbondioxide which indirectly affect the fertility of the entire ecosystem. Various methods have been suggested by different authors for the determination of total carbondioxide in sea water.

Wong (1969) has suggested an extraction method for total carbondioxide with which it can be determined with a precesion of $\pm$ 0.15%.. Edmond (1970) determined the titration alkalinity and total carbondioxide by using high precesion potentiometric method. Almgreen and Fonselius had described three important methods for determination alkalinity and total carbondioxide.

(1) Back titration method, Gripenberg (1936)

(2) pH method Anderson and Robinson (1946)

(3) The potentio metric titration Dryssen (1965)

Park Kilho and Donald (1968) has suggested a radiometric field measurement of carbondioxide exchange from atmosphere to the sea.

Kanamori and Satoru (1982) has used the sophisticated technology of the IR absorption to analyse carbondioxide.

TORNVE (1880) pointed out that carbondioxide in sea water occured in some combined form in addition to molecular carbondioxide in physical solution. Hamberg (1885) suggested that a solution of carbondioxide in sea water demanded the presence of undissociated H_2CO_3 as well as bicarbonate and carbonate ions. Krogh (1904) and Fox, (1909) studied the effect of variation of the partial pressure of carbondioxide and alkalinity on total amounts of carbondioxide present. Ringer (1908) demonstrated the inverse relationship between partial pressure of carbondioxide and pH. Palitzch (1910) looked for a relation between increase in alkalinity and increase in oxygen content. Moore et al (1912) worked on the changes in alkalinity of sea water induced by photosynthetic algae and other algae.

Buch (1914) carried out a series of determination of alkalinity, carbondioxide and pH in Pojowick. Atkins (1922) has studied the pH and its biological relation to sea water. Ramamoorthy. (1953) studied the seasonal changes in the hydrogen ion concentration and dissolved oxygen content of the surface waters of the Madras coast Harwey (1955) has discussed about the carbondioxide system in sea water. Spencer (1965) has given a critical appraisal of the carbon-dioxide in sea water. Keeling (1968) has studied the global distribution of carbondioxide in surface ocean water. He was able to show that the values of the partial pressure of the carbondioxide in the oceans as equivalent to that calculated from pH and alkalinity. Thomas and David (1969) pointed out the effect of hydration on carbondioxide exchange across an air-water interface. The studies revealed that carbondioxide exchange rate for a region whose pH is 6.5 was greater than in pH less than 4, (where carbondioxide acts as an inert gas) when pH is greater carbondioxide will react with water and hydroxyl ions.

Park Kilho (1969) suggested ten methods for investigation of oceanic carbondioxide system.

Murray and Riley (1971), Li and Tsui (1971) studied the solubility of carbondioxide in sea water and distilled water.

Joris (1974) discussed the alkalinity and total carbon-dioxide system in sea water. Castro et al (1978) has studied the carbondioxide system in Gulf of California.

Lazar (1983) has studied the carbonate system in hyper-saline solution, and alkalinity and Calcium Carbonate solubility in evaporated sea water. Kellay (1970) worked on the carbondioxide in the surface water of the North Atlantic Ocean and the Barents and Kara seas. In these studies for a one degree increase in surface temperature there is a ten ppm increase in carbondioxide concentration. An increase in oxygen concentration of 1 ml/1 is associated with decrease of 45 ppm carbondioxide. In the Barents sea a linear relationship is found between carbondioxide and salinity. A rise of 39 ppm carbondioxide occurs with an increase of 1 ppt surface a salinity.

Lal and Suess (1983) studied the exchange of carbondioxide across the air-sea interface. Weiss et al (1982) studied effects of temperature and salinity on the partial pressure of carbondioxide in the sea water.

Lewis and William (1982) studied the changes in pH and buffering capacity of lakes in Colarodo Rockies.

Li and Tsui (1971) has suggested that the carbondioxide solubility should decrease due to salting out effect. Pales and Keeling (1965) suggested that at present, about half of carbondioxide released by burning of coal and petroleum is accumulating in the atmosphere. The remainder is being absorbed by oceans and possibily to some extent by land plants. (Hutchinson, 1954).

Reid (1962) opined that carbondioxide concentration is influenced by the presence of high concentration of plankton.

The distribution of the chemical species as phosphate, nitrate, nitrite and dissolved oxygen is essential for the understanding of the major bio-chemical cycle in the sea. Temperature variation also is important because it is accompanied by minor changes in the composition of the sea. The marine concentration of the dissolved gases are in part determined by temperature at which equilibrium took place between atmosphere - water system.

The availability of Nutrients and other variations in Hydrographical parametres like salinity, dissolved oxygen and temperature has been extensively studied by various authors.

Rochford (1951) has elaborately studied the Australian hydrology. Spencer (1956) worked on the estuarine hydrology of the swan river.

Ramamritham and Jayaraman (1960) worked on the hydrographical parameters of the continental shelf waters off Cochin. They showed that South West monsoon has profound influence on hydrographical parameters and that the changes in conditions of these waters from time to time more or less reflects the changing pattern in the climatic condition.

Jayaraman (1954) studied the seasonal variation in salinity, dissolved oxygen and nutrient in the inshore waters of the Gulf of mannar and Palk Bay near Mandapam. Kasturi Rangan (1957) studied the seasonal changes in dissolved oxygen of the surface water of the sea on the Malabar coast. Ramamritham and Jayaraman studied the hydrographical conditions of the back waters around Willingdon Island. Srinivasan

(1964) studied the limnology and primary production in relation to fish production in a tropical pond.

Armstrong and Lafond (1966) discussed the relationship between the temperature,turbidity and nutrients. A correlated fluctuation in temperature turbidity and nutrients was observed.

The nutrient distribution of the Cochin back waters in relation to environmental characteristic was studied by Sankaranarayanan and Qasim (1969). Ramamoorthy (1953) studied the seasonal changes in pH and dissolved oxygen content of the surface waters of the Madras Coast. Venugopalan and Rajendran (1975) discussed the dissolved and particulate Nitrogen in Velar estuary. Zafiriou and True (1979) studied the Nitrate and Nitrite photolysis in the sea. Alvarez et al (1978) studied the nutrients in Gulf of California. Shiller and Gieskes (1980) worked on the processes effecting the oceanic distribution of dissolved calcium and alkalinity. Zafiriou et al (1980) studied the Nitric oxide in sea water. According to them detectable quantities of Nitric oxide was present in nitrite rich surface waters. Sen Gupta (1980) discussed the hydrochemical characteristic of the Central West Coast of India.

Gariside (1981) studied the nitrite and ammonia uptake in the apex of New York Bight. Roger Knowles et al (1981) discussed about the source of Nitrous oxide in the sea water.

Jonathan (1982) studied the chemistry of Delaware estuary. Yoram Avimelech (1983) worked on the phosphorus and Calcium Carbonate solubility in lake Kinnert. Eville Gorjam et al (1983) studied the chemical composition of the lakes in North Central U.S.

The availability of carbondioxide and Nutrients has been discussed by Park Kilho (1970).

Rao and Rao (1959) worked on the diurnal variation of the hydrographical condition of the Waltair coast. Shynamma and Balakrishnan (1973) and Singbal (1973) studied the diurnal variation of some physico-chemical parameters in Cochin back waters and Zuari estuary respectively. The studies on the availability of nutrients and fluctuations in the other parameters like dissolved oxygen, salinity and temperature is very much restricted. One among the works which are noteworthy is the diurnal fluctuation of certain hydrographical parametres in our culture ponds at Narakkal done by Ravindran (1983).

MATERIAL & METHODS

STUDY AREA

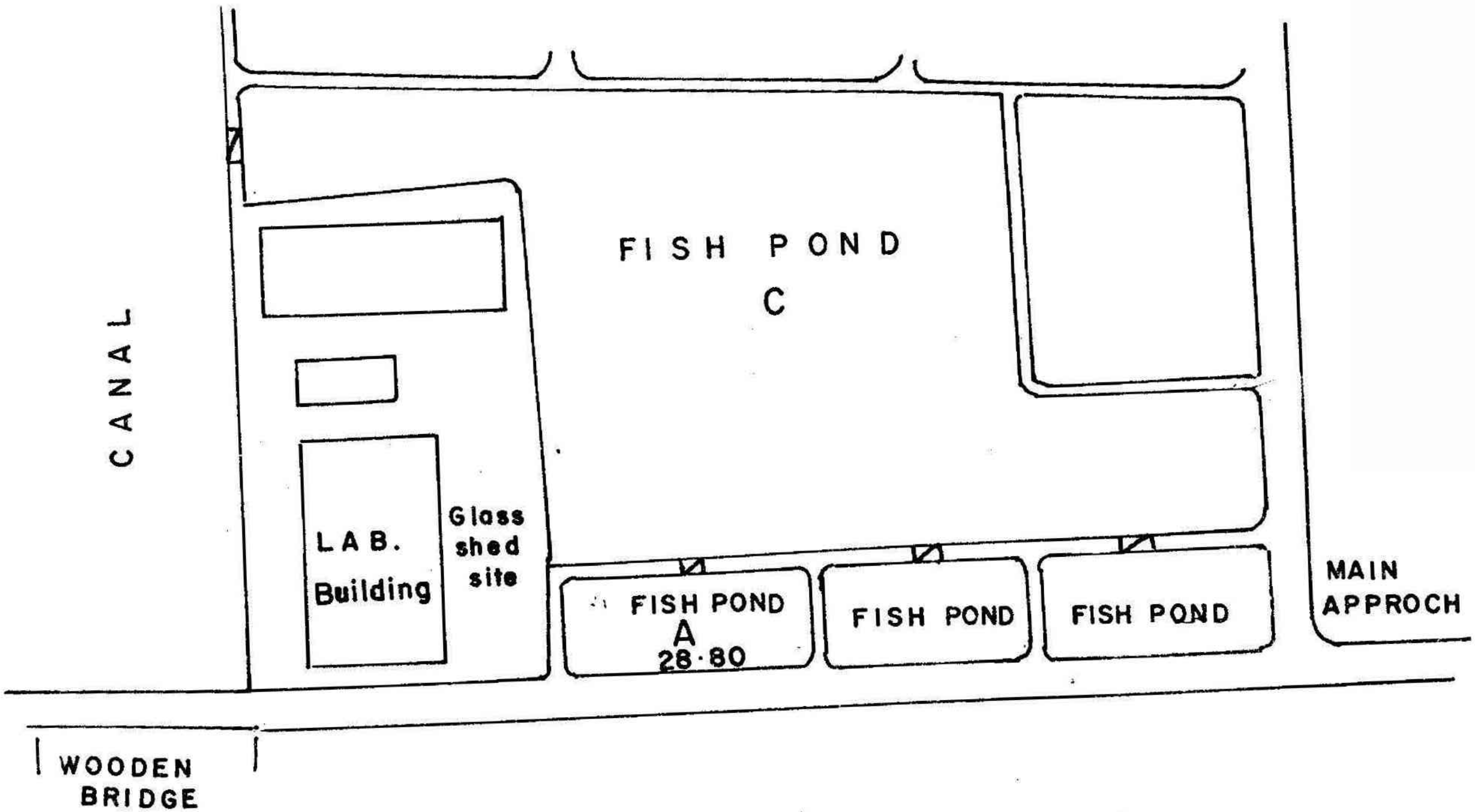
A short term study for a period of three months from mid June to mid September was carried out in the brackish water culture ponds at Narakkal. Narakkal (10.01°N - 75.16°E), is a fishing hamlet in Vypeen Island about 11 km North west of Cochin. The land strip is enclosed within the Arabian sea on the western side, and the Vypeen channel a branch of Cochin backwater on the eastern side.

Two ponds at Narakkal were selected as regular collection sites for the entire period of three months. One of the ponds were from the Marine Prawn culture laboratory and the other from the State Fisheries Fish Culture Centre. The ponds were at a distance of approximately 250 metres from the sea. Both the ponds are separated by a distance of about 200 Metres.

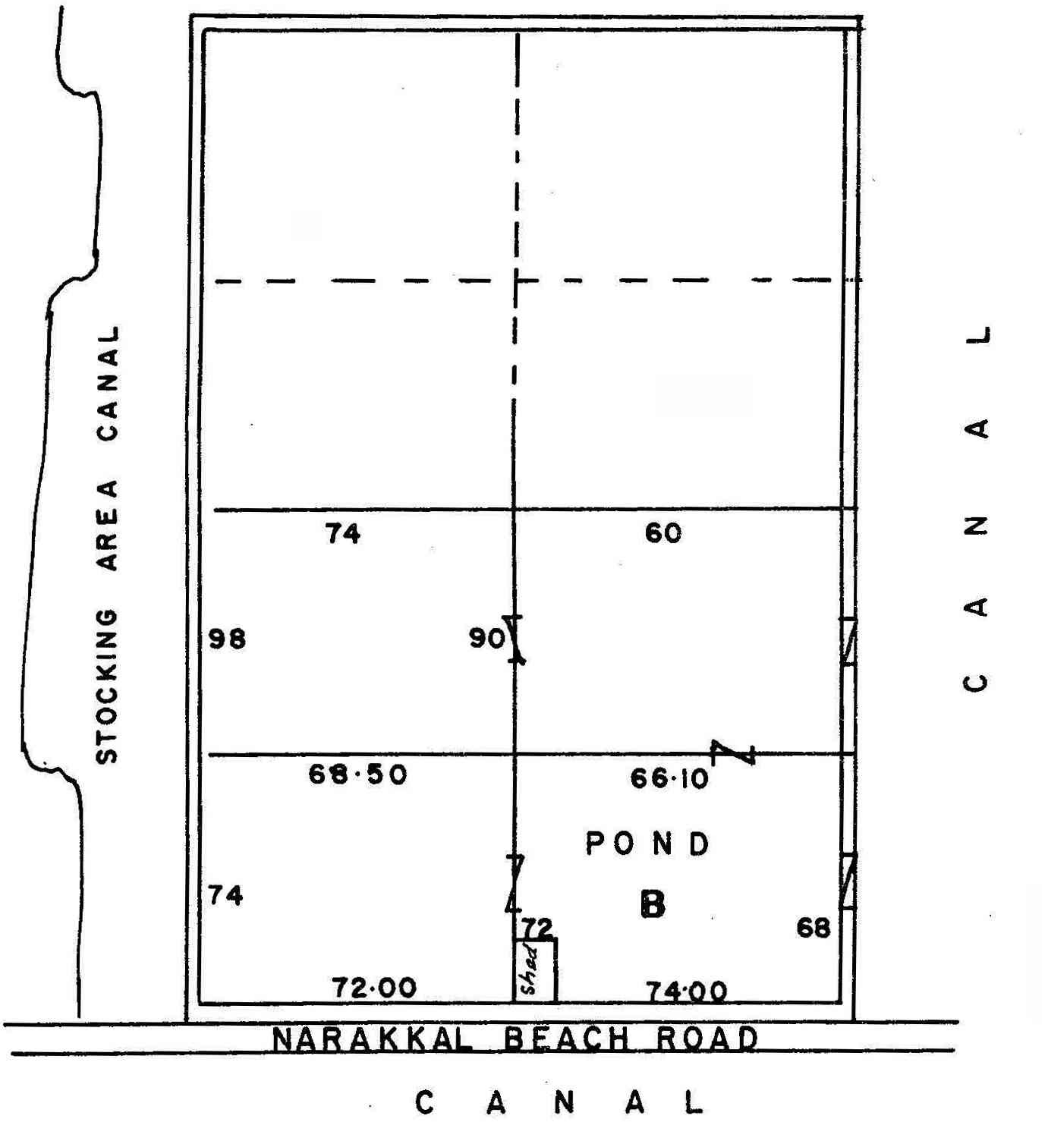
The diurnal variations for the major nutrients and carbondioxide was conducted twice during the three months of study. For these studies two ponds in Narakkal lab site itself were selected.

DESCRIPTION OF THE PONDS

POND A : It is a small pond having an area of about 200 Sq.mts. The bottom of the pond is mainly muddy. The depth of the pond varied from about 0.8 metres to even 0.45 metres during extreme low tide. *Peneaus indicus* is



EXPERIMENTAL PONDS AT NARAKKAL



CULTURE PONDS —— STATE FISHERIES FARM

being cultured in this ponds. There is no direct connection with the main channel.

POND B : Larger pond when compared to the other having an area of about 0.5 hectres. Water supply from the main channel is by an open type sluice gate. Depth varied from 0.7 to 1.3 mts. Prawns are being commercially cultured in this pond. Pond bottom is muddy.

POND C : It is a pond of area about 0.2 hectres and the depth of which varying from 0.8 to 1.2 mts. The pond is connected to the main channel by means of an open type sluice gate. The substratum is muddy.

Chanos chanos, , a highly esteemed fish is being experimentally reared in this pond.

Diurnal variation studies were conducted in Pond A & C on 07-07-'84 and 29-08-'84. Seasonal variation study was conducted in pond A & B during the entire period of three months. The frequency of sampling being once in a week. The departmental Canoe was given to facilitate easy collection of samples from Pond B.

METHOD

The sampling was usually carried out during the morning hours between 9 a.m. and 10 a.m. except during two days i.e. 28-06-'84 and 02-08-'84 (at 12.30 p.m.). Four regular collections spots were selected from these ponds. Water samples were collected from the water column by using a plastic bucket tied to the end of a 1.5 mt. rope.

The sample for carbon dioxide was taken in two 250 ml. amber coloured bottles. Care was taken not to entrap any air bubble. These bottles were at once transferred to an ice box (50 x 20 x 30 cm size) containing crushed ice so as to maintain lower temperature than the insitu temperature.

Samples for oxygen estimation was taken in 125 ml. bottles and fixed using Winkler A & B solutions. Nutrient samples were collected in 250 ml. white plastic bottles to which two ml. of chloroform was added as a preservative. Sample for the estimation of salinity was taken in a different plastic bottle.

Temperature was measured immediately and pH measured either at Narakkal or at Ernakulam within two hours of sampling. The amount of carbondioxide was measured at the lab immediately after arrival at Ernakulam. The nutrient samples were frozen and measured the next day.

During the diurnal variation studies the samples were collected once in two hours. The parametres like temperature, pH carbondioxide, oxygen and salinity were measured as soon as possible - on the same day itself and the nutrient samples were taken to the lab and analysed the next day.

The following parameters were measured during the sampling :

1. Atmospheric temperature,
2. Water Temperature
3. pH
4. Salinity
5. Dissolved oxygen
6. Free Carbondioxide
7. Nitrate Nitrogen
8. Nitrite Nitrogen
9. Reactive phosphorus
10. Total Alkalinity (by direct calculation from salinity)

TEMPERATURE

It was measured using an ordinary thermometer of range 0-100°C each division being 0.1°C.

pH : pH was measured using a digital pH meter within two hours of collection.

