STUDIES ON N-P-K RATIOS IN SOIL AND OVERLYING WATER IN SOME CULTURE PONDS IN RELATION TO PLANKTON BIOMASS

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CERTIFICATE

This is to certify that this Dissertation is a bonafide record of work carried out by Shri. C. Mohandass, 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

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PREFACE

The success or failure of any culture operation is dependant on the water quality and the condition of the bottom sediments. The nature and composition of bottom sediments have several vital roles to play in the productivity of culture ponds. The sediments store the nutrients and effectively control the mineralization of organic deposits at the bottom. They are the source of various organic and inorganic compounds which enter the water after biochemical and chemical changes in situ. The bottom soils provide food and shelter for the bottom dwelling organisms and also act as a bed for the growth of algal flora, which forms the food for many species of fish. Also, they form a substratum for bottom fauna that often constitute an important source of food. The sediments thus play several important and dynamic roles, in the food chain and in the production cycle in the pond eco-system.

Sediments are continuosuly supplied with organic material by sedimentation, autotrphic production, and food collection by benthic organisms (VERVEY 1952). Mineralisation of this material occurs throughout the sediment column, but the highest activities are found near the sediment surface (VOSJAW, OLANCZUKNEYMAN, 1977).

The overall productivity of the ponds mainly depends on the fertility of the bottom soil. The production of the planktons is based upon the inorganic nutrients such as nitrogen, phosphorus, potassium, organic carbon etc. But, the nitrogen, phosphorous and potassium are the major nutrients effecting the primary productivity. These are so to say the factors affecting the rate of primary production (P.V.R. NAIR 1979). *Production depends on many factors* but the most important is usually the availability of the inorganic nutrients. Essential elements for plankton growth include carbon, oxygen, hydrogen, phosphorus, nitrogen, sulphur, potassium, sodium etc. Phosphorus is most often the element regulating phytoplankton growth in ponds. The addition of phosphate fertilizer will cause an increase in plankton production. Inadequate supply of nitrogen, potassium, and carbon also limit phytoplankton growth. *Nitrogen probably is the* limiting factor in brackish water ponds.

The pathway by which inorganic nutrients are recycled in overlying waters in ponds, after the first step of phytoplankton assimilation are poorly understood. The classical view has been that nutrients are recycled in the euphotic zone by bacterial assimilation of both phytoplankton and by mineralisation of both phytoplankton and plankton excretion products and by direct grazing on phytoplankton by microzooplankton. In recent years there has been considerable evidence that frequently the bulk of nutrient regeneration occurs among plankton.

As a result of much progress in biological oceanography, the study of the planktons has been considerably developed, and a good amount of work has been carried out in this line.

The present investigation was conducted at Narakkal near Cochin. Two experimental fish culture ponds were selected for the study. The main purpose of this study was to know the fertility rate and the productivity of the ponds. The data was collected for a period of four months from June to September, 1986 and the results of the investigation are presented in this text.

I express my deep sense of gratitude to Shri. C.P. Ramamirtham, Scientist and my supervising teacher, with whose valuable guidance, support and suggestion this work have been materialised.

My thanks are due to Dr. P.S.B.R. James, Director, CMFRI for providing facilities to work on this problem. I also thank Shri. S. Muthusamy, Scientist and Shri. R.V. Singh, Technical Assistant for their help at various stages of this work. I also thank my colleagues for their timely help during this dissertation time. Last but not least I thank the Indian Council of Agricultural Research for providing me with the Junior Research Fellsowship during the post graduate programme in mariculature.

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INTRODUCTION

The biological wealth of a culture pond is largely dependant upon the dissolved nutrients. Studies of the nutrients and associated plankton production, have been in progress for many years. The water, which is the habitat of the fishes and other aquatic organisms, is in close contact with the bottom sediment. The nutrient status of both water and soil play the most important role in governing the production of planktonic organisms in fish ponds and that must be understood while considering both quality and quantity of production (Banerjea 1967).

Investigations of soils and their characters have been carried out from early times by many workers. Among them are Mortimer (1941, 1942 & 1950); Meehean and Marzulli (1945(, Stangenberg (1949); Povoledo (1964) and Danielewski (1965); Fitzgerald (1970); Ansari (1974). The early works of Breest (1924), Trong (1930); Schaeperclaus (1933), and Burrocos and Cordon (1936) are also noteworthy.

The distribution of mud phosphate in Cochin backwaters was studied by Ansari and Rajagopal (1974).

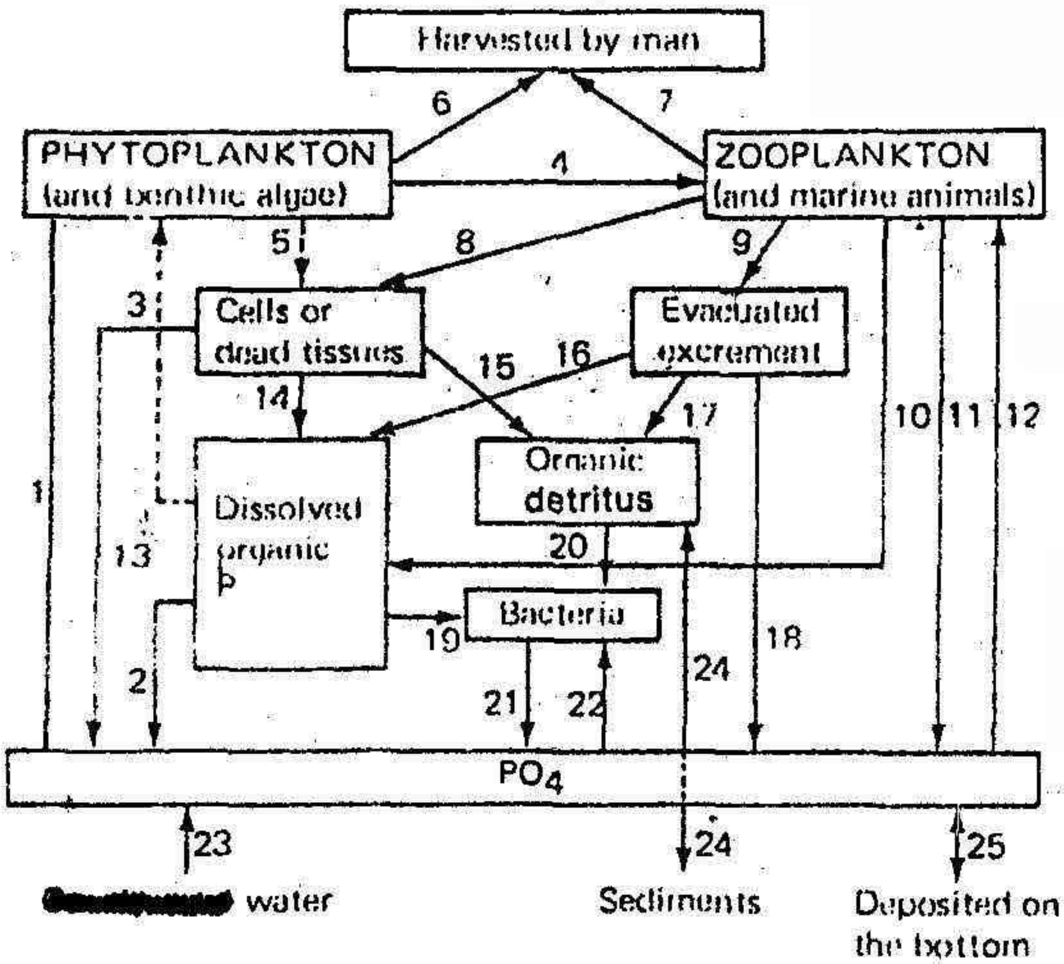
The total phosphate showed a wide variation from 258 to 1320 g/gm. of mud. It was high during monsoon and low in the pre and post monsoon periods.

Livingstone and Bogkin (1962) while studying the vertical distribution of phosphorous in Linsely pond state that sedimentary phosphorus is found largely by sorption reaction with mineral material and differences in lake productivity generally may be determined by sorption reactions in the surface mud strata. For any kind of sorption reaction the production would be inversely proportional to the sorptive capacity of the mud and for ion exchange it would also be directly proportional to the total alkalinity of the water.