Salinity : It was estimated by Mohrs titration method (Strickland & Parson 1968). The normality of standard silvernitrate was checked by using standard sea water periodically.

Dissolved-oxygen : The dissolved oxygen content was measured using Winkler method (Strickland and Parson 1968)

Nitrite Nitrogen : Shinh method modified by Bendschneider and

Robinson (Strickland and Parson 1968). The re-agent used were acidic Sulphanilamide and NNED (n-naphthyl ethylene diamine) the diazo compound which is formed after the reaction between sulphanilimide and nitrite-nitrogen react with NNED to form an azodye which is pink in colour. After eight minutes and within 2 hours the absorbance was measured in a colouri-meter at 530 nm. using ERMA photoelectric colorimeter. Model H.E. 11 N Japan.

Nitrate Nitrogen : Morris and Riley method (Strickland and Parson 1968) the water samples after keeping for reduction using Copper sulphate and hydrazine sulphate for 20 hours in darkness is treated with the Sulphanilamide and NNED and the absorbance was measured at 530 nm. using ERMA photoelectric colorimeter - Model H.E. 11 N Japan.

Reactive phosphorus : Murphy and Riley method (Strickland & Parson 1968) water is allowed to react with ammonium molybdate potassium antimony tartarate in an acid medium. (Sulphuric acid and Ascorbic acid) A blue complex is formed. The absorbance is measured using a spectrophotometer at 885 nm.

Free carbondioxide estimation (see STD methods - pp 298-301)

Principle : Carbondioxide reacts with sodium hydroxide or sodium carbonate to form sodium bicarbonate, completion of the reaction being indicated by the development of a pink colour characteristic of phenolphthalein at an equivalence pH of 8.3.

Re-agents : (1) Phenolphthalein reagent.

(2) STD alkali : Either 0.0454 N Sodium carbonate or 0.0227 Sodium hydroxide.

(3) STD-Sodium bicarbonate (for comparison of colour)

NOTE : All re-agents for carbondioxide estimation is prepared in freshly made distilled water free of carbondioxide.

The normality of sodium hydroxide is determined by ordinary acidimetry, alkalimetry titration using methyl orange indicator. Sodium carbonate being the STD.

Procedure :

Add about 5 to 10 drops of Phenolphthalein re-agent to 100 ml of sodium bicarbonate. The pink colour which develops is kept as a standard.

100 ml. of the sample is taken and 5 to 10 drops of phenolphthalein is added and is titrated against sodium carbonate and sodium hydroxide solution. The end point is the development of a faint colour by the addition of a single drop of the titrant.

Calculation :

The amount of free carbondioxide was calculated using the formula :

For Sodium carbonate mg/litre of free carbondioxide) $\frac{A \times N \times 22000}{ml.\ of\ sample}$

For Sodium Hydroxide mg/litre of free carbondioxide) $\frac{A \times N \times 440000}{ml.\ of\ sample}$

N = Normality of Sodium Carbonate or Sodium hydroxide

A = ml. of titrant

Total Alkalinity can be directly calculated from the salinity values by the following equation :

$$\text{Total alkalinity} = \frac{\text{Chlorinity } (^\circ/oo) \times 0.123}{10^3}$$

Statistical methods :

All statistical analysis were carried out according to Snedecor & Cochren (1967). For the present study 't' test are used to find the level of significance for the changing pattern of free carbondioxide with other parameters like dissolved oxygen, pH, Water temperature, salinity, alkalinity, for the entire period of three months. Linear regressions and simple correlation (Snedecor and Cochren, 1967) were worked out for the above parameters.

R E S U L T S

The investigations were restricted to Monsoon and early post Monsoon seasons of the year 1984, namely 14th June to 12th September. The direct influence of the Arabian Sea over the ponds is weak and tidal impacts are through a main connecting channel. Hence the Monsoon changes in the Arabian sea are not reflected in the Ponds in a noticeable way and whatever effects of the Monsoon are those resulting from heavy precipitation and local run off, the tidal amplitude. The maximum tidal amplitude in the ponds is nearly 50 cms. Thus there is always intense vertical mixing in the ponds and surface bottom differences in the hydrographic characteristic are negligible. The ponds are also subjected to unhindered solar radiation.

Keeping in mind the above backgrounds the characteristics of the ponds are described.

TEMPERATURE

Thus in Pond A the maximum temperature of 32.2°C was observed during early August but in Pond B the temperature was 33.4°C. The thermal conditions in both the ponds did not show a gradual change. But were dependent mostly on the monsoon precipitation. The minimum temperature in both the ponds were noticed during peak Monsoon. The graphical representation (Fig. 1A and 1B) shows these feature more clearly with the associated peaks.

Figure 1 - Summary of variation in Temperature in Pond I & II over the period of study.

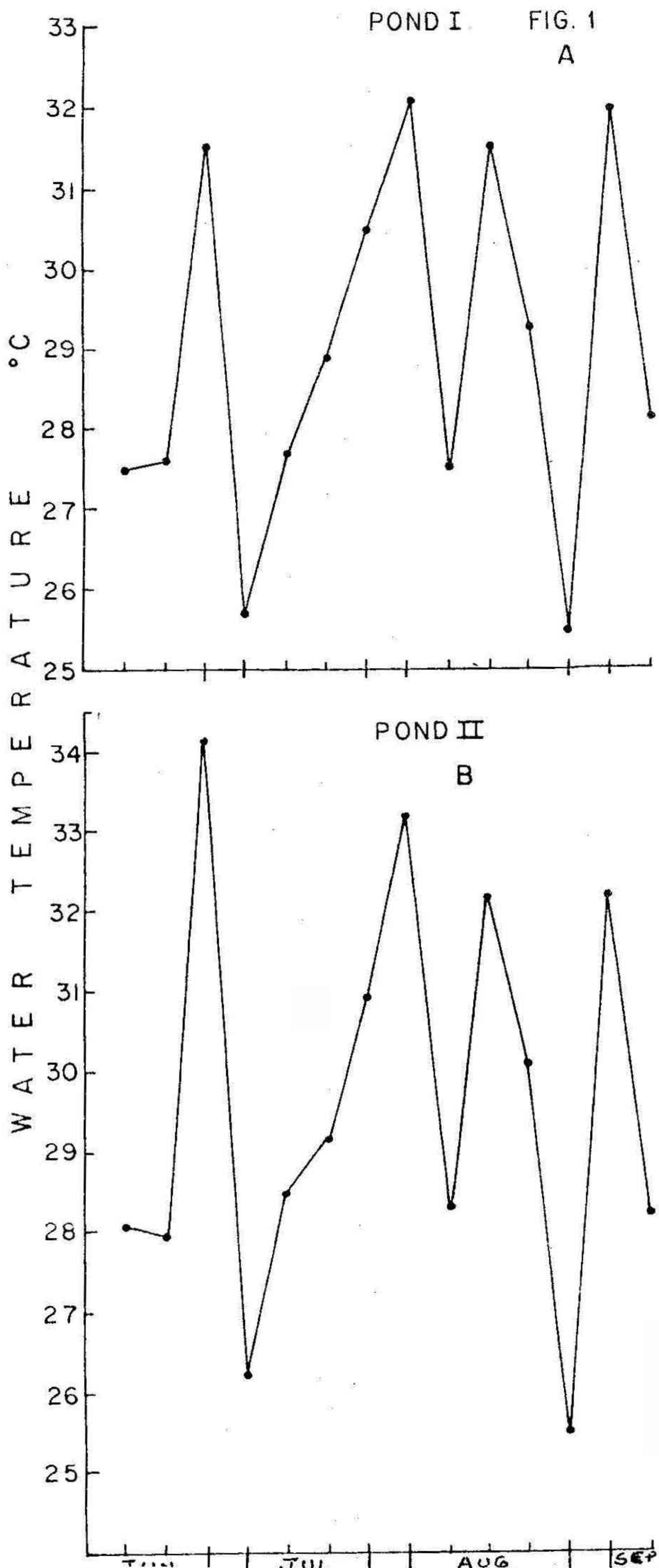

POND I
A
POND II
B
WATER TEMPERATURE °C
33
32
31
30
29
28
27
26
25
34
33
32
31
30
29
28
27
26
25
AUG
SEP

FIG. 1

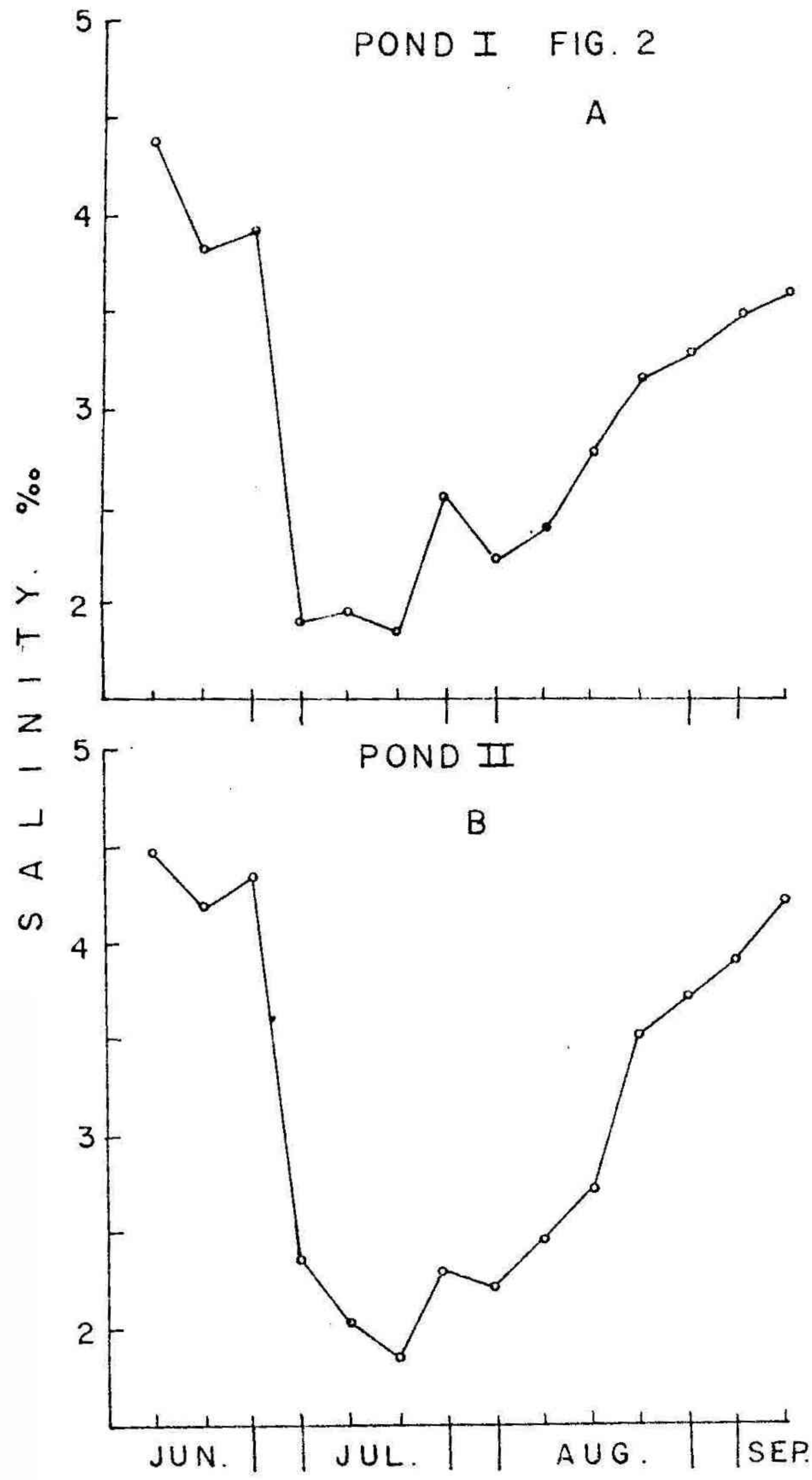
SALINITY

The changes in salinity in both the ponds with respect to time are more gradual and well defined, than thetemperature distribution. Thus a gradual decrease in Salinity is observed from June onwards, the minimum Salinity being observed during peak Monsoon (Fig. 2A and 2B). The minimum Salinity observed during the investigation period was 1.8‰. From July onwards there is observed a more or less gradual increase in Salinity and by mid September the values was 3.63‰ in pond A and 4.2‰ in pond B. Almost all the observations except for two diurnal studies were made during the morning hours, when the low tides prevailed in the region. The influence of these low tides also are remarkable in reducing the salinity value in the pond.

DISSOLVED OXYGEN

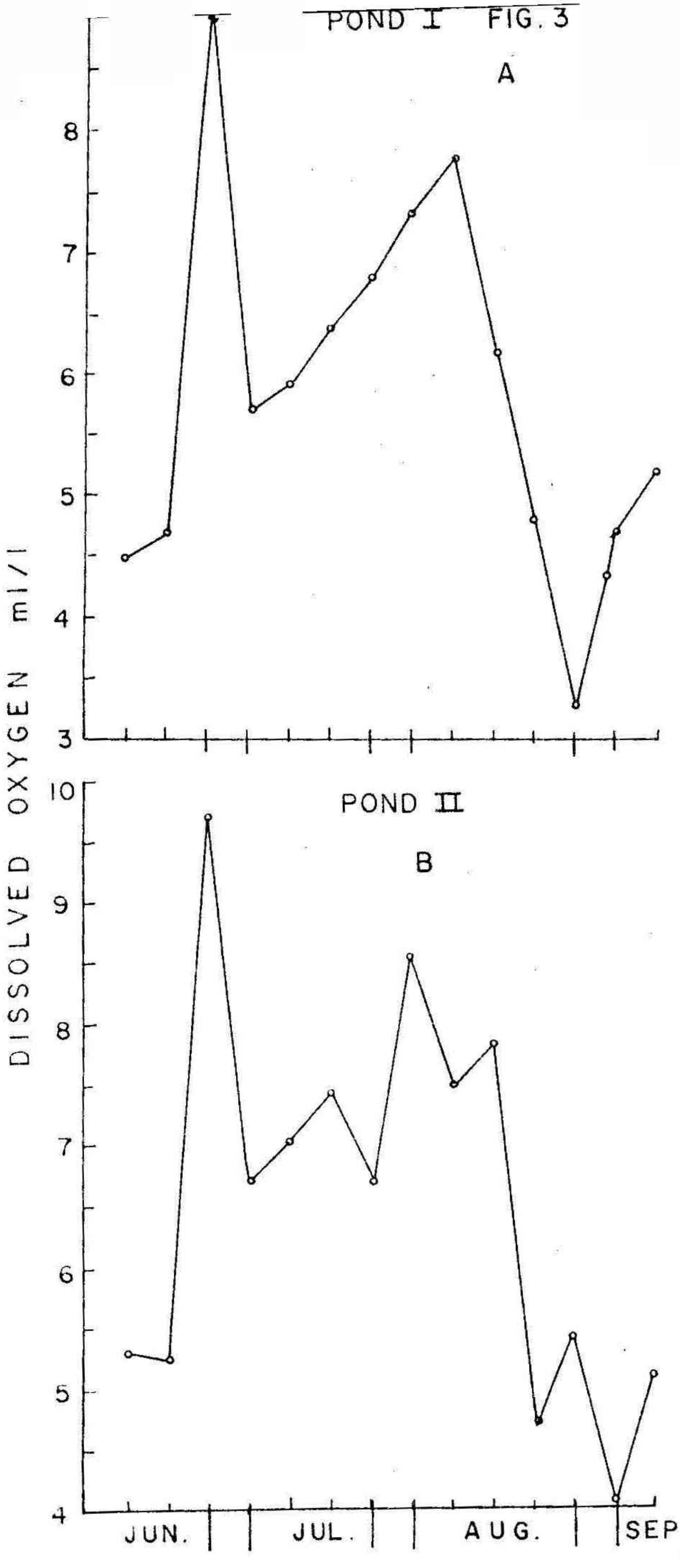
Super saturation of the water with respect to dissolved oxygen was observed during two days in the investigation. These collection were made in the noon hours and probably the high amount of photosynthesis might be attributed as a probable cause for this (Fig. 3A & 3B). Except for this the dissolved oxygen content showed a gradual distribution pattern with time. At any rate the values in both the Ponds, were more than 3.3 ml/litre. The shallow nature of the Ponds, the thorough vertical mixing and the high amount of photosynthesis could contribute much to these high values of oxygen.

Figure 2 - Summary of variation in Salinity
in Pond I & II over the period
of study.



POND I FIG. 2
A
POND II
B
SALINITY. ‰
5
4
3
2
JUN.
JUL.
AUG.
SEP.

Figure 3 - Summary of variation in Dissolved oxygen content in Pond I & II over the period of study.


POND I FIG. 3
A
POND II
B
DISSOLVED OXYGEN ml/l
3
4
5
6
7
8
4
5
6
7
8
9
10
JUN.
JUL.
AUG.
SEP

pH : These high values of oxygen are associated with high pH values also (Fig. 4A and 4B). High alkaline conditions are observed during these two observations and except for these the range of pH in both the Pond was between 7.7 - 8.25. Acidic conditions are never encountered. Comparitively the pH values were lower during the Peak Monsoon period. The minimum value occuring during late August when temperature was also minimum.

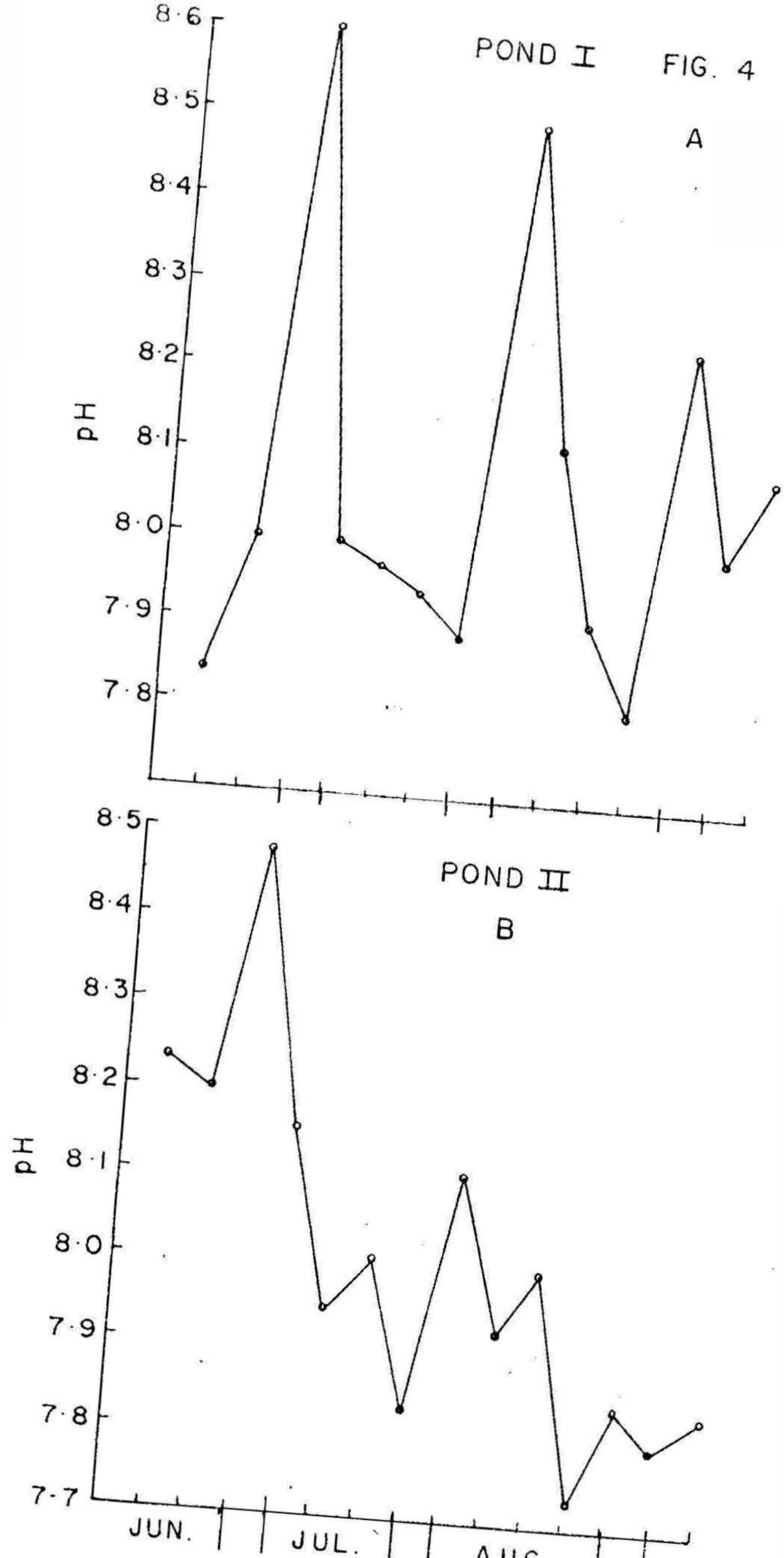
FREE CARBONDIOXIDE

These relationship are reflected in the time distribution pattern of free carbondioxide in both the ponds. (Fig. 5A and 5B). The maximum values of Free carbondioxide in pond A was 3.9 mg/litre and pond B it was 4.9 mg/litre. These maxima are clearly associated with minimum pH and minimum DO. As far as the two noon observations are concerned the carbondioxide values were at a minimum in general. Again there is observed a gradual tendency for increase in carbondioxide content with time in both the ponds. The values in pond B especially during late Monsoon and post monsoon were higher than pond A. It is pointed out here that the area of the 2nd pond is much larger when compared to pond A. The relationship between pH and carbondioxide of the water appeared to be more regular than the relation between dissolved oxygen and carbondioxide.

ALKALINITY

A rough estimate of the alkalinity in the ponds was

Figure 4 - Summary of variation in pH in Pond I & II over the period of study.



POND I
A
pH
8·6
8·5
8·4
8·3
8·2
8·1
8·0
7·9
7·8
POND II
B
pH
8·5
8·4
8·3
8·2
8·1
8·0
7·9
7·8
7·7
JUN.
JUL.

FIG. 4

Figure 5 - Summary of variation in Free CO_2 in Pond I & II over the period of study

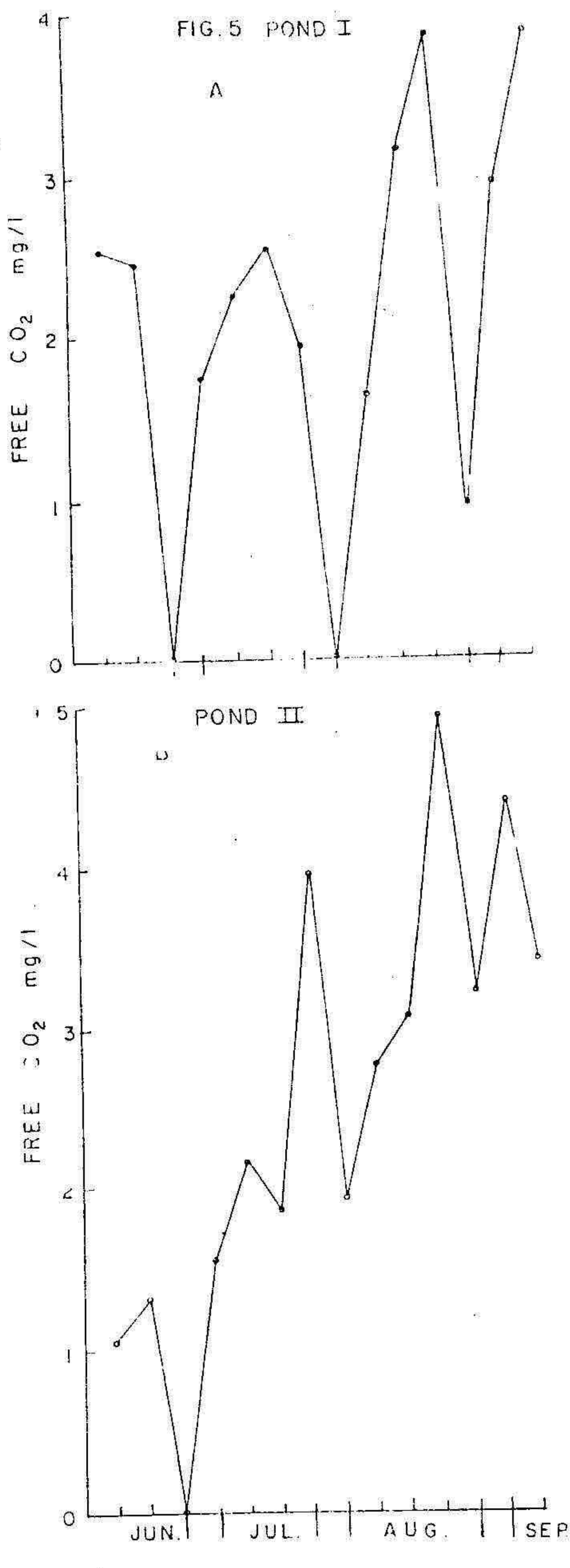
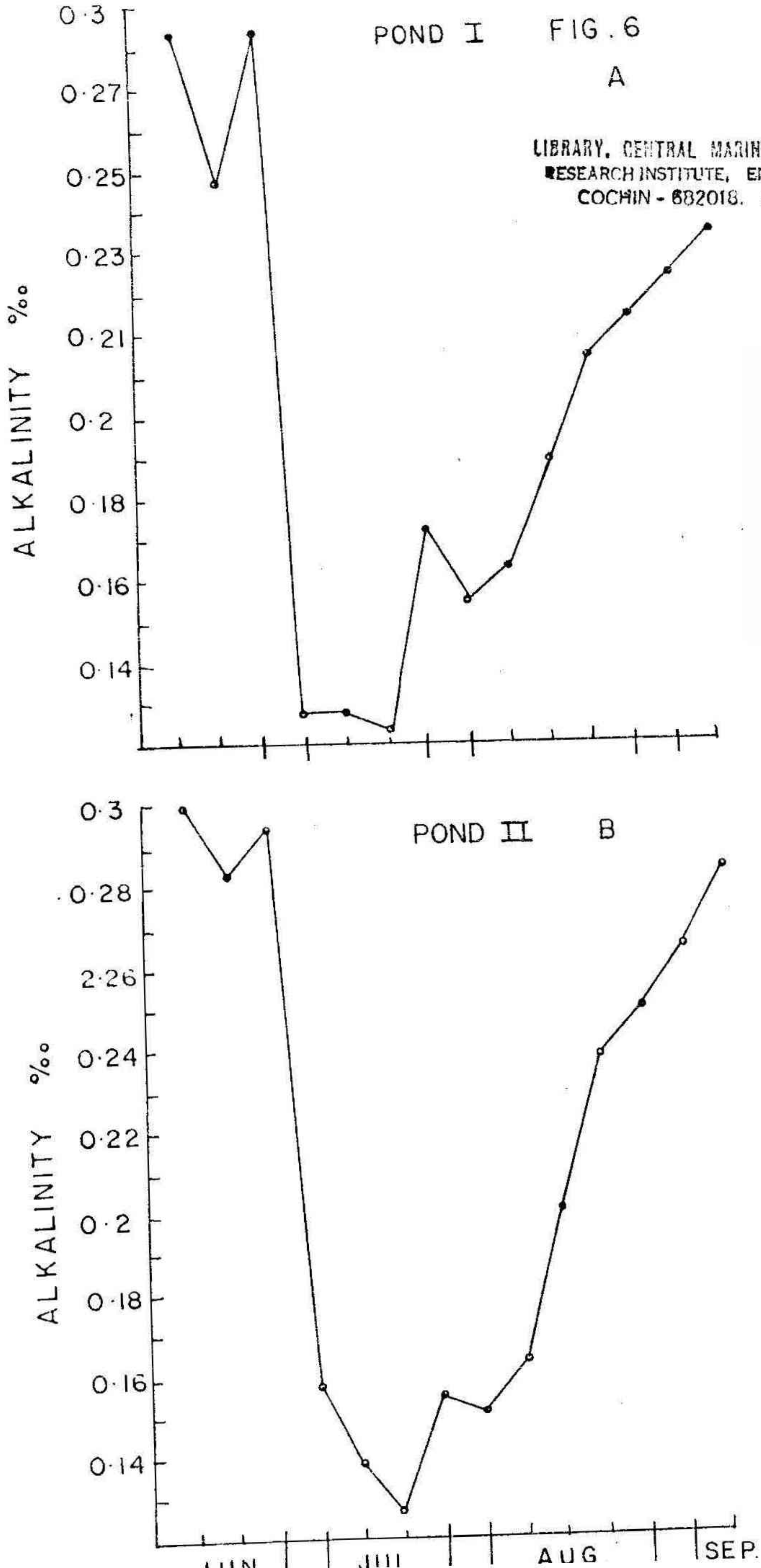


FIG. 5 POND I
A
FREE CO2 mg/l
4
3
2
1
0
POND II
5
4
3
2
1
0
JUN.
JUL.
AUG.
SEP

Figure 6 - Summary of variation in Alkalinity in Pond I & II over the period of study.

FIG. 6



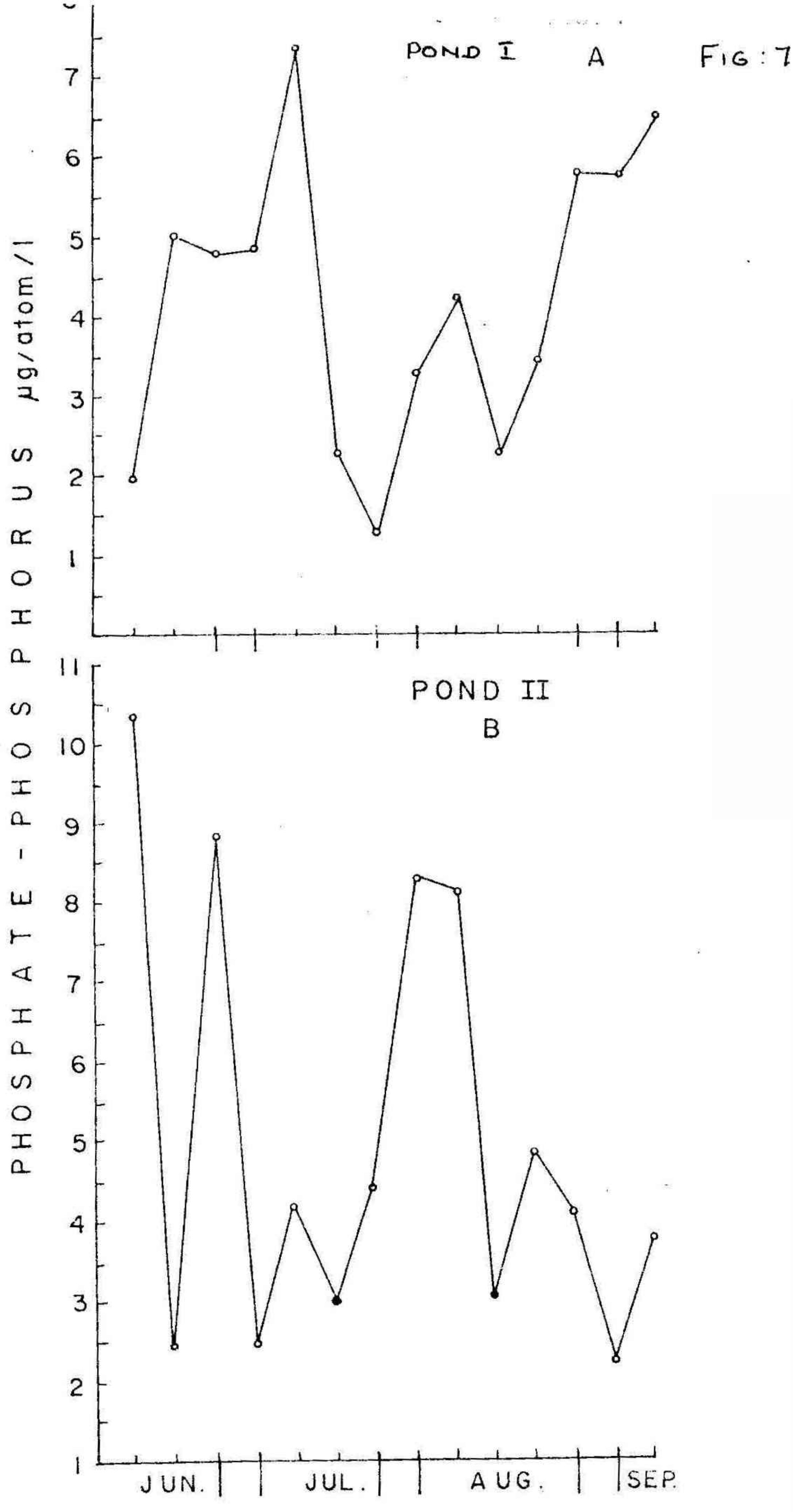
POND I
A
0·3
0·27
0·25
0·23
0·21
0·2
0·18
0·16
0·14
ALKALINITY ‰
POND II
B
0·3
0·28
2·26
0·24
0·22
0·2
0·18
0·16
0·14
ALKALINITY ‰
AUG
SEP.

computed using a formula which incorporates chlorinity. As has been discussed the chlorinity, values are generally low especially during the monsoon season and as such the computed values of alkalinity were also low. (Fig.6A & 6B). Looking at the figure for alkalinity and carbondioxide it can be noticed that the minimum carbondioxide value on 28-06-'84 corresponded to maximum alkalinity but the second minima of carbondioxide 02-08-'84 did not correspond in a like manner to alkalinity. The third minimum in carbondioxide in both the ponds were observed to have not much of correlation with alkalinity. Considering the complicated chemical equilibria attained when carbondioxide dissolves in water, this appears to be not much out of the way. The dissolution again depends on factors other than chlorinity, also like temperature and partial pressure of carbondioxide in the atmosphere. In this particular case a rough estimate of alkalinity only has been arrived at, by using chlorinity values alone.

PHOSPHATE - PHOSPHORUS

The time distribution of inorganic phosphate exhibits a better relationship with dissolved oxygen content than with free carbondioxide content. The high values of phosphate during the two noon observations corresponded to the high peaks in dissolved oxygen content. In pond B again the increasing trend of phosphate during late July and early August was reflected in the oxygen distribution also which can be seen from the Fig.7A & 7B. The trend of the time distribution

Figure 7 - Summary of variation in phosphate - phosphorus in Pond I & II over the period of study.


POND I A
FIG: 7
PHOSPHATE - PHOSPHORUS µg/atom/l
POND II
B
JUN.
JUL.
AUG.
SEP.

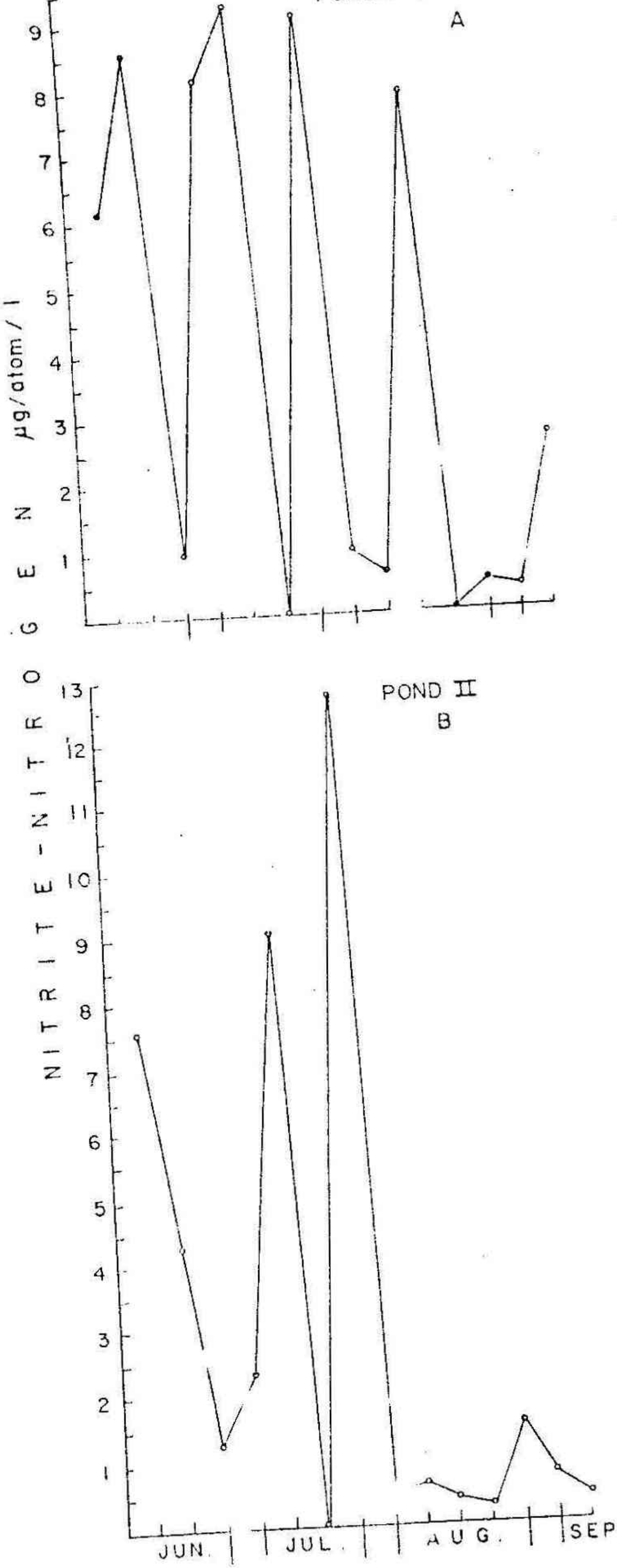
graph of phosphate is comparable to a high degree with that of dissolved oxygen. As in the case in preceeding parameters the observation during the noon hour exhibit6 high values of phosphate in pond B. The general trend was for a lesser concentration of phosphate in pond A. An inverse relationship is exhibited between phosphate and free carbondioxide content. Although a well defined correlation cannot be claimed the general trend is for high phosphate content when the waters are in a depleted condition with respect to free carbondioxide. Such a trend is observed during the observations in September.