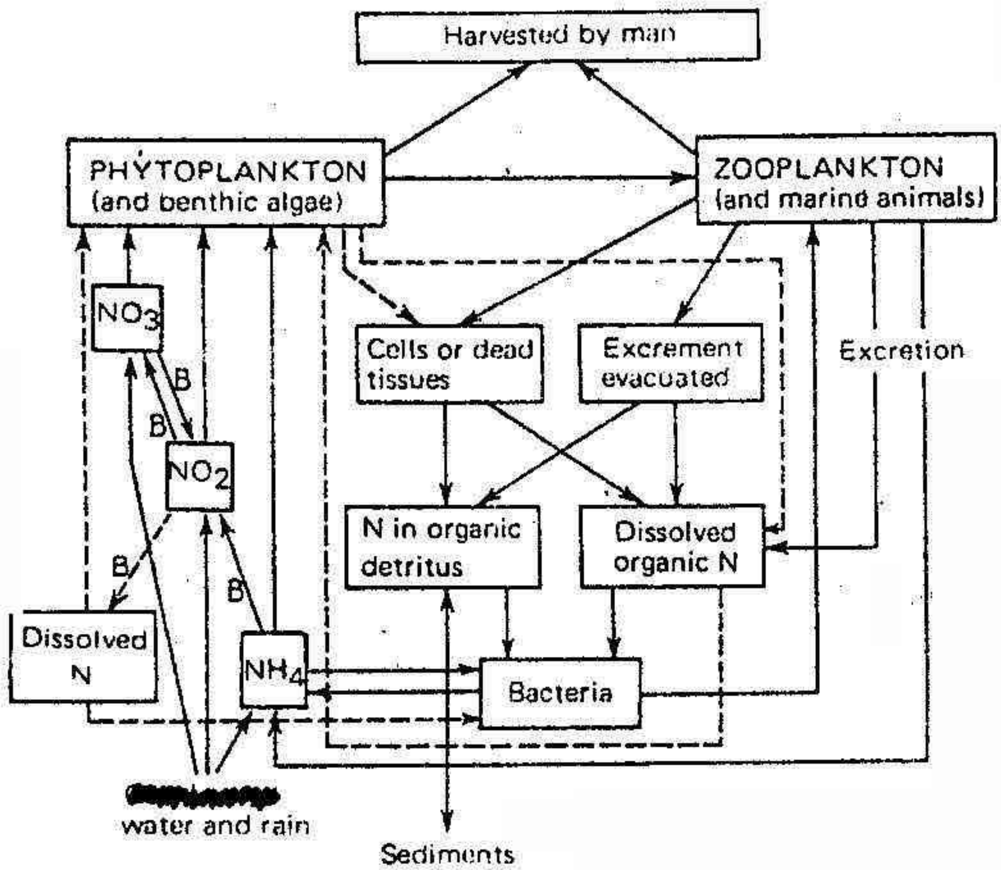
Kain & Fogg (1960) have stated that phytoplankton has to find the source of nitrogen in the marine environment and with the lack of nitrogen, growth is limited. The experiments of these authors using bacteria free culture of <u>Procentrum micans</u> give a detailed example of the requirements of phosphorous and the number of cells (no/m^3) after 23 days, was found to be proportional to the initial quantity of phosphate.

The Nitrogen and phosphorus cycle in the pond can be described diagramatically, (Fig. A). by (Kain & Fogg 1960)

PHOSPHORUS CYCLE IN PONDS.



. THE NITROGEN CYCLE IN PONDS.



Brondit theory that phosphate and nitrate may constitute the limiting factors in phytoplankton production has found proof in investigation of subsequent workers, Marshall and Orr (1927), Sctxiber (1927), Green (1930), Hentschel and Watternberg (1930) and others. The plankton community may vary according to the seasons also. George (1974) made an observation on the plankton of the Cochin backwaters. Seasonal fluctuations in the plankton biomass showed that the biomass was low during the monsoon months and very high in hot months. The zooplankton biomass was closely related to the salinity fluctuations.

Govind (1963) explained the preliminary studies on plankton of the Tungabadra reservoir. The qualitative study of phytoplankton, phosphate and nitrate showed that the rich rain washing of south - west monsoon seems to influence the production of plankton, much more than the north east monsoon.

The high temperature of the summer months was found to be less favourable to phytoplankton production in the reservoir.

Sundararaj and Krishnamoorthy (1970) have worked on the nutrients and planktons on the backwater and mangrove areas of Pichavarum mangrove forests.

Gopinathan (1972) made a study on seasonal abudance of phytoplankton in the Cochin backwater. The qualitiative and quantitative studies on the phytoplankton of the Cochin backwater showed that about 120 species of phytoplankton excluding nannoplankton commonly occur in the estuary. Of these 88 species of diatioms, 74 occur regularly and the rest 14 have been recorded for the first time from the Indian waters.

Two peaks of abundance were observed during the monsoon period (May to July) and other in the post monsoon period (September to October) in the backwater. The enrichment of water with nutrients largely occurs during the monsoon months. This seems to be the most important feature governing the quantitative abundance of the species. Not much work seems to have been done on the relations between Potassium and plankton productivity even though it is also involved in the plankton production.

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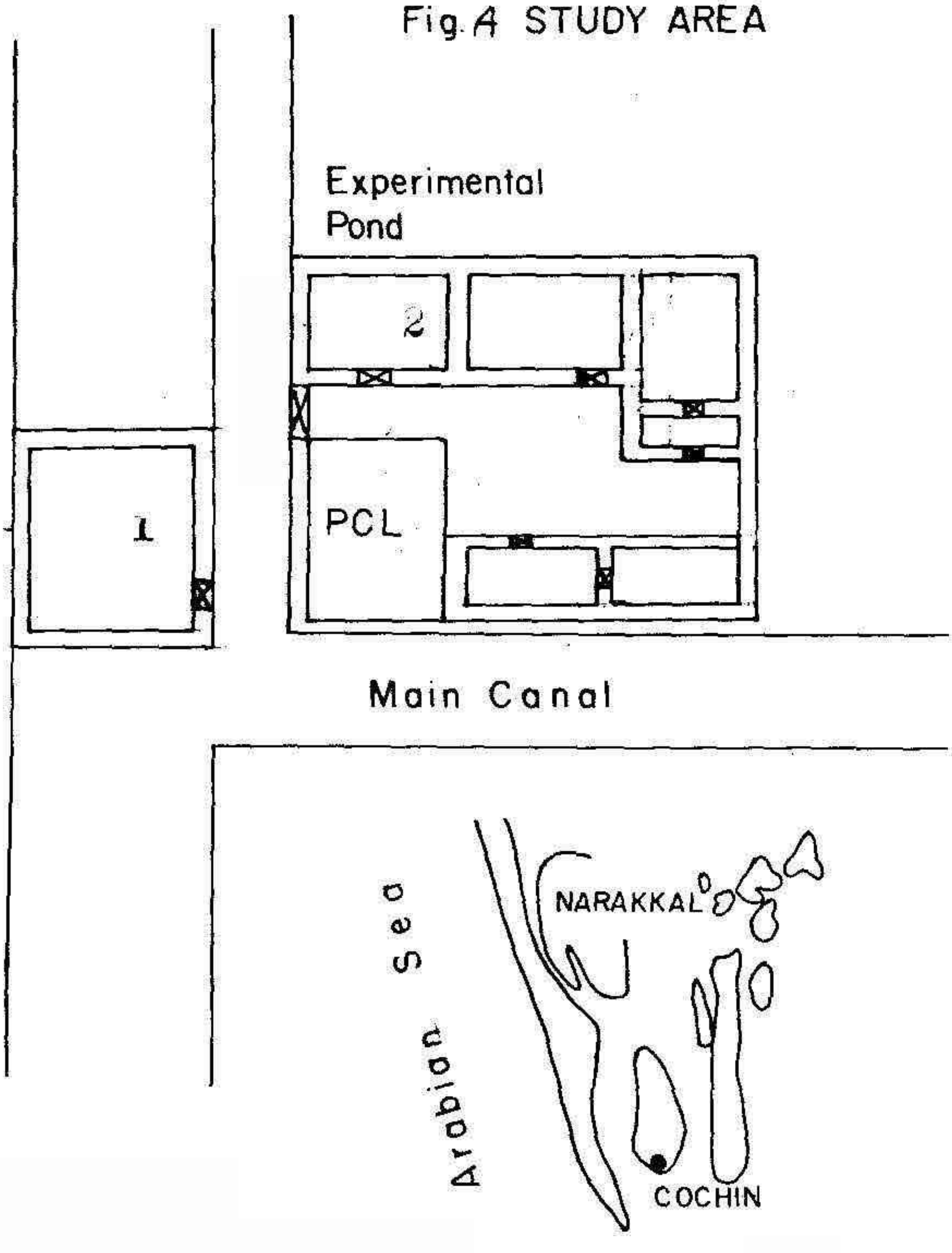
NARAKKAL POND-I

NARAKKAL POND-II

Fig. 4 STUDY AREA



MATERIALS AND METHODS

Studies on the Nitrogen, Phosphrous and Potassium of the Sediments and overlying water were carried out from two culture ponds in Narakkal(Fig A) Soil, Water and Plankton samples were collected monthly thrice and analysed for the following parameters.

In Sediments

1. Available Nitrogen
2. Available Phosphorus
3. Available Potassium
4. Sediment pH.

In Water

1. Nitrate - Nitrogen
2. Nitrite - Nitrogen
3. Reactive Phosphorus
4. Available Potassium

Then the environmental parameters such as:

1. Temperature
2. Salinity
3. pH
4. Dissolved Oxygen

In Plankton Samples

1. Phyto plankton biomass
2. Zoo plankton biomass

were estimated both qualitatively and quantitatively.

Collection of Soil Samples

The soil samples were collected using a Vanveen-grab of area 0.05 m^2. Bottom soils were taken from the four corners and centre of the ponds in each pond, and mixed throughly in a container before the samples were taken for analysis. Then, the samples were dried and powderered. This was used for the analysis.

Available Nitrogen on Sediments

Available Nitrogen was estimated colorimetrically. 5gm. of dry powdered soil with 100ml. distilled water was taken in a conical flask and this was shaken for one hour in a mechanical shaker. Then a pinch of (0.5gm.) copper sulphate was added, again shaked for a minute, and this was filtered and the filtrate extract was collected upto 50 - 100ml (accurately). From this 20ml. of the filtrate was taken in a china disc. Evaporated to dryness cooled and 2 - 3ml. of phenol disulphuric acid (mix 25 gm. of phenol crystals and 300ml. con. sulphuric acid warm upto

80°C and continue warming upto 5 - 6 hours; cool and keep separately), was added with the slow rotation of sides then waited for 10 minutes. 50ml. of distilled water was added to the disc and stirred well with glass rod and this was transferred to 100 ml. standard flask. Ammonia solution (1:1) was added till the solution turns yellow, then again 2 - 3 ml. of ammonia solution was added and this was made upto 100 ml. The colour intensity was measured by a colorimeter.

The procedure was repeated with 20 ml. of standard solution (0.722) gm. of AR potassium Nitrate in 1 litre of distilled water) and for 5 sub standards, and the calibration graph with OD on the 'Y' axis and concentration on the 'X' axis was drawn.

From the measured OD of the sample, inter polated its concentration in ppm using the calibration graph. [ESWARAN 1980]

Available Phosphorus on Sediments

The available phosphorus was determined colorimetrically using spectro photometer. 5 gm. of soil was taken, added one gram of activated charcoal and 100 ml. of olsen extracting reagent, (0.5 M Sodium Bicarbonate, 12 gm/L and adjust the pH to 8.5) and this was kept in the mechanical shaker for 30 minutes, filtered and then the filtrate was collected. The filtrate was used to determine the phosphate colorimetrically against 660μ filter.

5ml. of soil extract was pipetted out into a conical flask and to this 5 ml. of D & B reagent (15 gm. Ammonium molybdate dissolved in 300 ml. water warm upto 60°C and to this add 350 ml. of 10 N HCl and make upto 1 Litre) was added, then the sample was diluted to 22 ml. Added 1 ml. of diluted Stannous chloride, (Dissolve 10 gm. of stannous chloride in 25 ml. concentrated Hcl by warming and store in amber coloured bottle and before use dilute 1 ml. above to 66 ml.) and made upto 25 ml. Then the colour intensity was measured within five minutes.

For phosphate standard, 0.4390 gm. potassium dihydrogen phosphate in 100 ml. distilled water, 25 ml. of 7 N. Sulphuric acid was added and then made upto 1000 ml. From this 100 ppm solution, different sub standards were prepared (2, 5, 10, 20, 30, 50 and 70 ppm).

Same procedure was followed for the colour development for standard also. Repeated the procedure for all standards and the calibration curve with OD on 'Y' axis and the concentration on the 'X' axis, was drawn.

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From the measured OD of the sample its concentration was determined from the calibration curves. [OLSON 1954]

Available Potassium on Sediments

Available potasium was estimated by ammonium acetate extraction. 5gm. soil was added to 25 ml. of 1 N Ammonium acetate solution in an erlenmyer flask and shaken well in electric shaker for half an hour. The solution was then filtered and the filtrate was used to determine the available potassium with the help of an Elico digital flame photo meter; model CL-22D using the respective filters.

In this flamephotometer the sample combined with air and gas premixture is sprayed into a high temperature flame. The emitted photon energy is directed over a photo sensitive device, which is measured over a meter. The meter is calibrated with standard solutions and the concentrains of unknown samples were interpolated using a Calibration curve. (Dean. 1960).

Sediment pH

The dry soil pH was determined using the method by Bear (1964) using an elico digital pH meter, model LI-120. 10 gms. of the soil was weighed into a 50 ml. beaker and 10 ml. deionished water was added, the mixture was stirred intermitantly for one hour. Then the pH was determined by a pH meter.

The water samples were analysed for the following parameters.

1. Salinity
2. pH
3. Dissolved Oxygen
4. Temperature
5. Nitrate
6. Nitrite
7. Reactive phosphorus
8. Available potassium-

Salinity by Knudsen method 10-CC of standard sea water was pipted out into a 250 CC conical flask, then 4 drops of potassium chromate (10 gm. in 100 CC) solution was added and using a mechanical stirrer titrated against silver nitrate solution (24.5gm/litre). Repeated to concordance. Pipetted out 10 CC of pond water into the conical flask and proceeded as above. From the titre values salinity is calculated.

Water pH

The water pH was determined immediately after collecting the samples with the help of an elico digital pH meter model LI-120.

Dissolved Oxygen:

Dissolved oxygen was estimated in both the culture* ponds by Winkler method.

The water samples were collected in 125 ml. glass stoppered bottle without entangling any air bubbles. Took out the stopper and added 1cc each of winkler A & B (winkler A - 20 gms. of Mncl2 in 100ml. of water; winkler B - 41 gm. of NaoH + 25 gms. of KI. in 100cc water), solution and closed the bottle. Shook the bottle gently till the precepitate formed is evenly distributed, allowed the sample to settle, then added 2 ml. con Hcl. closed the bottle and gently shook till the precipitate is completely dissolved.

10 ml. of standard potassium Iodate (Accurately weigh 0.1784 gm. potassium Iodate into a 1 litre volumetric flask and dissolve and make up to 1 litre this is 0.005N) solution was pipetted out, and then one gram of KI was added and 2ml. con. Hcl was added, this was diluted to 100ml and then titrated against sodium thio sulphate solution (1.25 gms. in 1 litre).

When the colour becomes pale yellow 1 ml. of starch solution (1 gm. of starch made into a paste with distilled water and diluted to 100cc, boiled and kept.) was added and the sample was shaken well and the titration was continued till the blue colour disappears. Repeated to concordance.

Pipetteout 100 ml. of preserved sample and titrate against standard sodium thio sulphate as above.

Calculations

The normality of thiosulphate was calculated like this

$$= \frac{N1 \times 10}{\text{Titrate value for 10 ml. of potassium Iodate}} = N2$$

Hence amount of Dissolved Oxygen in ml. / litre

$$= \frac{\text{ml thio} \times N2 \times 8 \times 1000 \times R}{100 \times 1.429}$$

Where (1.429 being weight of 1 ml. of O_2 in Mgs. R-is known as correction factor equal to 1.01)

The Nutrients in water samples were estimated by Strickland and Parsons method (1965). The water samples were collected in 1 litre polythene bottles and after collection that the water samples were filtered immediately with Whatman No.42 paper and frozen until analysis which was carried out after a few hours. Before analysis water samples were brought to ambient room temperature.

Temperature

Temperature was measured using a centigrade thermometer.

Planktons

Plankton was collected using a small conical net (length 50cm. mouth diameter 14.5 cm, Caudal end diameter 3.25 cm.) suitable for shallow water areas. Immediately after collection the plankton samples were preserved in 5% formalin and was examined in the laboratory and were quantitatively estimated by plankton counting chamber.

Nitrate, Nitrite Nitrogen in Water Samples

In water, the Nitrate and Nitrite were estimated adopting standard procedures as given by Strickland and Parsons (1965).