NITRITE - NITROGEN

The significance of the particular time of observation in the pond ecosystem is again conspicuous in the distribution of nitrate nitrogen in both the investigational ponds. (Fig. 8A & 8B). Thus during the noon observations as in the other parameters, nitrite - nitrogen values were uniformly low whereas phosphate - phosphorus content was high. It is possible that precipitation and fresh water influx can modify the nutrient distribution and hence a uniformity in the distribution pattern cannot generally be expected especially because the ponds are very shallow. Even then an ill defined uniformity is observed in pond B during late monsoon and early post monsoon. The maximum values of nitrite were again the pond B value of which is 12.93 microgram/ litre, and that of pond A was only 9.25. Nitrite-Nitrogen values were higher during the peak monsoon period.

Figure 8 - Summary of variation in Nitrite-Nitrogen in Pond I & II over the period of study.

POND I FIG. 8



NITRATE - NITROGEN

As is the general case, the nitrate - nitrogen values show an inverse relationship to that of nitrite - nitrogen. The maximum for nitrate - nitrogen in Pond A was 35 µg/ltr. and for pond B it is 31 µg/litre. But the relationship of nitrate nitrogen with dissolved oxygen content is more or less direct. High peaks in the distribution pattern (Fig. 9A & 9B) of nitrate corresponded to similar peaks in dissolved oxygen distribution. Again high peaks of nitrate nitrogen values more or less corresponded to low peaks in carbondioxide distribution. The minimum value for nitrate nitrogen were during the onset of monsoon when the carbondioxide content was high. The minimum value for pond A was 3.945 and that of pond B was 5.67.

DIURNAL VARIATION STUDIES IN PONDS ON 07-07-'84 & 28-09-'84.

For a supplementary understanding of the nutrient availability and carbondioxide content a diurnal study was conducted in pond A and in a neighbouring pond other pond B which was referred to in the text. These variations are shown in Fig. 10A & 10C and 11A & 11C .

The investigations pertain to two solar days for each pond. The observations were started at 10.30 a.m. and were closed, at 8.30 a.m. in the next day. Frequency of sampling was once in two hours.

The salinity variations are very negligible and the concerned figures for salinity are not presented below.

Figure 9 - Summary of variation in Nitrate-Nitrogen in Pond I & II over the period of study.

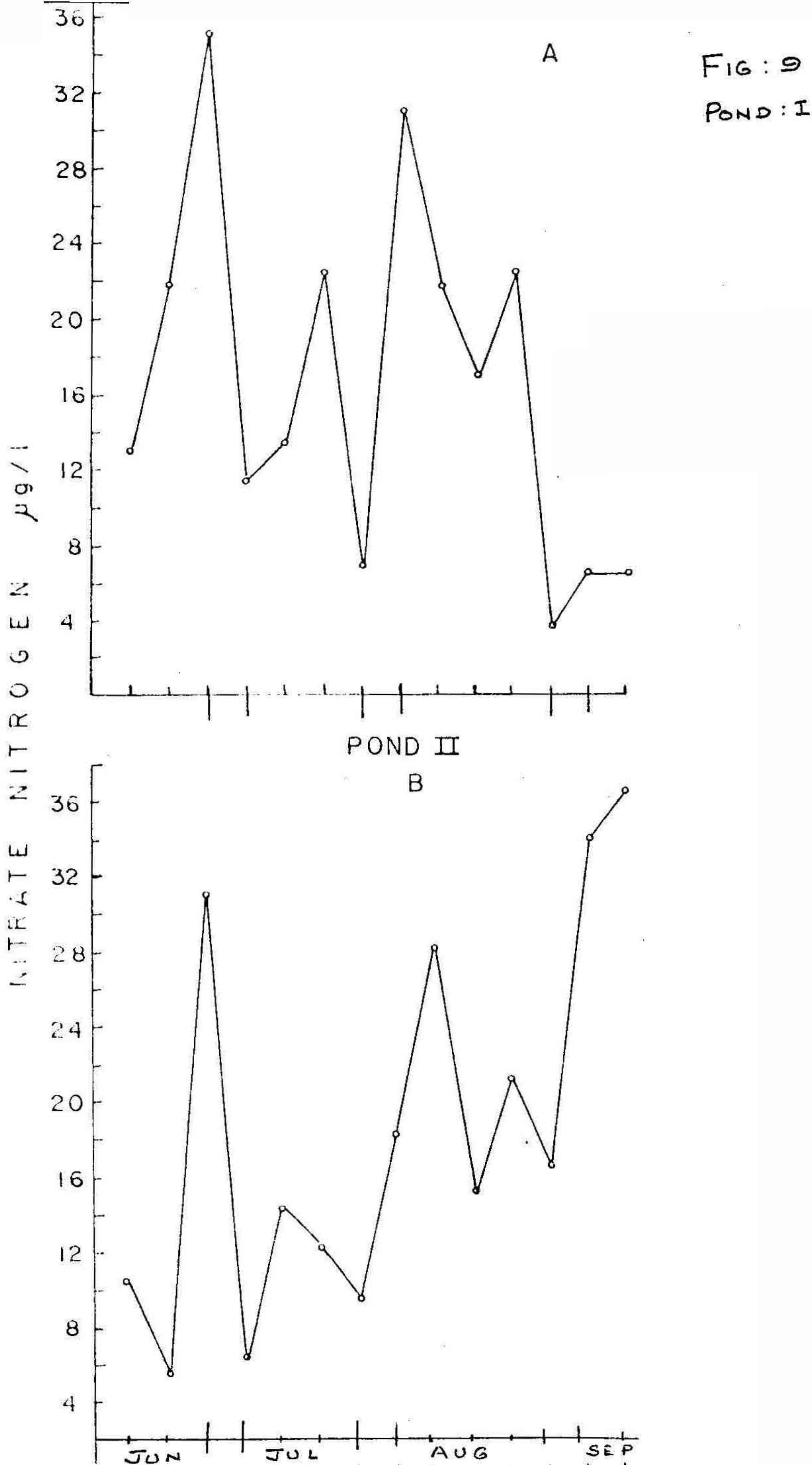


FIG: 9
POND: I
A
POND II
B
NITRATE NITROGEN µg/l
36
32
28
24
20
16
12
8
4
JUN
JUL
AUG
SEP

The temperature pattern showed a maximum at 2.30 p.m. and minimum was at 4.30 a.m. the next day. The variations in pH showed a comparable pattern. The maximum peak of 8.63 was again at 2.30 p.m. and the minimum at 6.30 a.m. (7.79). Thus there is a wide range in pH variation throughout the day.

Free carbondioxide content was more or less absent till 6.30 p.m. Thereafter a gradual increase in carbondioxide was observed upto 6.30 a.m. where it showed a maximum, and it can be noticed from the figure that this maximum peak corresponded to the minimum of dissolved oxygen contents. As usual this again corresponded to the lowest pH.

The nitrite contents showed three maxima during the day. The inverse relationship between nitrite nitrogen and nitrate nitrogen as mentioned earlier could be observed in the diurnal variation also. The minimum phosphate content in the pond at 12.30 a.m. and the maximum was at 6. 30 p.m. The range of variation was 3.6 - 6.81 microgram atom/litre.

The variation in temperature, pH, free, carbondioxide and dissolved oxygen contents in pond C were almost comparable to those in pond A. It may be noted that the nutrient sample were not taken from pond C.

The experiment was repeated for another day viz. 29th August, 1984 . In Both the ponds the general pattern of variation (Fig.11A & 11C) where comparable to the previous date. The inverse relationship between nitrite nitrogen and nitrate nitrogen were noticeable to a certain extent. Similarly the variations in the other properties too.

POND A SPOT 1

Date	At. temp: °C	Water temp: °C	Salinity °/oo	pH	D O mg/l	Free CO2 mg/l	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/l		
									PO_4^-	NO_2^-	NO_3^-
14-06-84	28	27.5	4.2	7.85	4.53	2.29	2.31	0.2841	2.05	6.75	12.8
21-06-84	28	27	3.75	7.98	4.65	2.55	2.06	0.2533	4.73	9.43	26
28-06-84*	34	31.5	3.9	8.59	9.2	0	2.15	0.2644	4.75	0.97	37
05-07-84	26	25.8	1.87	8.1	5.55	2.04	1.02	0.1254	4.83	8.1	12
12-07-84	28	27.8	1.97	7.97	5.75	2.29	1.08	0.1328	7	8.7	15
19-07-84	29.5	29	1.85	7.93	6.37	2.43	1.01	0.1242	2.12	0	21
26-07-84	31	30	2.45	7.91	6.7	1.41	1.34	0.1648	1.15	8.97	6.7
02-08-84*	33	32.5	2.23	8.56	8.8	0	1.22	0.1500	3.3	0.87	30
08-08-84	28	28	2.4	8.17	7.67	1.41	1.32	0.1622	4.1	0.54	20.5
16-08-84	32.5	31.8	2.8	7.93	6.15	3.14	1.54	0.1894	2.42	7.95	14.25
23-08-84	30	29.5	3.202	7.8	4.73	3.91	1.76	0.2164	3.72	0.09	22.1
30-08-84	25	25.5	3.23	8.21	3.71	0.9988	1.78	0.2189	6	0.05	31.79
04-09-84	32.5	31.8	3.47	8	4.68	2.99	1.91	0.2349	5.8	0.28	6.43
12-09-84	28	28.5	3.56	8.07	4.94	3.99	1.97	0.241	6.4	2.52	6.45

POND A SPOT 2

Date	At. temp: °C	Water temp: °C	Salinity °/oo	p^H	D O mg/l	Free CO_2 mg/l	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/l PO_4^-	NO_2^-	NO_3^-
14-06-84	28	27.8	4.3	7.83	4.73	2.30	2.37	0.2915	1.93	6.83	11.4
21-06-84	28	28	3.84	7.97	4.68	2.82	2.11	0.2595	4.83	9.468	25.7
28-06-84*	34	31.8	3.95	8.57	9.15	0	2.17	0.2669	4.87	1.06	35
05-07-84	26	25.9	1.87	8.07	5.40	2.05	1.02	0.1254	4.8	7.96	10
12-07-84	28	27.9	1.98	7.95	5.81	2.43	1.08	0.1328	7.2	8.69	14.2
19-07-84	29.5	29.1	1.88	7.93	6.13	2.80	1.03	0.1266	2.4	0.095	22.9
26-07-84	31	30.4	2.48	7.9	6.89	1.43	1.36	0.1672	1.2	9	6.57
02-08-84*	33	32.7	2.24	8.13	6.83	0	1.23	0.1512	3	0.9	33.95
08-08-84	28	27.4	2.45	8.11	7.8	1.476	1.34	0.1648	4	0.6	22.12
16-08-84	32.5	32	2.82	7.92	6.3	3.21	1.55	0.1906	2.31	8.25	16.245
23-08-84	30	29.8	3.20	7.83	4.87	3.78	1.76	0.2091	3.63	0.083	21.75
30-08-84	25	25.8	3.34	8.25	3.95	0.87	1.84	0.2263	5.98	0.03	3.95
04-09-84	32.5	32	3.5	8.01	4.89	2.83	1.92	0.2361	5.6	0.3	6.758
12-09-84	28	28.4	3.7	8.11	4.84	3.66	2.01	0.247	6.8	2.72	6.6

POND A SPOT 3

Date	At. temp: °C	Water temp: °C	Salinity °/oo	pH	D O Ml/l	Free CO_2 mg/l	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/l		
									$PO_4^{\cdot\cdot\cdot}$	NO_2^-	NO_3^-
14-06-84	28	27.3	4.4	7.86	4.52	2.81	2.42	0.2976	2.03	4.59	14.2
21-06-84	28	26.5	3.82	8	4.74	2.30	2.1	0.2583	5.78	10.11	8.7
28-06-84*	34	31	3.95	8.65	8.87	0	3.17	0.3899	5.1	0.97	36
05-07-84	26	25.5	1.91	8.08	5.98	1.54	1.04	0.1279	5.01	8.25	12
12-07-84	28	27.8	1.89	7.98	5.97	2.24	1.03	0.1266	8.1	11.2	15
19-07-84	29.5	28.5	1.84	7.95	6.57	2.56	1.00	0.123	2.4	nil	23
26-07-84	31	29.8	2.62	7.93	6.89	2.43	1.44	0.1771	1.4	9.5	7
02-08-84*	33	32	2.31	8.59	6.98	0	1.27	0.1562	3.8	1.2	31.5
08-08-84	28	27.9	2.43	8.12	7.91	1.40	1.33	0.1635	4.9	0.65	24.5
16-08-84	32.5	31.2	2.88	7.91	6.30	3.21	1.58	0.1943	2.31	8.28	19.37
23-08-84	30	29	3.21	7.83	4.81	3.87	1.76	0.2164	3.63	0.033	20.52
30-08-84	25	25	3.37	8.25	3.7	0.997	1.85	0.2275	5.8	0.878	3.98
14-09-84	32.5	31.5	3.5	8.01	4.75	3.01	1.92	0.2311	5.9	0.31	6.538
12-09-84	28	28.1	3.61	8.08	4.87	3.98	1.98	0.2435	6.5	2.6	6.523

POND A SPOT 4

Date	At Temp °C	Water Temp. °C	Salinity °/oo	pH	D.O mg/l	Free CO_2 mg/l	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/l		
									$PO_4^{\cdots}$	NO_2^-	NO_3^-
14-06-84	28	27.4	4.37	7.85	4.52	2.79	2.49	0.3062	2.1	6.783	13.7
21-06-84	28	27.9	3.81	7.98	4.8	2.29	2.1	0.2583	4.65	8.453	27.5
28-06-84*	34	32.9	3.85	8.59	8.95	0	2.12	0.2607	4.77	0.88	34
05-07-84	26	25.8	1.95	8.08	6.1	1.49	1.07	0.1361	4.9	7.95	11.5
12-07-84	28	27.3	1.87	7.98	6.23	2.14	1.02	0.1254	1.1	8.57	14.5
19-07-84	29.5	29	1.84	7.95	6.71	2.45	1.00	0.123	2.4	0.033	16
26-07-84	31	30.8	2.74	7.85	6.92	2.39	1.5	0.184	1.5	8.75	22
02-08-84*	33	31.3	2.37	8.149	7.01	0	1.29	0.158	3.4	0.97	7.8
08-08-84	28	27	2.5	8.1	7.88	1.39	1.37	0.168	4.2	0.45	30
16-08-84	32.5	31	2.79	7.9	6.234	3.15	1.53	0.188	2.87	7.35	21
23-08-84	30	29.2	3.19	7.8	2.95	3.75	1.75	0.215	3.39	0.033	18.7
30-08-84	25	25.9	3.4	8.27	3.8	0.875	1.87	0.230	6	0.798	4.1
04-09-84	32.5	32.1	3.57	7.99	4.67	2.99	1.96	0.241	6.1	0.457	7.2
12-09-84	26	27.5	3.66	8.1	4.92	2.8	2.01	0.247	6.7	2.8	6.6

MEAN VALUES FOR POND A

Date	Water Temp. °C	Salinity °/oo	D O mg/l	pH	Free CO_2 mg/l	Alkalinity °/oo	Nutrients		
							PO_4^{---}	NO_2^-	NO_3^-
14-06-84	27.53	4.385	4.57	7.84	2.55	0.2948	2.029	6.24	13.02
21-06-84	27.57	3.80	4.71	7.98	2.49	0.2573	4.99	8.69	21.97
28-06-84*	31.5	3.91	9.04	8.6	0	0.2954	4.87	0.97	35.5
05-07-84	25.75	1.9	5.76	8.08	1.78	0.1287	4.90	8.27	11.37
12-07-84	27.7	1.92	5.93	7.97	2.27	0.1294	7.35	9.29	13.62
19-07-84	28.9	1.85	6.49	7.94	2.56	0.1242	2.33	0.031	22.22
26-07-84	30.55	2.57	6.85	7.89	1.92	0.1732	1.313	9.055	7.01
02-08-84*	32.12	2.28	7.405	8.50	0	0.1567	3.37	0.985	31.36
08-08-84	27.57	2.44	7.81	8.12	1.42	0.1647	4.30	0.56	22.03
16-08-84	31.5	2.82	6.24	7.91	3.18	0.1903	2.35	7.95	17.84
24-08-84	29.37	3.20	4.84	7.81	3.84	0.2166	3.59	0.47	20.79
30-08-84	25.5	3.33	3.33	8.24	0.936	0.2256	5.94	0.43	3.94
04-09-84	31.95	3.51	4.72	8.00	2.9579	0.2357	5.85	0.33	6.73
12-09-84	28.125	3.63	4.89	8.09	3.8623	0.2447	6.6	2.66	6.54