50 ml. of water sample was measured into a 250 CC conical flask when the sample has acquired room temperature. Added 2 ml. of buffer reagent (25 ml. of phenol solution into a dry beaker and add 25 ml. of NaoH) and mixed. After the buffer has been added to all the samples, added with rapid mixing 1.0ml. of reducing agent (mix 25 ml. of copper sulphate solution and 25 ml. of hydrazine sulphate solution

and this solution is stable for one hour). The flasks were kept away from the sun light in a dark place for about 20 hours. Then added about 20 ml. of acetone and after 2 minutes but not later than 8 minutes add 1 ml. of NNED solution and mixed. Compared the colour with standard potassium Nitrate solution treated similarly, using a Spectrophotometer.

For Nitrite, 50ml. of water sample was collected, then one ml. of sulphanilamide solution was added to each sample. After two minutes but not later than eight minutes added 1 ml. of NNED solution to each and mixed immediately. Carried out the procedure with standard Nitrite solution also. Compared the colour using a Spectrophotometer.

Standards 0.345gm. of AR Sodium Nitrite in 1000 ml. of distilled water, stored in a dark bottle with 1 ml. of chloroform. 1 ml. = 5 μ g. at. Diluted 10 ml. of the solution to 100 ml. with distilled water and used for analysis.

Reactive Phosphorus

The water Samples are to be collected in polythene bottles of roughly 150 ml. capacity and analysis is to be carried out within an hour of collection. If the analysis is to be delayed the samples must be frozen and can be kept for months together.

100 ml. of sample at the laboratory temperature was mixed with 10 ± .5ml. of mixed reagent (mix together 100 ml. of Ammonium Molybdate, 250 ml. of Sulphuric acid, 100 ml. of Ascorbic acid and 50 ml. of Antimony tartarate solution). Mixed well and the solution can be kept for 6 hours. After 5 minutes and preferably within the first 2 - 3 hours measured the extinction of the solution, in a 10 centimeter cell against distilled water at a wave length of 885 A units.

Warmed another portion of the sample to laboratory temperature in a thermostat water bath and measured the extinction of the sample by substracting both the turbidity and reagent blank. Calculated the phosphate concentration inmicrogram atoms of Phosphate phosphorus per litre.

Phosphate Standard:

Dissolved accqurately 0.816 gm. of unhydrous potassium dihydrogen phosphate in 1000 ml. of distilled water. Stored in a dark bottle with 1 ml. of chloroform. 1 ml. of the solution = 6 microgram atom phosphate phosphorus. Out of this solution 5 ml. is taken and diluted to 100 ml. From this 5 ml. is taken and diluted to 100 ml. 100 ml. sample is taken in a conical flask, and 10 ml. of mixed reagent is added to the standard and sample. After 10 minutes the colour comparison of these 2 solutions were made using a

Spectrophotometer.

The strength of the colour developed being proportional to amount of phosphate concentration in sample, the phosphate concentration is calculated from the OD'S of standard and samples.

For potassium in water, the same method as in sediments was followed.

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RESULTS AND DISCUSSIONS

The time distribution pattern of water characteristics in the culture ponds such as temperature, salinity etc. are presented in figure 1 to 10. Considering the temperature variations it can be noted that more or less uniform trend is maintained during the various part of the investgational period and the water was quite warm during the period in Pond 1 (Fig. 1). But in Pond II fluctuations could be observed (Fig. 2). The maximum being in early June and the minimum during peak monsoon. The atmospheric temperature was uniformly lower than the water temperature.

Salinity fluctuations in the ponds during June to September are more or less similar (Fig. 3). The effects of the monsoon precipitation in reducing the salinity values were not so conspicuous as it should have been, since the monsoon was of a highly fluctuating nature during this year. Except for an increasing trend during September (Values 7 - 7.5 ppt) the time distribution was more or less uniform.

During the monsoon the dissolved oxygen contents in the ponds were low (Fig. 4). In pond II two minima could be observed, one in monsoon and another in post

WATER ANALYSIS

TEMPERATURE - POND - I °C

SAMPLES	ATMOS. TEMP.	WATER TEMPERATURE
1	30°C	29°C
2	27°C	29°C
3	25.5°C	28°C
4	27°C	29°C
5	27.5°C	29°C
6	27.5°C	29°C
7	26.5°C	29°C
8	26.2°C	29°C
9	26.5°C	29°C
10	24°C	26°C
11	24°C	27°C

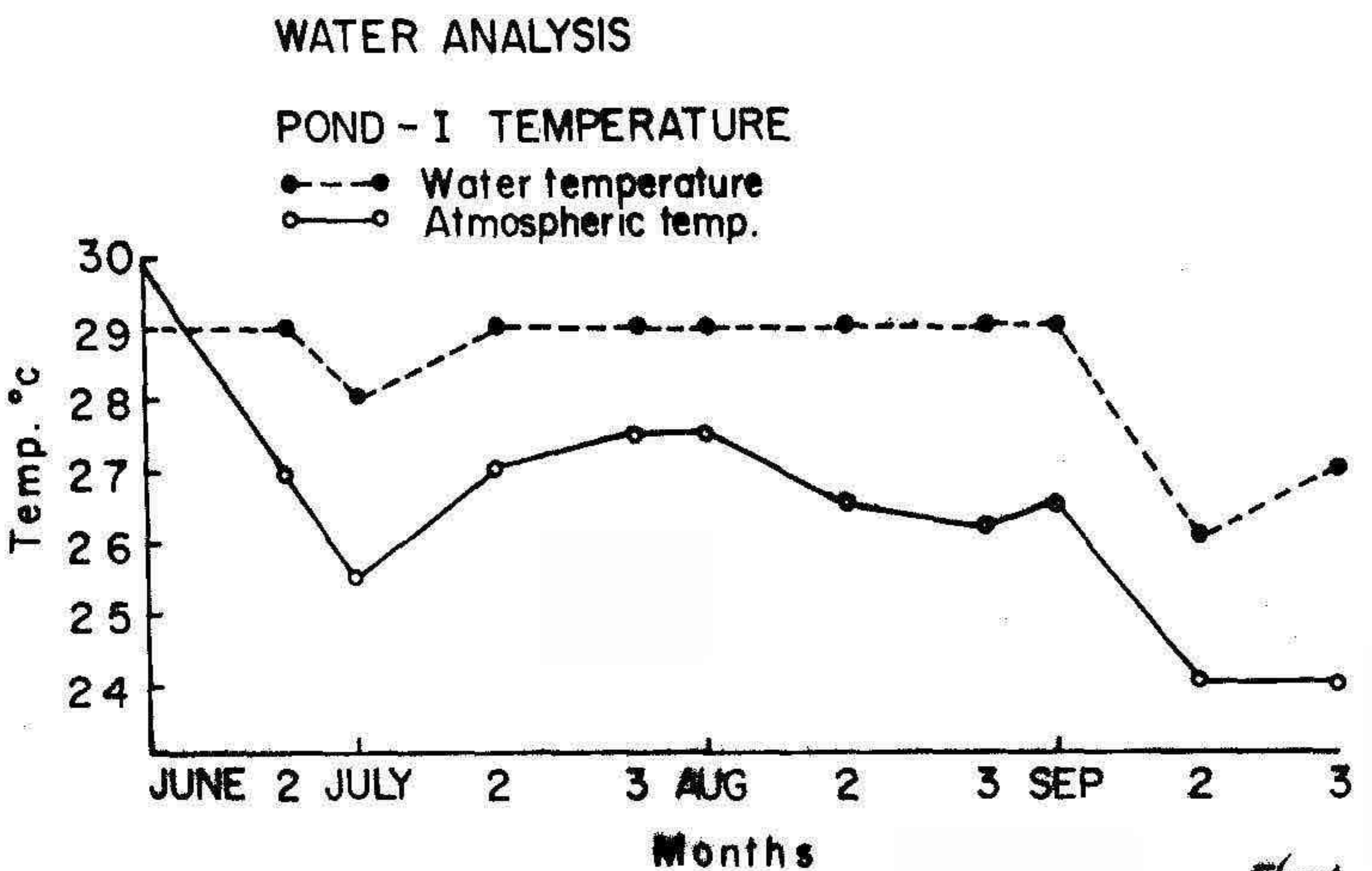

WATER ANALYSIS
POND - I TEMPERATURE
Water temperature
Atmospheric temp.
Temp. °c
30
29
28
27
26
25
24
JUNE 2 JULY 2 3 AUG 2 3 SEP 2 3
Months