* .... noon observation

POND B SPOT 1

Date	At Temp °C	Water Temp. °C	Salinity °/oo	pH	D O mg/1	Free CO_2 mg/1	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/1		
									PO_4...	NO_2-	NO_3-
14-6-84	28.5	28.2	4.47	8.23	5.25	1.12	2.46	0.3025	10	8.95	10.2
21-6-84	28.3	28	4.11	8.22	4.95	1.27	2.26	0.2779	2.7	4.2	5.71
28-6-84*	35	34.3	4.31	8.56	9.95	0	2.36	0.2902	9	1.06	33
05-7-84	27	26	3.34	8.19	6.45	1.54	1.28	0.1574	2.7	2.17	5
12-7-84	29	28.3	2.04	7.96	5.83	2.18	1.11	0.1365	3.6	10.14	15
19-7-84	30	29	1.83	8.09	7.20	1.79	1	0.123	2.4	0	11.5
26-7-84	31.2	30.9	2.28	7.84	6.56	3.84	1.25	0.153	4.8	12	8.5
02-8-84*	34	33.5	2.19	8.12	8.77	1.89	1.19	0.146	9	0.0225	9.5
08-8-84	29	28.2	2.39	7.95	7.26	2.95	1.31	0.161	8.5	0.45	32
16-8-84	33	32.1	2.92	8.01	7.96	2.08	1.6	0.196	3.3	0.33	17.1
26-8-84	31	29.9	3.47	7.75	4.63	4.99	1.91	0.234	4.78	0.12	20.52
30-8-84	26	25.6	3.66	7.86	5.29	3.24	2.01	0.2472	4.29	1.42	15.39
04-9-84	33	32.3	3.84	7.81	4.18	4.49	2.11	0.2595	2.3	0.495	37.6
12-9-84	29	28.2	4.11	7.85	5.04	3.47	2.26	0.2779	2.7	0.33	39

POND B SPOT 2

Date	At Temp. •C	Water Temp. •C	Salinity •/oo	pH	D.O mg/l	Free CO_2 mg/l	Chlorinity •/oo	Alkalinity •/oo	Nutrients µg atom/l		
									PO_4•••	NO_2^-	NO_3^-
14-6-84	28.5	28	4.52	8.25	5.45	1.057	2.49	0.3062	9.75	8.7	11.12
21-6-84	28.3	27.9	4.21	8.2	6.45	1.498	2.32	0.2853	2.5	4.1	5.68
28-6-84*	35	34.1	4.35	8.49	9.42	0	2.4	0.2952	9	2.01	32
05-7-84	27	26.2	2.42	8.16	7.53	1.58	1.33	0.1635	1.5	2.89	6.5
12-7-84	29	28.2	2.06	7.94	7.64	1.114	1.13	0.7389	6	5.77	13
10-7-84	30	28.7	1.9	8.07	8.07	1.849	1.04	0.1279	3.6	0	11.5
26-7-84	31.2	30.8	2.3	7.83	6.89	3.995	1.26	0.1549	4.2	12.75	10
02-8-84*	34	33	2.21	8.1	7.91	1.997	1.21	0.1488	6.5	0.3	21.25
08-8-84	29	28.1	2.41	7.93	7.90	2.996	1.32	0.1623	7.5	0.75	17
16-8-84	33	31.9	3.01	8.0	7.91	3.171	1.65	0.2029	3.4	0.5	18.2
23-8-84	31	29.1	3.51	7.73	5.01	4.994	1.93	0.2373	4.8	0.5	21.2
30-8-84	26	25.2	3.59	7.83	5.57	3.495	1.97	0.2423	4.3	0.5	16.12
04-9-84	33	31.9	3.83	7.79	4.3	4.475	2.11	0.2595	2.23	0.53	36.2
12-9-84	29	27.9	4.12	7.8	5.2	3.495	2.27	0.2792	2.69	0.33	35

POND B SPOT 3

Date	At Temp. °C	Water Temp. °C	Salinity °/oo	pH	D.O mg/1	Free CO_2 mg/1	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/1		
									PO_4...	NO_2-	NO_3-
14-6-84	28.5	27.9	4.46	5.3	8.23	1.057	2.46	0.3025	11	9	10.9
21-6-84	28.3	28	4.21	4.87	8.21	1.2473	2.32	0.2853	2.23	4.3	5.8
28-6-84*	35	33.9	4.35	9.87	8.45	0	2.4	0.2952	8.71	1.1	32
05-7-84	27	26.4	2.32	6.54	8.17	1.4982	1.127	0.1562	2.82	2.18	6
12-7-84	29	28.7	2.06	6.84	7.95	2.2473	1.12	0.1377	3.7	10.2	16
19-7-84	30	29.7	1.9	7.35	8.01	1.8497	1.03	0.1266	3.01	0	12.7
26-7-84	31.2	31	2.31	6.67	7.83	3.9952	1.27	0.1562	4.75	13.1	9
02-8-84*	34	33.3	2.21	8.84	8.11	1.9976	1.21	0.1488	9	0.0235	20.1
08-8-84	29	28.5	2.42	7.23	7.93	2.6425	1.33	0.1635	9.52	0.49	30.3
16-8-84	33	31.9	3.02	7.96	8.0	2.9964	1.66	0.2041	3.21	0.4	16.9
24-8-84	31	30.7	3.51	4.62	7.73	4.875	1.93	0.2373	4.81	0.2	21.2
30-8-84	26	25.8	3.75	5.34	7.83	3.145	2.06	0.2533	4.32	1.5	12.1
04-9-84	33	32.4	3.95	4.21	7.79	4.55	2.17	0.2669	2.5	0.95	33
12-9-84	29	28.1	4.25	5.05	7.84	3.648	2.34	0.2878	2.95	0.55	37

POND B SPOT 4

Date	At Temp. °C	Water Temp. °C	Salinity °/oo	pH	D O mg/l	Free CO_2 mg/l	Chlorinity °/oo	Alkalinity °/oo	Nutrients µg atom/l		
									PO_4...	NO_2-	NO_3-
14-6-84	28.5	28	4.51	5.25	8.21	1.15	2.48	0.305	10.8	8.7	12.5
21-6-84	28.3	27.9	4.25	4.73	8.19	1.325	2.33	0.2865	2.3	4.4	5.5
28-6-84*	35	34.5	4.38	9.75	8.45	0	2.41	0.2964	8.82	1	31
05-7-84	27	26.5	2.35	6.62	8.13	1.585	1.29	0.1586	2.95	2.5	7.8
12-7-84	29	28.7	2.07	6.83	7.92	2.114	1.13	0.1389	3.78	10.1	12.3
19-7-84	30	29.2	1.95	7.23	8.06	1.997	1.08	0.1328	3.02	0	12.9
26-7-84	31.2	30.9	2.32	6.72	7.83	4.07	1.27	0.1562	4	12.8	10.8
02-8-84*	34	33.4	2.23	8.75	8.11	1.84	1.22	0.15	8.78	0.07	20.1
08-8-84	29	28.7	2.51	7.34	7.92	2.51	1.38	0.1697	9.2	0.5	33
16-8-84	33	32.7	3.03	7.84	8	2.84	1.66	0.2041	2.28	0.62	16.7
24-8-84	31	30.7	3.6	4.637	7.74	5.05	1.99	0.2447	4.95	0.38	22.3
30-8-84	26	25.6	3.76	5.42	7.85	2.996	2.07	0.2546	3.5	1.8	12.35
04-9-84	33	32.7	3.98	4.31	7.8	4.249	2.19	0.2693	2.12	0.99	30
12-9-84	28	28.7	4.32	5.25	7.83	3.303	2.39	0.2939	2.87	0.63	35

MEAN VALUE POND B

Date	Water Temp. °C	Salinity °/oo	pH	D.O mg/l	Free CO_2 mg/l	Alkalinity °/oo	Nutrients µg atom/l		
							PO_4...	NO_2-	NO_3-
14-6-84	28.02	4.49	8.23	5.32	1.096	0.304	10.38	7.58	10.58
21-6-84	27.95	4.19	8.20	5.25	1.33	0.2837	2.435	4.252	5.67
28-6-84*	34.2	4.34	8.43	9.74	0	0.2942	8.897	1.293	32
05-7-84	26.27	2.25	8.16	6.78	1.55	0.1589	2.49	2.311	6.32
12-7-84	28.27	2.06	7.94	7.03	2.16	0.138	4.2	9.06	14.15
19-7-84	29.15	1.89	8.07	7.46	1.87	0.1275	3.007	0	12.15
26-7-84	30.9	2.30	7.83	6.71	3.97	0.1552	4.437	12.93	9.57
02-8-84*	33.29	2.12	8.11	8.56	1.934	0.1518	8.32	0.5	18
08-8-84	28.37	2.43	7.93	7.05	2.775	0.1637	8.12	0.6525	28.07
16-8-84	32.15	2.74	8.02	7.81	3.024	0.2015	3.04	0.4625	15.97
23-8-84	30.1	3.52	7.73	4.72	4.975	0.2385	4.84	0.3	21.3
30-8-84	25.25	3.69	7.84	5.4	3.212	0.2491	4.417	0.55	13.99
04-9-84	32.32	3.3	7.79	4.25	4.452	0.2637	2.271	0.7417	34.2
12-9-84	28.22	4.2	7.83	5.13	3.48	0.2847	3.802	0.46	36.5

* ... noon observation.

RESULTS BY STATISTICAL METHOD

The statistical analysis was carried out and correlation and regression co-efficients were calculated. Even though there is not much of a correlation between nutrients and carbondioxide, some other relations were found to be significant. 't' test was conducted for various factors use in the formula -

$$t = \frac{r \sqrt{n-2}}{\sqrt{1 - r^2}}$$

at 54 degrees of freedom, at 5% level of significance.

POND A

	CORRELATION CO-EFFICIENT	
CO_2 vs PHOSPHATE	- 0.048	NS
CO_2 vs NITRITE	- 0.1992	NS
CO_2 vs NITRATE	- 0.376	S
CO_2 vs TEMP:	- 0.106	NS
CO_2 vs D O	- 0.5262	S
CO_2 vs SALINITY	- 0.1638	NS
CO_2 vs ALKALINITY	- 0.0409	NS
CO_2 vs pH	- 0.1094	NS

POND B

CO_2 vs pH	- 0.655	S
CO_2 vs ALKALINITY	- 0.2676	S
CO_2 vs PHOSPHATE	- 0.3995	S
CO_2 vs NITRITE	- 0.07892	NS

CO_2 vs	NITRATE	- 0.338	S
CO_2 vs	DISSOLVED OXYGEN	- 0.536	S
CO_2 vs	TEMP:	- 0.0322	NS
CO_2 vs	SALINITY	- 0.0928	NS

S - SIGNIFICANT

NS - NOT SIGNIFICANT

DIURNAL VARIATION STUDIES IN POND A & C

07-07-'84

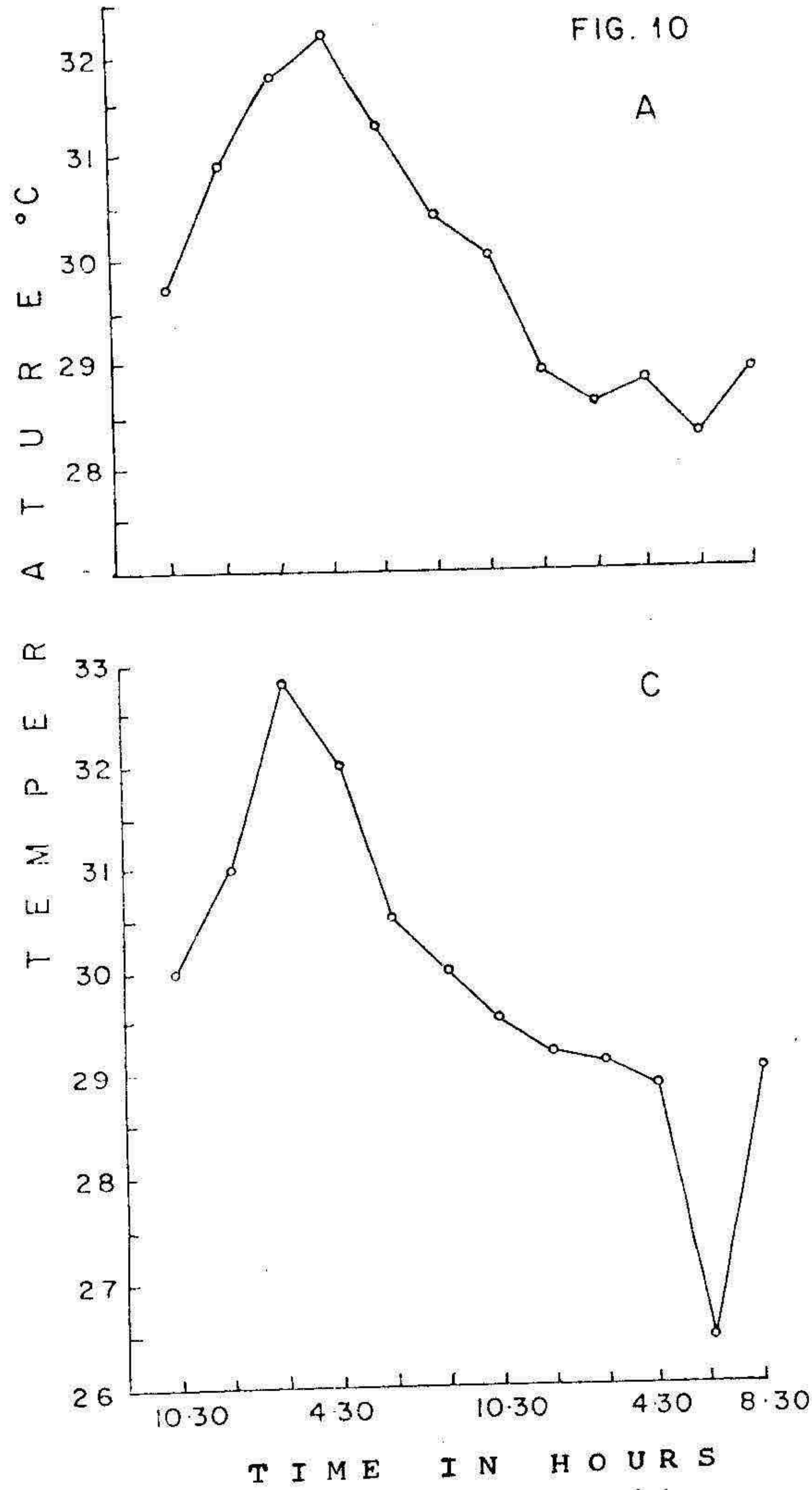
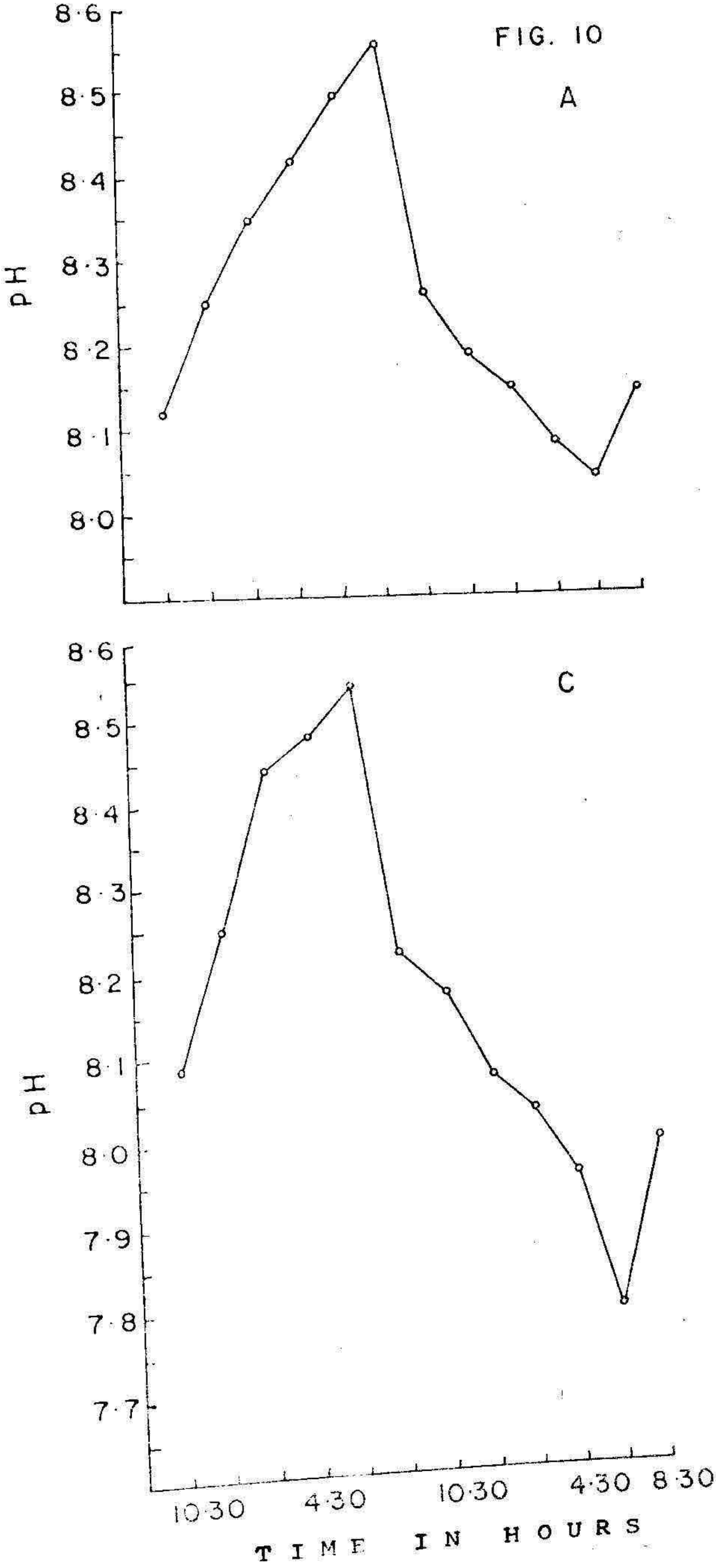


FIG. 10
A
C
TEMPERATURE °C
32
31
30
29
28
33
27
26
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 10


A
C
pH
8·6
8·5
8·4
8·3
8·2
8·1
8·0
7·9
7·8
7·7
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

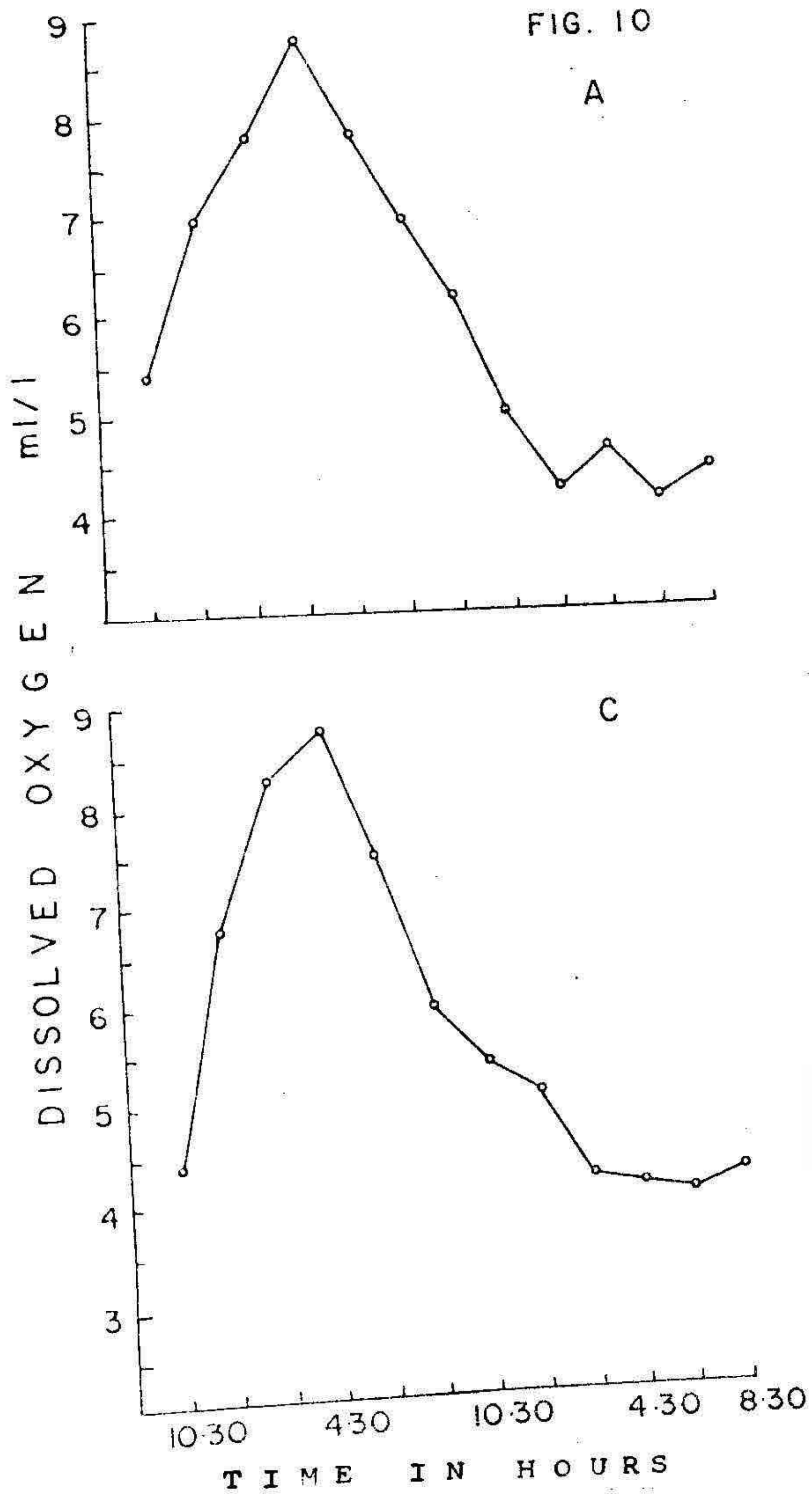


FIG. 10
A
C
DISSOLVED OXYGEN ml/l
9
8
7
6
5
4
3
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 10

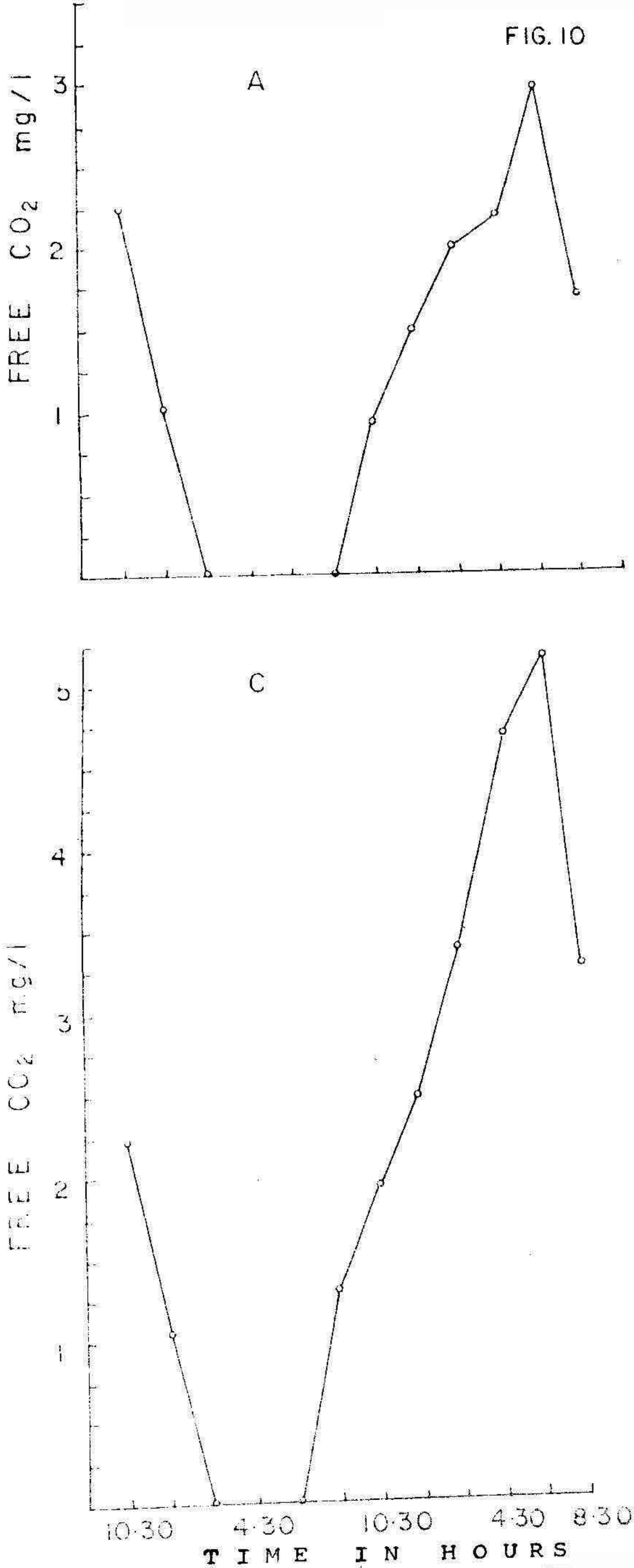
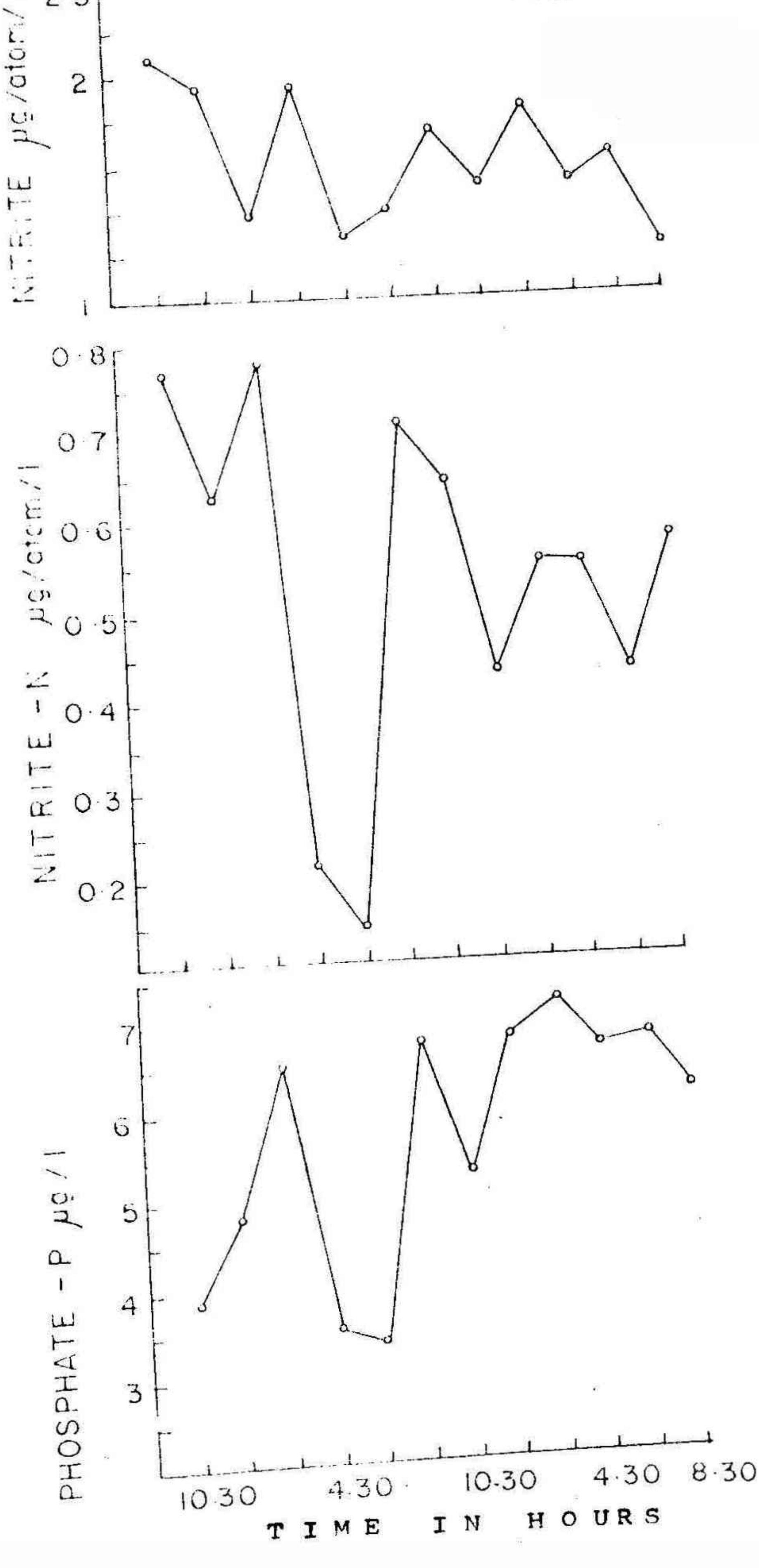

A
FREE CO_2 mg/l
3
2
1
C
FREE CO_2 mg/l
5
4
3
2
1
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 10 A


NITRITE μg/atom/l
2·5
2
1
NITRITE - N μg/atom/l
0·8
0·7
0·6
0·5
0·4
0·3
0·2
PHOSPHATE - P μg/l
7
6
5
4
3
10.30
4.30
10.30
4.30
8.30
TIME IN HOURS

DIURNAL VARIATION STUDIES IN POND C dA

07-07-'84

POND C SPOT 1

Time	At. temp:	Water temp:	pH	DO mg/1	CO2 mg/1	Salinity °/oo
10.30	31	30	8.15	5.008	2.114	2.834
12.30	34	31	8.27	6.445	1.0572	"
14.30	31.5	33.5	8.41	8.531	Nil	"
16.30	29	32	8.49	8.708	Nil	"
18.30	28.5	30.5	8.52	7.1809	Nil	"
20.30	28	30	8.23	5.994	1.2684	"
22.30	26.5	29.5	8.17	5.088	1.8501	"
24.30	26	29.2	8.10	4.919	2.643	"
2.30	25.5	29.1	8.07	4.071	3.458	"
4.30	25	28.7	8.01	3.958	4.75	"
6.30	27	28.3	7.81	3.675	5.286	"
8.30	27.5	29	8.05	3.53	3.498	"

POND C SPOT 2

Time	At. temp: °C	Water temp. °C	pH	DO mg/l	Salinity °/oo	Free CO_2 mg/litre
10.30	31	30	8.08	4.070	2.834	2.505
12.30	34	31.5	8.27	7.010	"	1.078
14.30	31.5	32.5	8.45	8.2548	"	nil
16.30	29	32	8.48	8.820	"	nil
18.30	28.5	30.5	8.57	7.576	"	nil
20.30	28	30	8.2	5.9367	"	1.278
22.30	26.5	29.5	8.18	5.484	"	1.97
24.30	26	29.2	8.05	3.0414	"	2.587
2.30	25.5	29.1	8.0	4.127	"	3.558
4.30	25	29	7.93	4.070	"	4.675
6.30	27	25.5	7.80	4.014	"	5.15
8.30	27.5	29	7.95	4.41	"	3.212

POND C SPOT 3

Time	At. Temp: °C	Water temp: °C	pH	Salinity °/oo	Free CO_2 mg/litre	DO mg/L
10.30	31	30	8.05	2.834	2.114	4.1
12.30	34	31.5	8.22	"	1.089	7.21
14.30	31.5	32.5	8.46	"	nil	8.15
16.30	29	32	8.89	"	nil	8.78
18.30	28.5	30.5	8.55	"	nil	7.63
20.30	28	30.	8.23	"	1.381	5.875
22.30	26.5	29.5	8.17	"	1.998	5.384
24.30	26	29.2	8.06	"	2.578	5.0512
2.30	25.5	29.1	8.0	"	3.458	4.212
4.30	25	29	7.92	"	4.78	4.071
6.30	27	25.5	7.78	"	5.23	4.081
8.30	27.5	29	7.98	"	3.212	4.42

POND C — Mean Value

Time	Water temp. °C	pH	Salinity °/oo	DO mg/lr.	Free Co2 mg/litre
10.30	30	8.09	2.834	4.41	2.24
12.30	31	8.25	"	6.88	1.074
14.30	32.8	8.44	"	8.25	nil
16.30	32	8.48	"	8.76	nil
18.30	30.5	8.54	"	7.46	nil
20.30	30	8.22	"	5.93	1.309
22.30	29.5	8.17	"	5.31	1.939
24.30	29.2	8.07	"	5.00	2.599
2.30	29.1	8.03	"	4.13	3.491
4.30	28.9	7.95	"	4.03	4.73
6.30	26.43	7.79	"	3.92	5.2
8.30	29	7.99	"	4.12	3.307

POND A SPOT 1

Time	At. Temp. °C	Water Temp. °C	pH	Salinity °/oo	Free CO_2 mg/l	D.O mg/l	Nutrients mg/l		
							PO_4---	NO_2-	NO_3-
10.30	31	29.5	8.12	3.023	2.114	5.823	4	0.786	21.09
12.30	34	31	8.27	2.834	1.022	7.011	4.8	0.642	19.9
14.30	31.5	32	8.39	2.834	Nil	7.972	6.6	0.786	14.0
16.30	29	32.5	8.45	2.834	Nil	8.820	3.6	0.214	19.9
18.30	28.5	31.5	8.55	2.834	Nil	7.916	3.4	0.143	12.8
20.30	28	30.5	8.6	2.834	Nil	7.01	6.9	0.714	14
22.30	26.5	30	8.29	2.834	.9988	6.219	5.2	0.642	17.5
24.30	26	29	8.21	2.834	1.576	5.654	6.8	0.429	15.2
2.30	25.5	28.7	8.15	2.834	1.9976	4.24	7.2	0.571	18.7
4.30	25	29	8.09	2.834	2.114	4.523	6.6	0.5	15.2
6.30	27	28.5	8.07	2.834	2.998	4.127	6.7	0.429	16.4
8.30	27.5	29	8.21	2.834	1.576	4.410	6.2	0.571	11.7

POND A SPOT 2

Time	At. Temp °C	Water Temp. °C	pH	Salinity °/oo	D.O mg/l	Free CO_2 mg/l	Nutrients mg/l		
							$PO_4^{\cdots}$	NO_2^-	NO_3^-
10.30	31	30	8.11	3.023	5.73	2.546	3.9	0.775	21
12.30	34	31.5	8.23	2.834	7.1	1.124	4.85	0.632	20.1
14.30	31.5	32	8.32	2.834	7.82	Nil	6.45	0.783	13.5
16.30	29	32.3	8.39	2.834	8.82	Nil	3.5	0.204	19.8
18.30	28.5	31.4	8.45	2.834	7.83	Nil	3.23	0.14	12.7
20.30	28	30.2	8.51	2.834	7.12	Nil	6.75	0.712	14.2
22.30	26.5	29.8	8.27	2.834	6.22	1.002	5.12	0.652	18.7
24.30	26	29	8.17	2.834	5.65	1.675	6.75	0.449	15.1
2.30	25.5	28.7	8.15	2.834	4.28	2.075	7.1	0.561	18.8
4.30	25	28.8	8.08	2.834	4.575	2.345	6.55	0.55	14.8
6.30	27	28	8.01	2.834	4.21	3.02	6.78	0.487	16.3
8.30	27.5	28.7	8.13	2.834	4.51	1.97	6.12	0.581	12.1

POND A SPOT 3

Time	At. Temp. °C	Water Temp. °C	pH	Free CO_2 mg/1	D O mg/1	Salinity °/oo	Nutrients µg/1		
							$PO_4^{\cdots}$	NO_2^-	NO_3^-
10.30	31	29.8	8.13	2.234	5.735	3.023	3.8	0.753	20.1
12.30	34	30.7	8.26	1.022	7.021	2.835	4.75	0.638	19.7
14.30	31.5	31.5	8.36	Nil	7.872	2.834	6.5	0.796	14.2
16.30	29	32	8.43	Nil	8.78	2.834	3.65	0.215	19.3
18.30	28.5	31.2	8.52	Nil	7.815	2.834	3.43	0.143	12.8
20.30	28	30.7	8.59	Nil	7.001	2.834	6.75	0.721	14.1
22.80	26.5	30.3	8.28	0.9988	6.875	2.834	5.32	0.651	17.3
24.00	26	28.9	8.2	1.478	5.786	2.834	6.71	0.439	15.2
2.80	25.5	28.4	8.12	1.9976	4.34	2.834	7.1	0.531	18.7
4.80	25	28.8	8.07	2.27	4.78	2.834	6.8	0.45	15.1
6.30	27	28.4	8.05	2.998	4.123	2.834	6.7	0.439	16.3
8.30	27.5	29	8.19	1.765	4.47	2.834	6.15	0.571	12.7

MEAN VALUES POND A.