Fig.1

WATER ANALYSIS

TEMPERATURE - POND - II °C

SAMPLES	A. TEMPERATURE	H_2O TEMP.
1	28°C	31°C
2	26.5°C	29°C
3	26.5°C	29°C
4	28°C	30°C
5	27°C	29.5°C
6	26.5°C	28°C
7	27°C	29.5°C
8	26.5°C	30°C
9	33.5°C	30°C
10	26°C	28°C
11	24°C	28°C

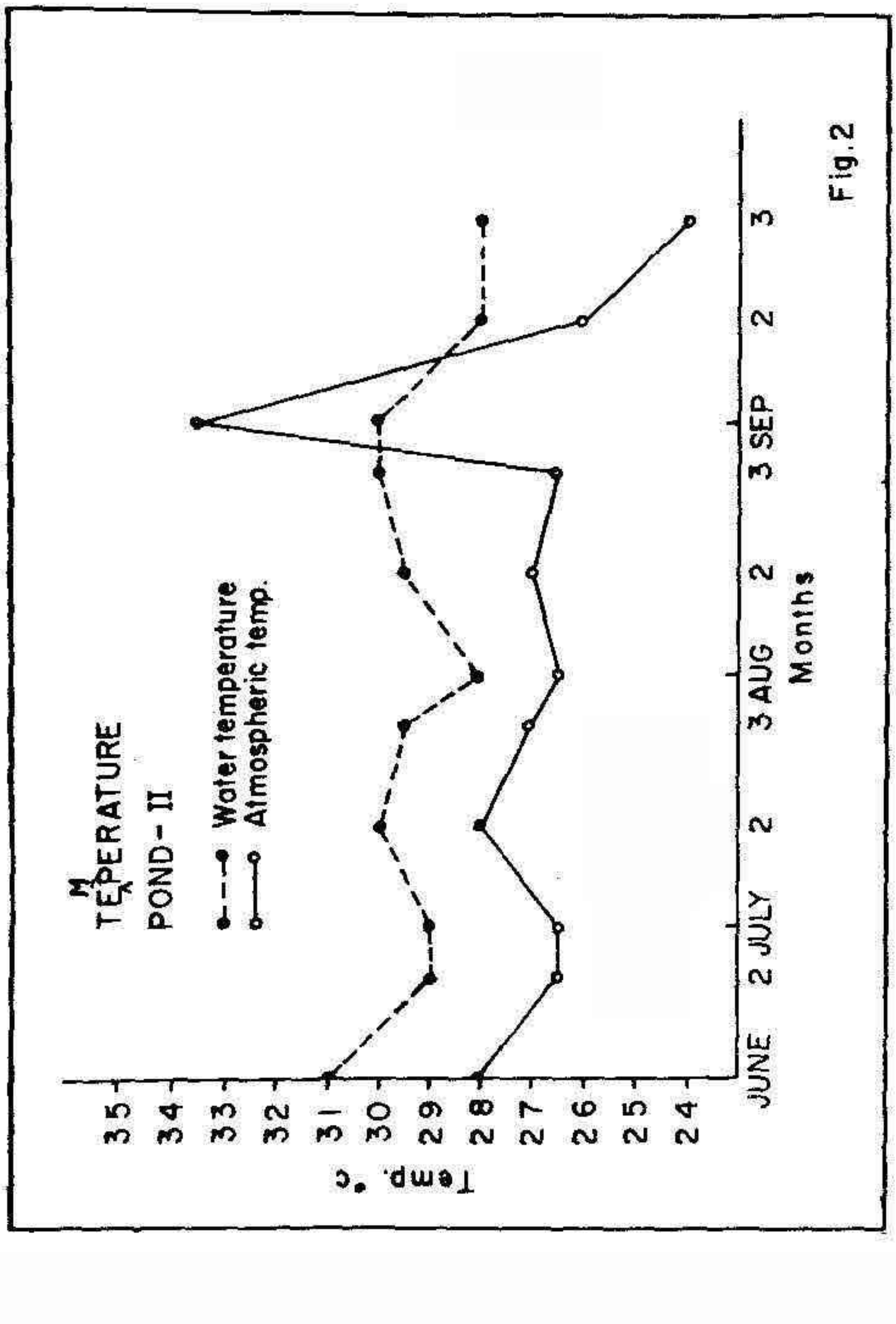

TEMPERATURE
POND - II
Water temperature
Atmospheric temp.
Temp. °c
35
34
33
32
31
30
29
28
27
26
25
24
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig.2

WATER ANALYSIS - SALINITY (PPt)

SAMPLES	POND - I	POND - II
1	5.02	6.10
2	5.02	6.10
3	3.96	5.96
4	4.12	5.16
5	4.48	5.11
6	3.96	5.16
7	4.12	4.94
8	2.24	3.14
9	7.55	6.48
10	6.5	5.84
11	4.49	4.94

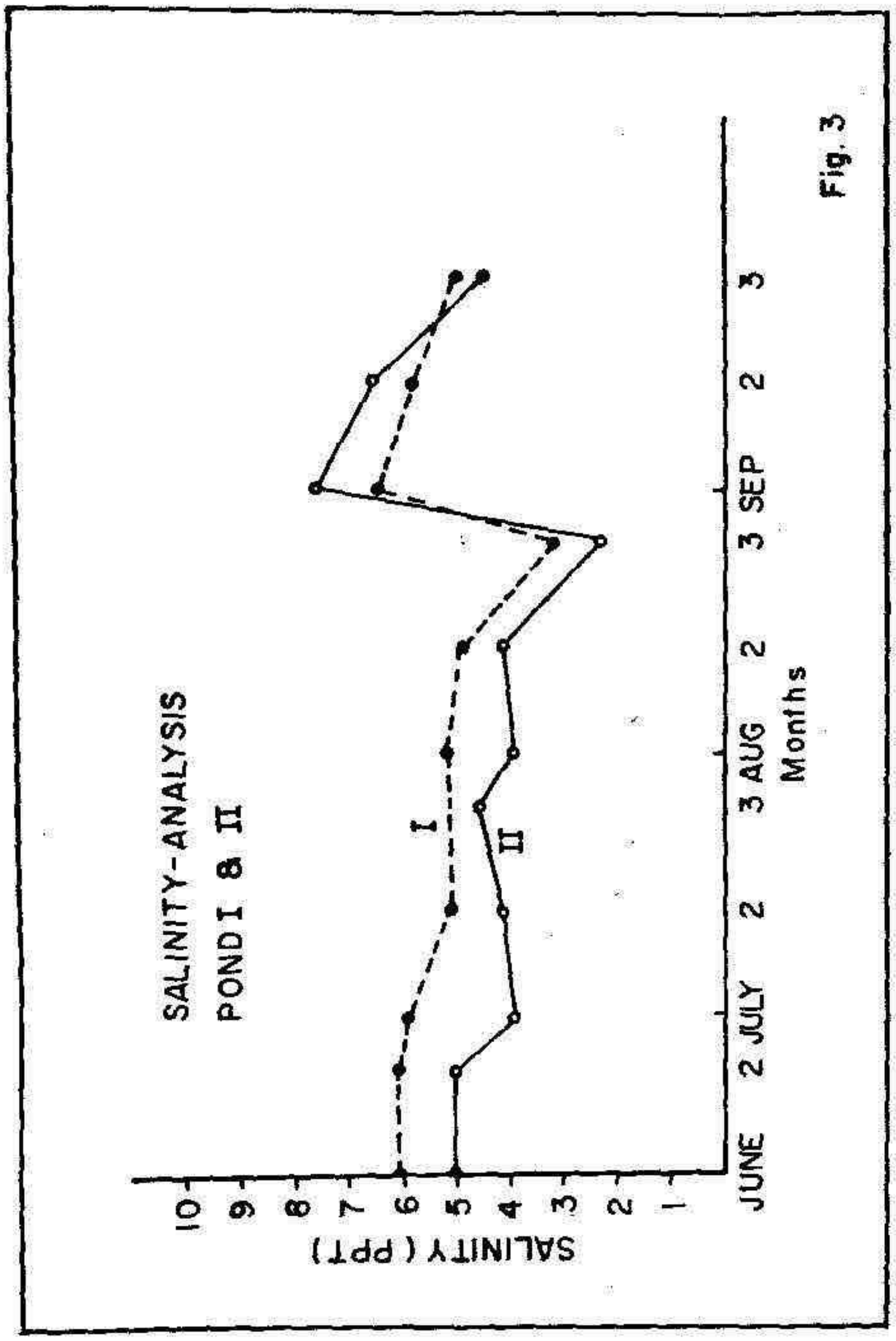

SALINITY-ANALYSIS
POND I & II
I
II
SALINITY (PPT)
10
9
8
7
6
5
4
3
2
1
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 3