Time	Water Temp. °C	pH	Salinity °/oo	D.O mg/1	Free CO_2 mg/1	Nutrients µg/1		
						$PO_4^{\cdots}$	NO_2^-	NO_3^-
10.30	29.76	8.12	3.023	5.762	2.298	3.9	0.771	2.07
12.30	30.9	8.25	2.834	7.04	1.056	4.8	0.627	1.98
14.30	31.8	8.35	2.834	7.38	0	6.51	0.788	1.39
16.30	32.36	8.42	2.834	8.8	0	3.58	0.211	1.06
18.30	31.36	8.5	2.834	7.85	0	3.35	0.142	1.27
20.30	30.46	8.56	2.834	7.07	0	6.76	0.715	1.97
22.30	30.06	8.26	2.834	6.27	0.9998	5.21	0.649	1.78
24.30	28.96	8.19	2.834	5.09	1.576	6.75	0.439	1.516
2.30	28.6	8.15	2.834	4.28	2.023	7.13	0.554	1.83
4.30	28.86	8.08	2.834	4.62	2.243	6.65	0.55	1.50
6.30	28.3	8.04	2.834	4.15	3.005	6.72	0.435	1.63
8.30	28.9	8.14	2.834	4.43	1.77	6.156	0.574	1.21

DIURNAL VARIATION IN POND A+C

29-08-'84

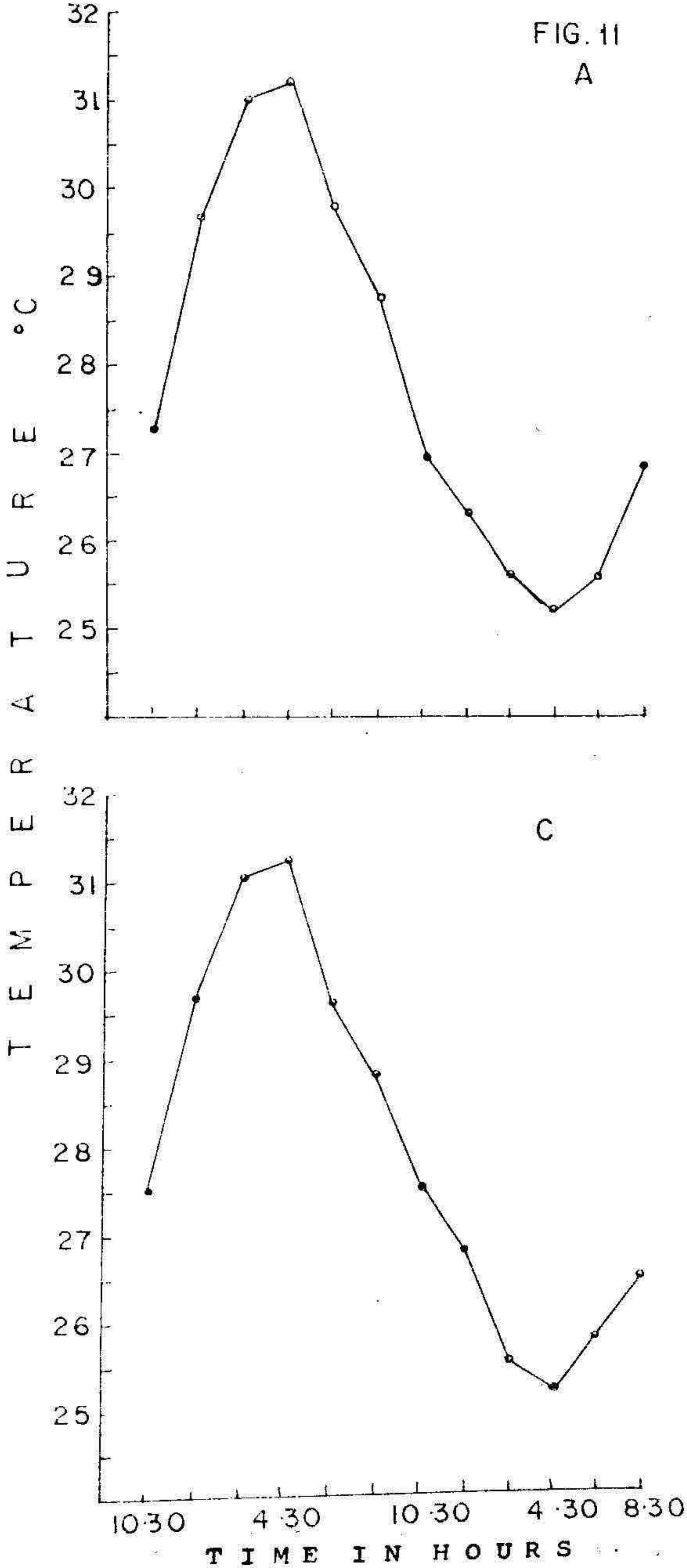
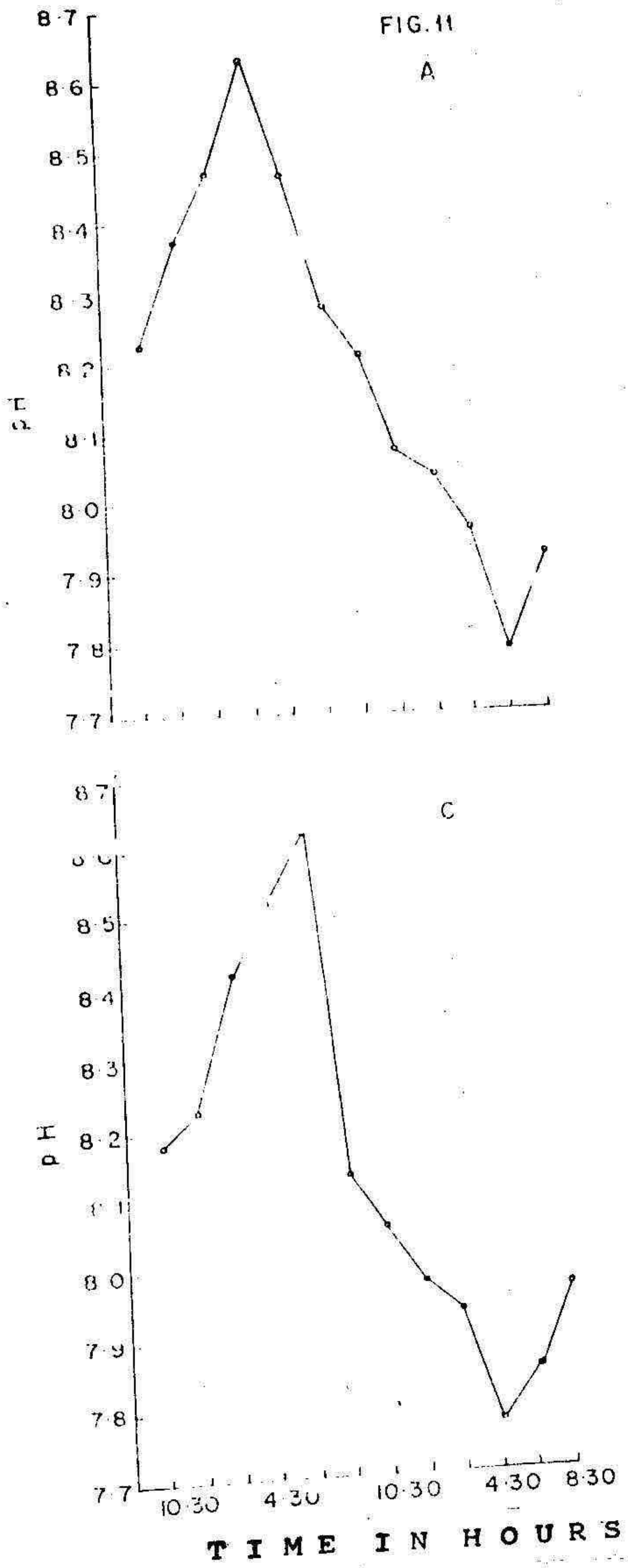


FIG. 11
A
C
TEMPERATURE °C
32
31
30
29
28
27
26
25
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 11


A
C
pH
8·7
8·6
8·5
8·4
8·3
8·2
8·1
8·0
7·9
7·8
7·7
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

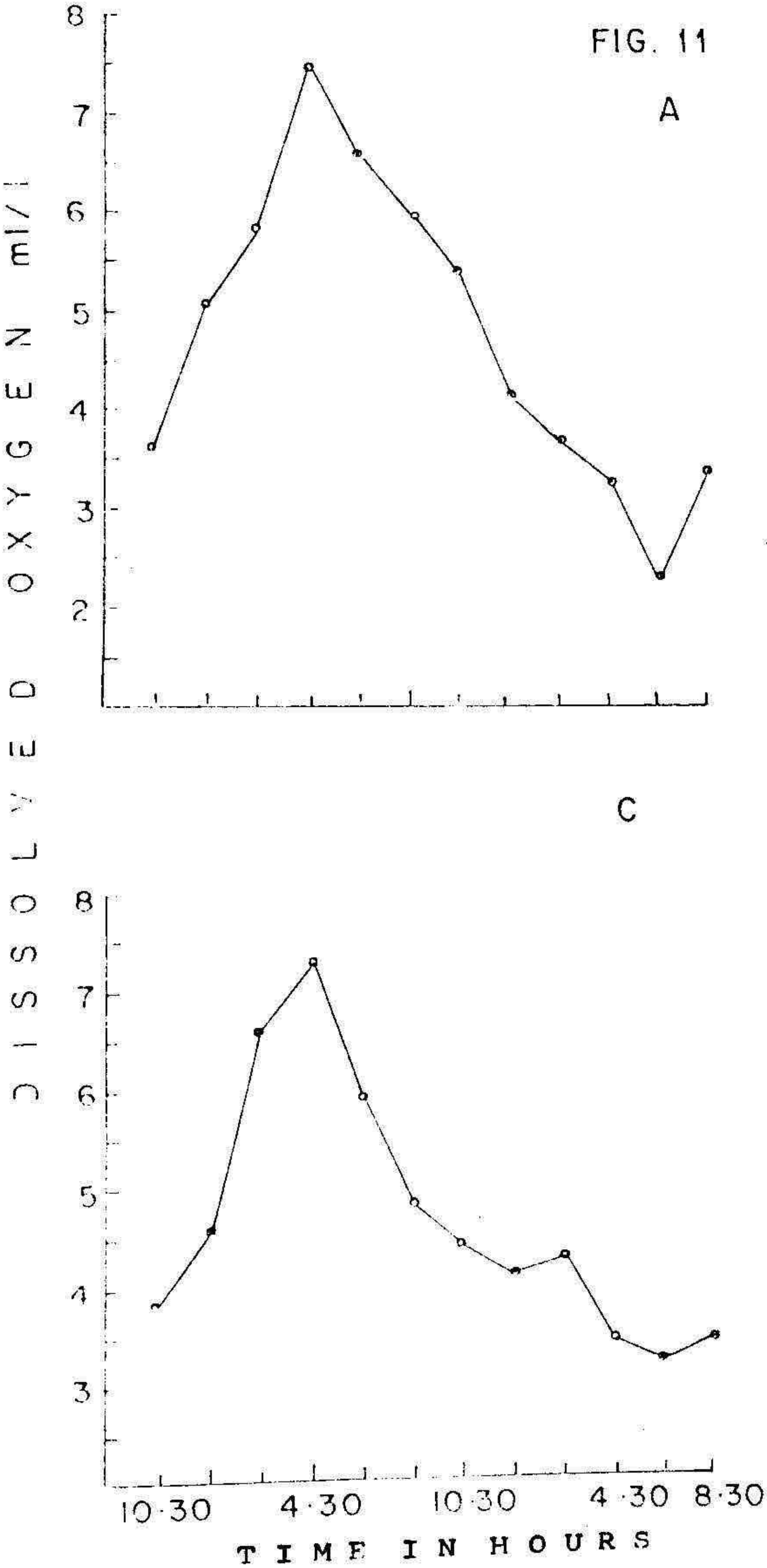
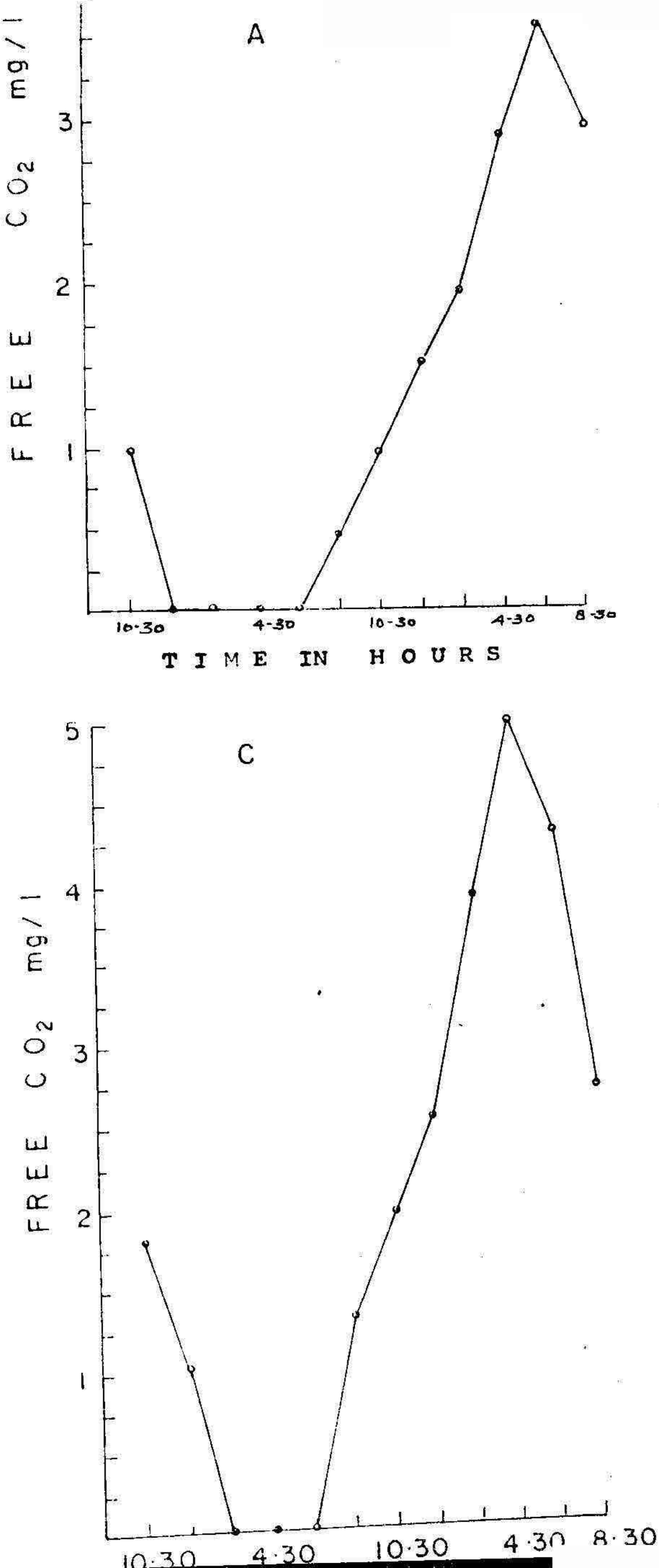

A
C
DISSOLVED OXYGEN ml/l
8
7
6
5
4
3
2
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 11

FIG. 11


A
FREE CO_2 mg/l
1
2
3
10-30
4-30
10-30
4-30
8-30
TIME IN HOURS
C
FREE CO_2 mg/l
1
2
3
4
5
10·30
4·30
10·30
4·30
8·30

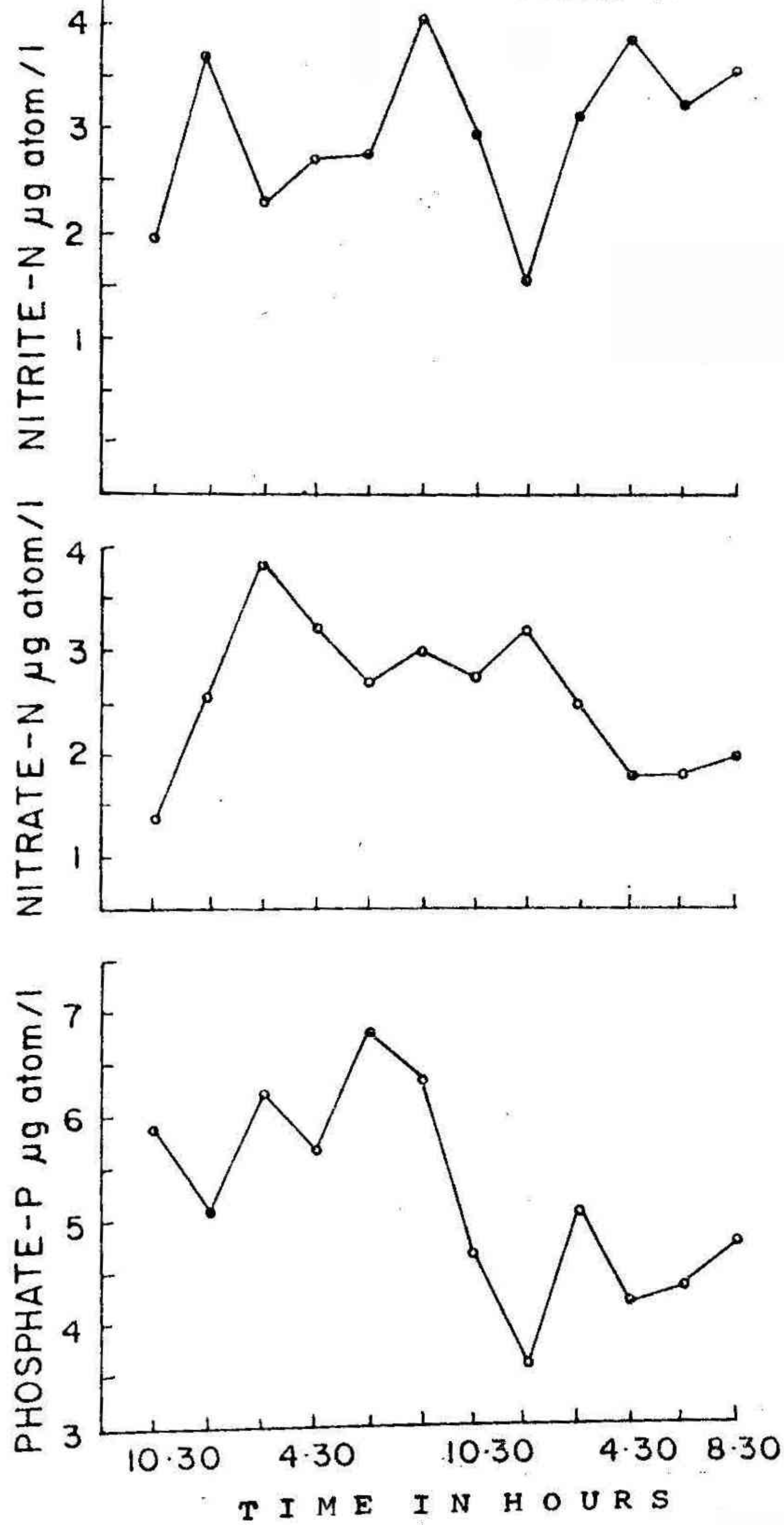

NITRITE-N µg atom/l
NITRATE-N µg atom/l
PHOSPHATE-P µg atom/l
10·30
4·30
10·30
4·30
8·30
TIME IN HOURS