WATER ANALYSIS - DISSOLVED OXYGEN (ML/L)

SAMPLES	POND - I	POND - II
1	3.50	3.45
2	3.55	3.66
3	2.74	1.96
4	2.78	2.006
5	2.70	1.130
6	2.78	2.71
7	3.55	2.78
8	4.30	2.414
9	4.27	4.04
10	2.78	2.71
11	3.41	2.45

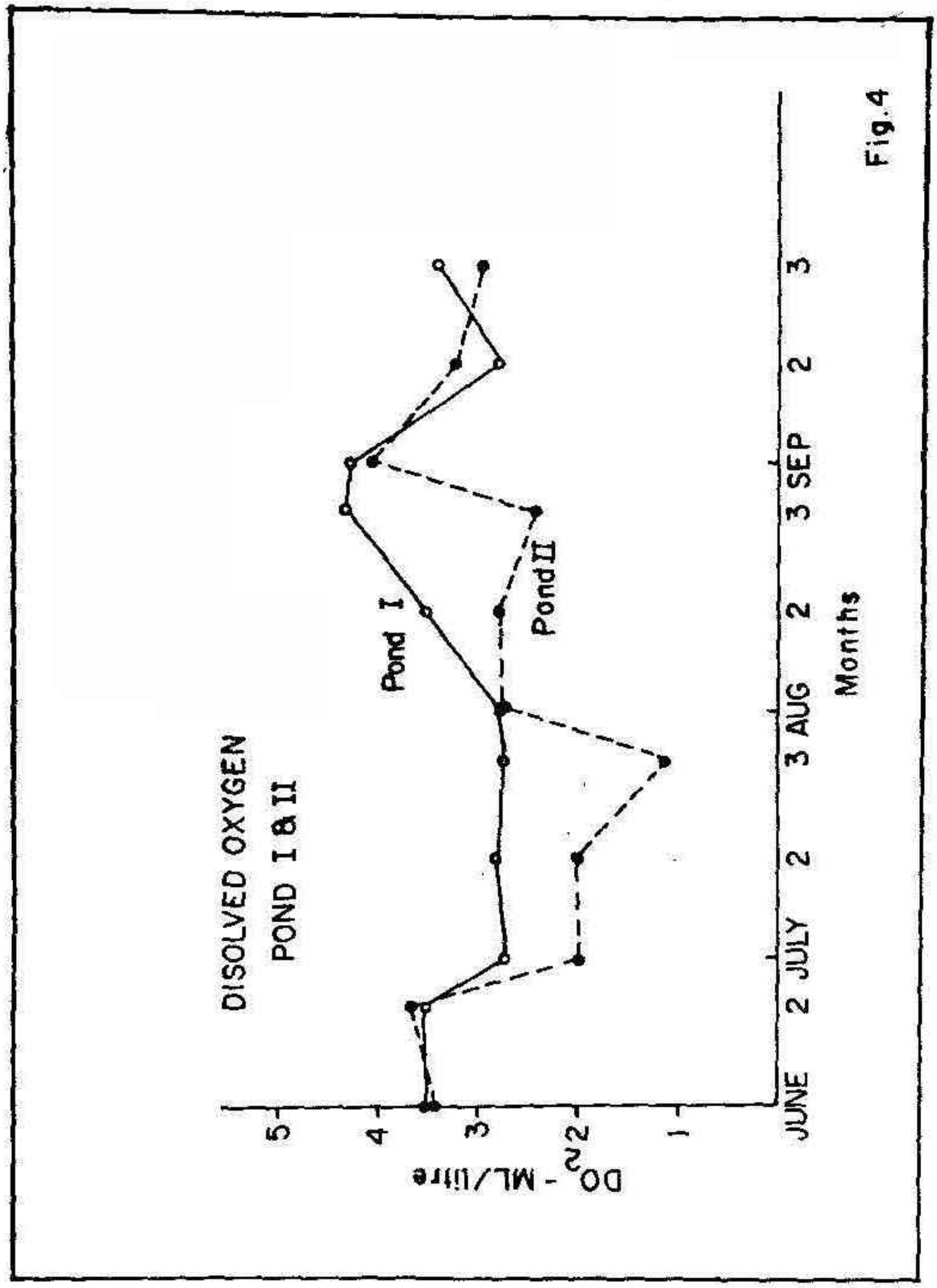

DISOLVED OXYGEN
POND I & II
Pond I
Pond II
DO2 - ML/litre
5
4
3
2
1
JUNE
2
JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig.4

WATER ANALYSIS

PH

SAMPLES	POND - I	POND - II
1	6.5	6.5
2	6.15	6.15
3	6.8	7.0
4	6.5	7.0
5	7.67	7.8
6	7.65	7.8
7	7.6	7.6
8	7.65	7.69
9	8.09	7.81
10	7.5	7.52
11	7.07	7.45

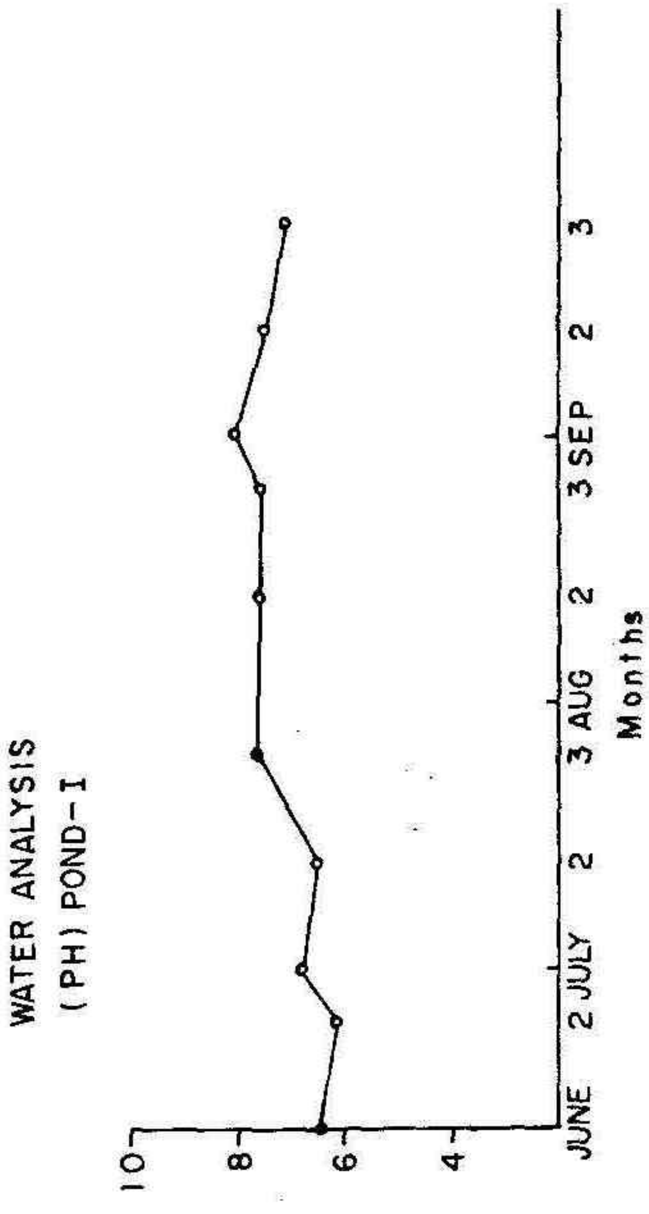

WATER ANALYSIS
(PH) POND-I
10
8
6
4
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 5

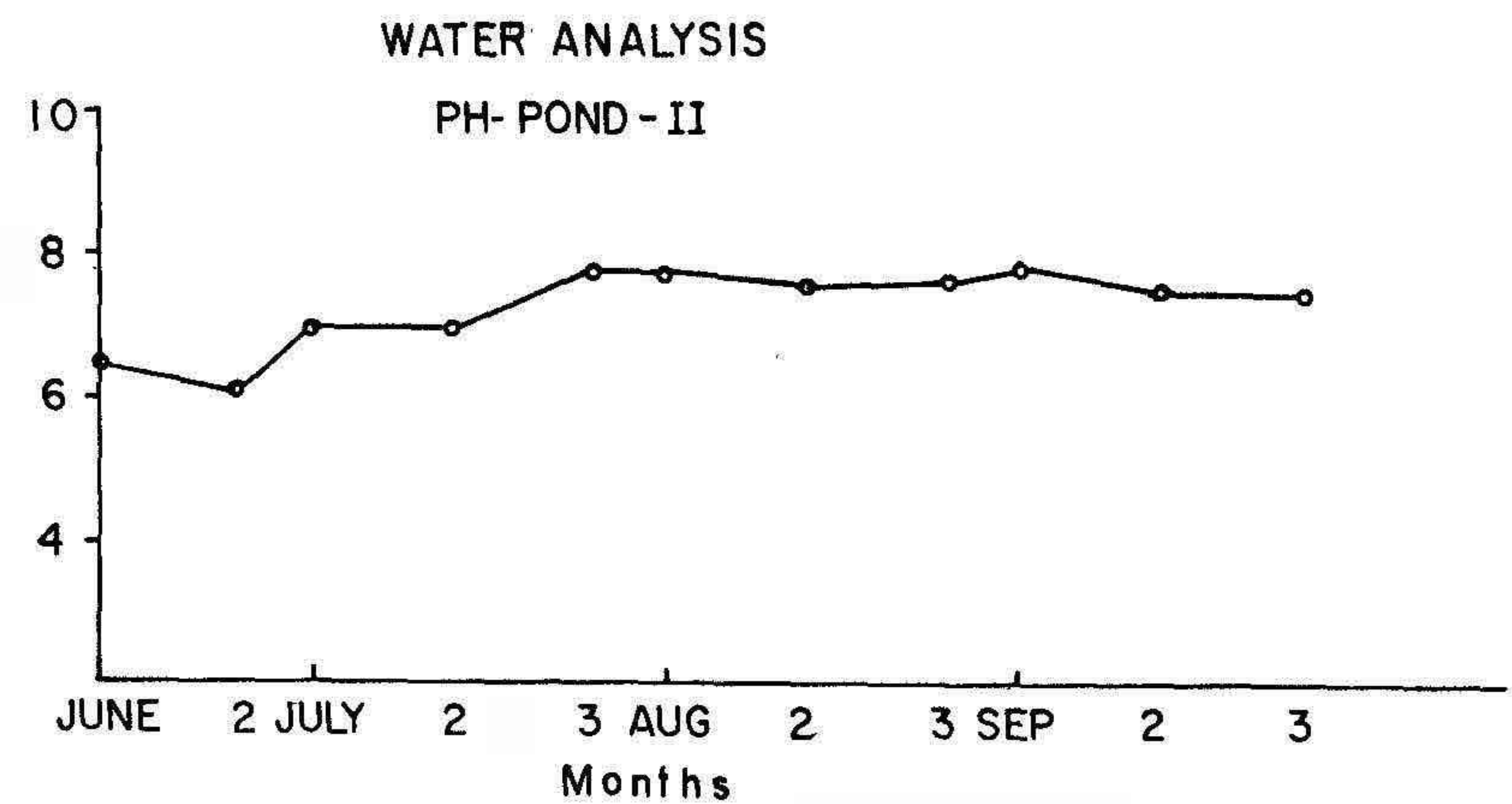

WATER ANALYSIS
PH- POND - II
10
8
6
4
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig.6

WATER ANALYSIS -

NITRITE - Mg at No.2 N/Litre

SAMPLES	NARAKKAL POND I	POND - II
1.	1.96	1.52
2.	3.91	4.57
3.	1.96	1.52
4.	4.13	4.57
5.	3.91	1.52
6.	1.30	1.74
7.	1.52	3.91
8.	1.74	4.57
9.	0.87	1.30
10.	1.09	1.52
11.	11.74	8.48

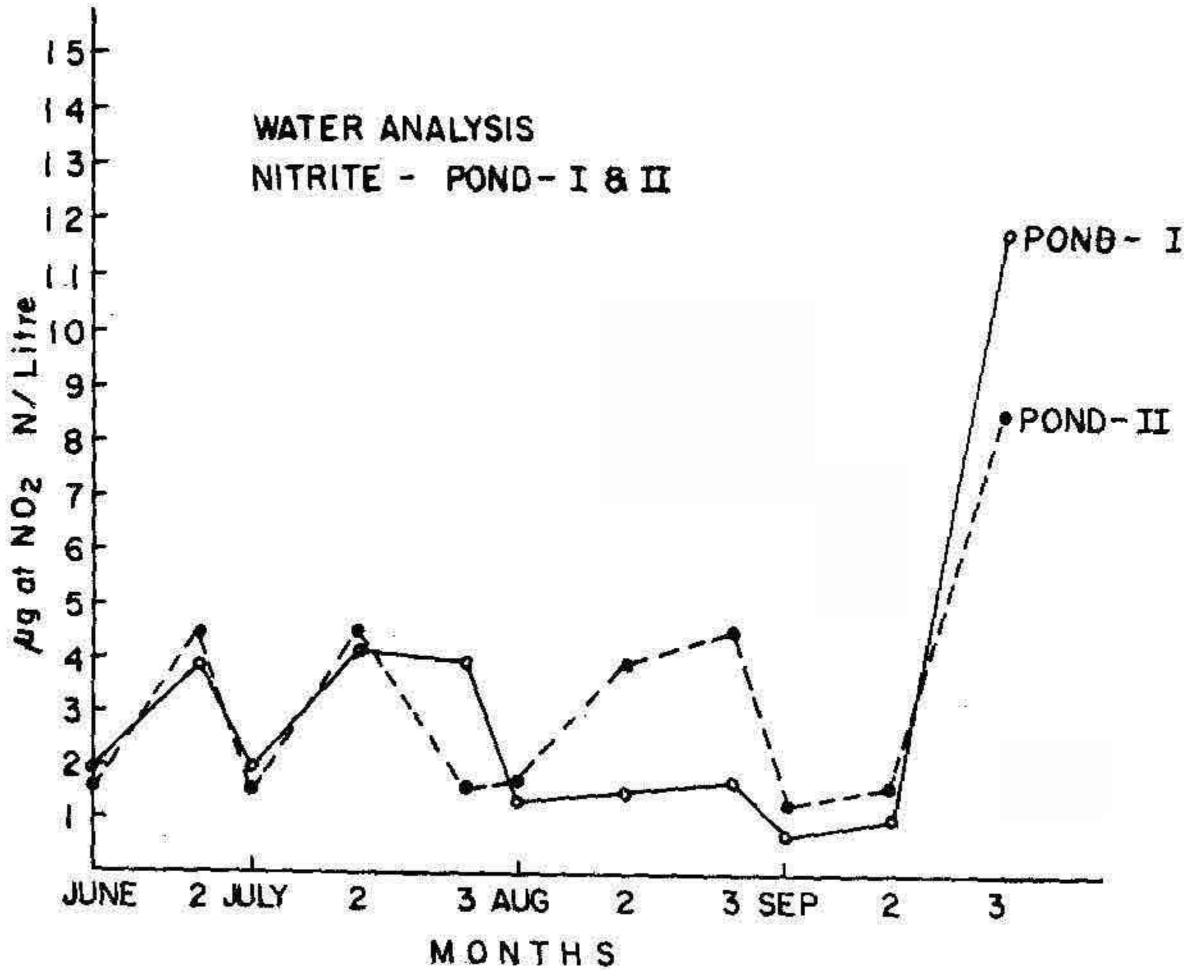

WATER ANALYSIS
NITRITE - POND - I & II
POND - I
POND - II
µg at NO2 N/Litre
1
2
3
4
5
6
7
8
9
10
1.1
12
13
14
15
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
MONTHS

Fig. 7

WATER ANALYSIS

NITROGEN - (NITRITE & NITRATE)

NITRATE (Mg at No_3 - N/litre)

SAMPLES	MARAKKAL POND - I	POND - II
1.	16.85	12.17
2.	19.66	18.72
3.	18.72	6.55
4.	8.42	12.17
5.	6.55	4.67
6.	6.55	6.55
7.	8.42	8.42
8.	7.48	11.23
9.	4.67	8.42
10.	4.67	6.55
11.	19.66	18.72