FIG. 11. A

DIURNAL VARIATION IN POND C & A

29-08-'84

POND C SPOT 1

Time	At.temp °C	Water temp. °C	pH	Salinity °/oo	DO mg/lr	Free CO_2 mg/lr.
10.30	26	27.5	8.1	3.269	3.789	1.7465
12.30	28	30	8.24	3.41	4.792	0.9984
14.30	30	31	8.48	3.41	6.648	nil
16.30	31	31.5	8.57	3.32	7.202	nil
18.30	29	30	8.68	3.41	2.8724	nil
20.30	27	29.3	8.14	3.269	4.7921	1.2475
22.30	26	29	8.08	3.069	4.376	1.996
24.30	25.5	28.5	8.01	3.41	4.0996	2.495
2.30	25	25.7	7.95	3.41	4.2381	3.7425
4.30	26.8	25.5	7.78	3.41	3.3517	5.2395
6.30	27	27	7.86	3.41	3.2409	4.7405
8.30	27.8	26	7.98	3.41	3.434	2.465

POND C SPOT 2

Time	At. temp. °C	Water temp. °C	pH	Salinity °/oo	Free CO_2 mg/lr	DO mg/lr
10.30	26	27.6	8.13	3.269	1.996	3.8
12.30	28	29.9	8.25	3.41	0.9988	4.45
14.30	30	31.2	8.41	3.41	nil	6.575
16.30	31	31.4	8.52	3.32	nil	7.202
18.30	29	29.8	8.63	3.41	nil	5.92
20.30	27	28.8	8.12	3.269	1.37	4.82
22.30	26	26.7	8.05	3.069	2.001	4.40
24.30	25.5	26	8	3.41	2.57	4.12
2.30	25	25.5	7.92	3.41	3.98	4.25
4.30	25.8	25	7.76	3.41	4.9988	3.45
6.30	27	25.9	7.83	3.41	4.185	3.29
8.30	27.8	26.8	7.95	3.41	2.895	3.45

POND C SPOT 3

Time	At.temp: °C	Wat.temp: °C	pH	Salinity °/oo	Free CO_2 mg/lr	DO mg/lr.
10.30	26	27.4	8.12	3.269	1.875	3.98
12.30	28	29.2	8.23	3.41	1.02	4.51
14.30	30	31	8.39	3.41	nil	6.61
16.30	31	30.9	8.49	3.32	nil	7.212
18.30	29	29.7	8.6	3.41	nil	5.91
20.30	27	23.7	8.13	3.269	1.45	4.83
22.30	26	26.9	8.04	3.00	1.9988	4.45
24.30	25.5	25.9	7.98	3.41	2.58	4.15
2.30	25	25.3	7.9	3.41	4.01	4.29
4.30	25.8	25.1	7.79	3.41	4.875	3.47
6.30	27	25.7	7.85	3.41	4.275	3.31
8.30	27.8	26.7	7.96	3.41	2.975	3.52

MEAN VALUES - POND C

Time	Wat.temp: °C	pH	Salinity °/oo	DO mg/l	Free CO_2 mg/l
10.30	27.5	8.116	3.269	3.849	1.8726
12.30	29.7	8.226	3.41	4.584	1.0057
14.30	31.06	8.426	3.41	6.61	nil
16.30	31.26	8.52	3.32	7.205	nil
18.30	29.6	8.626	3.41	5.9008	nil
20.30	28.83	8.13	3.269	4.814	1.35
22.30	27.53	8.05	3.069	4.408	1.9986
24.30	26.8	7.97	3.41	4.12	2.548
2.30	25.5	7.93	3.41	4.25	3.91
4.30	25.2	7.77	3.41	3.403	5.037
6.30	25.8	7.84	3.41	3.28	4.38
8.30	26.5	7.967	3.41	3.468	2.778

MEAN VALUES POND A

29-08-1984

Time	Water Temp. °C	pH	Salinity °/oo	Free CO_2 mg/l	D O mg/l	Nutrients mg/l		
						PO_4···	NO_3-	NO_2-
10.30	27.3	8.22	3.2395	0.9988	3.658	5.93	1.413	2.07
12.30	29.775	8.37	3.43	Nil	5.083	5.125	2.61	3.71
14.30	31.05	8.47	3.43	Nil	5.883	6.2	3.87	2.389
16.30	31.225	8.63	3.33	Nil	7.558	5.7	3.21	2.765
18.30	29.8	8.47	3.2395	Nil	6.513	6.81	2.77	2.81
20.30	28.825	8.28	3.2395	0.432	6.0282	6.356	3.03	4.43
22.30	27.03	8.21	3.00	0.9833	5.4396	4.783	2.79	3.0396
24.30	26.33	8.075	3.23	1.526	4.191	3.6	3.21	1.575
2.30	25.63	8.04	3.23	1.9644	3.7646	5.1	2.56	3.186
4.30	25.28	7.96	3.23	2.953	3.374	4.2	1.79	3.924
6.30	26.1	7.79	3.23	3.619	2.371	4.383	1.76	3.346
8.30	26.9	7.92	3.23	2.9978	3.423	4.775	2	3.65

POND A SPOT 3 29-08-1984

Time	At Temp. °C	Water Temp. °C	pH	Salinity °/oo	Free CO_2 mg/l	D.O mg/l	Nutrients mg/l		
							PO_4^{---}	NO_3^-	NO_2^-
10.30	26	27.3	8.22	3.2395	0.9985	3.71	5.9	1.475	2
12.30	28	29.8	8.40	3.43	Nil	5.05	5.1	2.8	3.67
14.30	30	31	8.48	3.4	Nil	5.875	6.1	3.85	2.434
16.30	31	31.2	8.61	3.3	Nil	7.581	5.75	3.25	2.763
18.30	29	29.6	8.45	3.2395	Nil	6.678	6.75	2.75	2.8
20.30	27	28.9	8.27	3.2395	0.45	6.00	6.35	3	4.18
22.30	26	26.9	8.22	3.00	1.002	5.41	4.6	2.8	3.05
24.30	25.5	26.3	8.1	3.23	1.510	4.1	3.3	3.3	1.57
2.30	25	25.8	8.04	3.23	1.9976	3.66	5.1	2.75	3.21
4.30	25.8	25.2	7.96	3.23	2.9874	3.451	4.3	1.8	4
6.30	27	26.3	7.78	3.23	3.967	2.315	4.45	1.88	3.4
8.30	27.8	27	7.88	3.23	3.01	3.41	4.75	2	3.6

POND A SPOT 2 29-08-1984

Time	At Temp °C	Water Temp. °C	pH	Salinity °/oo	Free CO_2 mg/l	D.O mg/l	Nutrients µg/l PO_4^{---}	NO_3^-	NO_2^-
10.30	26	27	8.21	3.2395	0.9988	3.568	5.9	1.24	2.0
12.30	28	29.5	8.33	3.43	Nil	5	5.1	2.35	3.68
14.30	30	31.2	8.45	3.43	Nil	5.958	6.25	3.87	2.34
16.30	31	31	8.63	3.33	Nil	7.476	5.8	3.1	2.78
18.30	29	29.8	8.51	3.23	Nil	6.573	6.9	2.78	2.85
20.30	27	28.7	8.27	3.23	0.398	6.049	6.32	3	4
22.30	26	27.2	8.21	3	0.957	5.536	4.95	2.78	3
24.30	25.5	26.2	8.10	3.23	1.572	4.375	3.7	3.15	1.59
2.30	25	25.6	8.02	3.23	1.898	3.978	5.2	2.35	3.05
4.30	25.8	25	7.95	3.23	2.876	3.537	4.1	1.78	3.78
6.30	27	25.8	7.78	3.23	3.447	2.475	4.3	1.65	3.28
8.30	27.8	26.8	7.93	3.23	2.987	3.48	4.75	2	3.65

POND A SPOT 1

Time	At Temp. °C	Water Temp. °C	pH	Salinity °/oo	Free CO_2 mg/1	D O mg/1	Nutrients mg/1		
							PO_4^{---}	NO_3^-	NO_2^-
10.30	26	27.5	8.23	3.2395	0.9988	3.698	6	1.525	2.22
12.30	28	30	8.38	3.43	Nil	5.0414	5.2	2.7	3.8
14.30	30	31.8	8.49	3.43	Nil	5.817	6.2	3.9	2.434
16.30	31	31.5	8.66	3.33	Nil	7.617	5.8	3.3	2.753
18.30	29	30	8.47	3.2395	Nil	6.703	6.8	2.8	2.8
20.30	27	29	8.29	3.2395	0.4494	6.0386	6.4	3.1	2.167
22.30	26	27	8.20	3.00	0.9984	5.373	4.8	2.75	3.069
24.30	25.5	26.5	8.12	3.23	1.4982	4.0996	3.8	3.2	1.5675
2.30	25	25.5	8.05	3.23	1.9976	3.6561	5	2.6	3.3
4.30	25.8	25.3	7.98	3.23	2.9964	3.434	4.2	1.8	3.993
6.30	27	26.2	7.81	3.23	3.994	2.325	4.4	1.75	3.36
8.30	27.8	27	7.95	3.23	2.9964	3.379	4.8	2	3.7

DISCUSSION

Thus from the foregoing descriptions it can be understood that the nutrient content, free carbondioxide and the temperature conditions in these culture ponds are subjected to a wide range of variations eventhough, the period of observation was of short duration. But the selected period was one, when the South West Monsoon was very active and one when the hydrographic conditions in the Cochin backwaters and the neighbouring sea are subjected to drastic changes.

During the Peak Monsoon seasons (July) the effect of Monsoon in reducing the water temperature of the ecosystem were noticed. As stated in the previous paragraph except for the noon observations the water temperature was uniformly low and the minimum was observed during late August, When the Monsoon was again active. Disregarding the noon observation a range of variation of nearly 6°C was observed during this period. Reference may be made in connection to Ramamritham and Jayaraman (1960) wherein it has been stated that the surface waters of the Arabian sea undergo drastic thermal fluctuations during peak monsoon. A same range of diurnal temperature variation this also noticed in the present study. A comparable thermal trend has been noticed by Ravindran (1983) wherein a diurnal variation of nearly 2 to 4.7°C has been observed. The tidal amplitude in the ponds was low and so much so a definite relationship between tidal amplitude and temperature has observed by Qasim and Gopinathan (1969), Shynamma and Balakrishnan (1973) in the Cochin backwaters, is not observed in the present study. The full fledged influence of the tides may not be present in the pond ecosystem as it is usually felt in the backwaters. This is again perceptible in the diurnal variation study of salinity in the culture ponds, wherein it is observed that very little variation in salinity occur. The reasons may be either intense rainfall or the very weak effect of tidal currents and its effect of the culture ponds. The considerable distance of the ponds away from the main feeder channel and the restricted water flow of the ponds also may contribute to this.

The salinity variations in the culture ponds are mainly dependent on precipitation and land run off only, and here again the Monsoon minimum is noticeable.

The high amounts of dissolved oxygen in the ponds appear to have aclose relation with water temperature, in the sense that the increasing and decreasing trends with time are similar in both. Photosynthesis,respiration of planktonic organisms and water temperature are the major influencing factors for the dissolved oxygen content in the pond waters. Such a relation between oxygen and water temperature has been observed by Kasturi Rangan (1957). But the observations of Qasim and Gopinathan (1969), Singbal (1975) and Rao & Rao (1962) in the Cochin backwaters, Zauri estuary and Waltair coast respectively are contradictory to these observations.

The pH variations in the ponds also show a wide range of variation, a variation of nearly 1.3 units as evidenced from the distribution pattern. There is generally a trend to maintain a constant pH in the sea and adjacent waters. This stability can better be exemplified perhaps if one considers the buffer capacity of sea water with respect to dissolved carbondioxide (Wetzel 1975) in the present case there is found a more or less good correlation between pH and dissolved oxygen content which is positive. Such a relationship has been given by Ravindran also. The buffering capacity of sea water has mentioned above is not so striking in the case of culture ponds which are, rather enclosed water bodies. But still the pH has never gone below the neutral range to the acid range.

As mentioned above the buffer capacity of sea water can be exemplified perhaps if one considers this buffer capacity with respect to dissolved carbondioxide. This parameter (Beta carbondioxide) can be defined as incremental change in dissolved inorganic carbondioxide required to shift the pH of a solution by one pH unit, Wetzel (1975). It has inferred that the increase in carbondioxide must be counterbalanced by other processes that tend to increase the pH of sea water. In the present case a more or less well defined inverse relationship between pH and carbondioxide has been observed. This inverse relationship is in good agreement with that shown by Ringer (1908). The graphs show the following relations :

pH	CO_2 mg/l
8.6	0
7.4	3.9

Therefore for 1.2 unit pH change the amount of carbondioxide change is calculated to be 3.9 mg/litre. Hence a rough estimate of Beta carbondioxide parameter can be calculated as 3.25 mg/litre. Various limitations has to be borne in mind such as restricted tidal flow., the fresh water influx and the monsoon changes, in this context.

According to the statistical analysis in the present case the carbondioxide and dissolved oxygen correlation in both the ponds, there is found to be significance, but the relation of carbondioxide and other parameters is not so significant, in the first pond. The reasons for this may be 1: The smaller area of the pond, 2: the less exchange of water through the single sluice gate. But in the 2nd pond free carbondioxide is found to have a better correlation with pH, dissolved oxygen, Nitrate, Phosphate and Alkalinity. The main factors which may be responsible for this is -

1. the presence of three sluice gates on the bunds which facilitate a better exchange of water between the main channel and the pond,

2. the surface area of this pond is much more when compared to the other. "The more the surface area of water the more will be the exchange of carbondioxide across the air-water interface".

The surface water temperature, salinity, dissolved oxygen in the North Atlantic has been correlated with carbon-dioxide concentration, by Kelley (1970). The author reports that for a one degree centigrade increase in surface temperature there is a ten. ppm. increase in carbondioxide concentration. In the present case during the 2nd week of July an increase of nearly 1.75 mg/litre of carbondioxide has been observed for nearly 2°C increase in temperature. This high amount might be a local modification of the peculiar eco-system. But in general the increase in carbondioxide content with increase in temperature is perceptible.

Except for the first few observation the relationship between dissolved oxygen and carbondioxide is more or less similar to that reported by the same author, when the time distribution pattern of carbondioxide is analysed. But in the diurnal variation study a different pattern is observed where there is observed a gradual increase in carbondioxide content with decrease in temperature and dissolved oxygen content. This probably refers to photosynthesis. The depletion of carbondioxide is clearly related in photosynthesis and thus during the night observations carbondioxide is high, oxygen and pH and temperature are low.

The variation of the nutrient parameters with time, although having an approximate direct relationship with temperature, phosphate does not follow a definite pattern. The peak phosphorus concentration was during peak monsoon when the temperature was not at the maximum. The relation between free carbondioxide content and phosphate phosphorus is also irregular. Yoram Avi-Melech (1983) has observed a rapid decrease in phosphorous and alkalinity with an increase in pH in Lake Kinnert. Increase in pH is associated with decrease in carbondioxide and in the present case the general trend is also for decrease in phosphorus with decrease in carbondioxide content at least during peak monsoon.

The nitrate concentration does not follow a regular pattern nor show any definite relationship with free carbondioxide. Roger Knowles (1981) has inferred that Nitrous oxide is released during the dissimilatory reduction of nitrate during de-nitrification and also during oxidation of ammonium and nitrite ion by nitrifying bacteria. Hence the increase in nitrate concentration has to be generally associated with decrease in oxygen and increase in carbondioxide. Such a close relationship is not observed in the present case except for one or two occasions in the seasonal distribution. In the diurnal variation studies also this hypothesis is not reflected.

Desousa (1983) while investigating the Mandovi estuary during pre-monsoon has stated that the estuarine waters generally has got an internal source of nitrate in the chlorinity range of 3 to 10 parts per 1000. Denitrification may not be the cause for the removal of nitrate in well oxygenated estuaries and the biological productivity is maximum in pre-monsoon season. The nitrate loss has been entirely attributed to the biological utilisation. In the present case during peak monsoon the nitrate content were low whereas the nitrite contents were high. The biological denitrification probably is in vogue during this season. The chlorinity range was 1 to 3.07 parts per thousand and it is possible that this range of chlorinity is more or less conducive to the denitrification.

Stffenson and Richardson (1963) reveals that towards the high salinity region there is a slight increase in phosphate. ~~But probably due to the enclose nature of ponds and the restricted tidal flow this slight increase in phosphate.~~ But probably due to the enclose nature of ponds and the restricted tidal flow this slight increase in phosphate is not so conspicuous in the culture ponds, except for late monsoon and post monsoon season and that too in pond A only.

Park Kilho et al (1970) by investigating the carbondioxide and the nutrient contents in the Colombia River has not put forward any correlation between these two parameters. In the present case also a definite correlation is not at all obvious and as such the biological cycle of nutrients seems to be independent of free carbondioxide.

Respiration replenishes the bicarbonate (via carbondioxide) available for photosynthesis and no carbondioxide is added by solution from the air, in surface waters, and from dissolving carbonate. The equilibria here are biological and

and are quite complicated. As the pH increases carbondioxide diminishes and carbonate increases and this liberate some excess base with sets free borate ions from undissociated boric acid. Thus we have both carbonate and borate equilibria to buffer the sea water, and this buffering act is of great importance for biology (Fergusson Wood 1967).

SUMMARY

The present investigation pertain to the study of hydrological parameters such as salinity free carbondioxide, dissolved oxygen, pH, and water temperature and phosphate, nitrate and nitrite in two culture ponds at Narakkal. Weekly observations has been carried out for all these properties and the results are graphically presented and discussed. Two diurnal variation studies are also graphically presented. Since the period of observation was during peak monsoon and early post monsoon the salinity values were uniformly low in both the ponds. Intermittent low and high temperature values where observed which mainly depend on the monsoon precipitation. Super saturation with respect to dissolved oxygen was observed in both the ponds and these high oxygen values corresponded to low carbondioxide contents. The ponds were uniformally well oxygenated during the period of investigations. The time of observation during a day was found to be significant especially in the case of carbondioxide and dissolved oxygen contents. The pH value showed a general decrease with time although intermittent high values were also observed. The bicarbonate alkalinity rather availability was found to be high during the peak monsoon season. The overall alkalinity of the pond waters was also low during the peak monsoon. This high bicarbonate alkalinity during the monsoon is congenial to healthy phyto plankton growth, since plants depend mainly on bicarbonate ion as the source for carbon. The nutrient

availability in the ponds did not show a definite pattern although there was a rough direct relationship between phosphate and nitrate. Nitrite content showed and inverse relationship with that of nitrate. The carbondioxide equilibria were observed to be mostly dependent on water temperature pH and time of observation and very little correlation was observed with the biological cycle of nutrients. The diurnal variation studies in the concerned ponds also, more or less confirmed the relationship between carbondioxide content, dissolved oxygen, and pH, especially the observations during the night period.

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