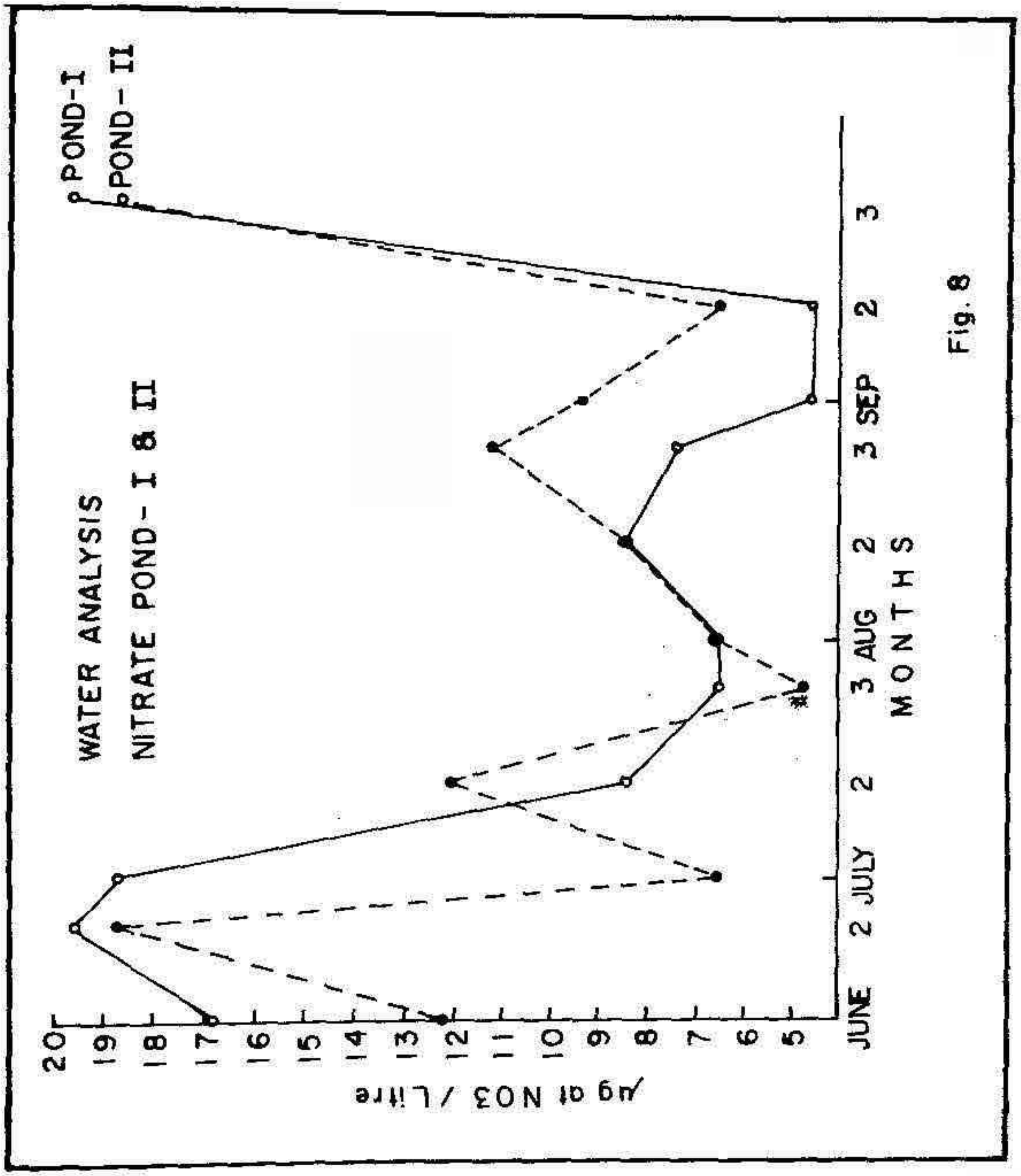

WATER ANALYSIS
NITRATE POND - I & II
POND-I
POND-II
µg at NO3 / Litre
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
MONTHS

Fig. 8

monsoon and the maximum was observed, during beginning of September. In general Pond I contained more of dissolved oxygen than Pond II.

The time distribution patterns of pH in the ponds are represented in Fig. 5 and 6. It can be observed that during the earlier half of the monsoon period the pH was mostly on the acid side and during the latter half on the alkaline side.

The time variations of nitrite - nitrogen, nitrate - nitrogen, available phosphorus and available potassium are presented in figures 7 to 10. During the monsoon the nitrate values exhibited 3 maxima (Fig 7) and during the post monsoon a conspicuous increase occured. Since the ponds are similarly affected by the waters of the main connecting canal, the distribution patterns in both the ponds were comparable. In general the nitrite values were low during the monsoon.

A different trend is exhibited by nitrate in the sense that the values are much higher than nitrite, the periods of the minima were comparable in both the nutrient distribution patterns, (Fig 8).

WATER ANALYSIS -

Available Phosphorus - Mg at PO_4P/L

SAMPLES	POND - I	POND - II
1.	0.50	0.57
2.	0.48	0.67
3.	0.48	0.74
4.	0.53	0.65
5.	0.45	0.53
6.	0.48	0.57
7.	0.50	0.53
8.	1.48	0.57
9.	0.15	0.20
10.	0.18	0.32
11.	0.18	0.33

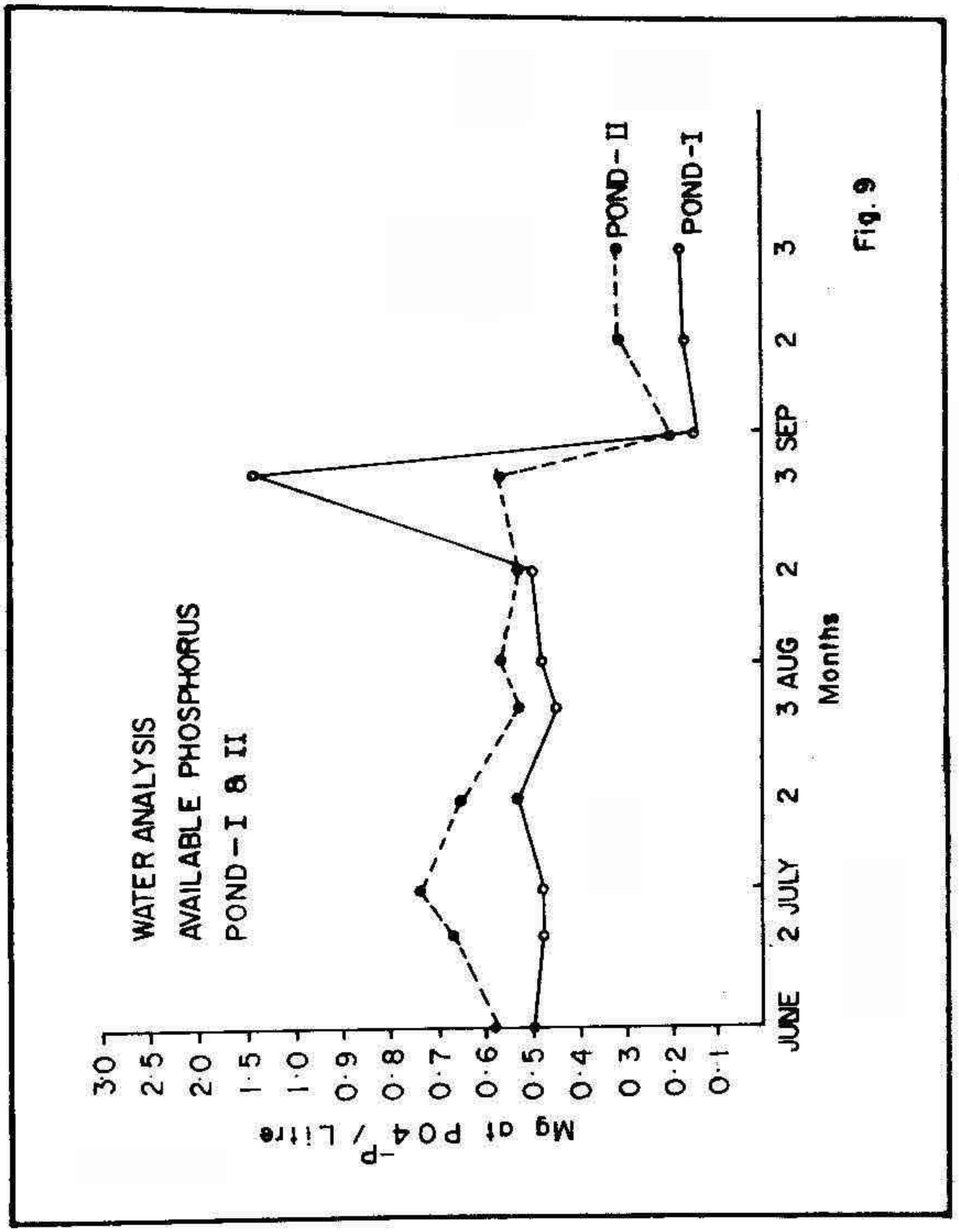

WATER ANALYSIS
AVAILABLE PHOSPHORUS
POND – I & II
Mg at PO4 -P / Litre
3·0
2·5
2·0
1·5
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months
POND – II
POND – I

Fig. 9

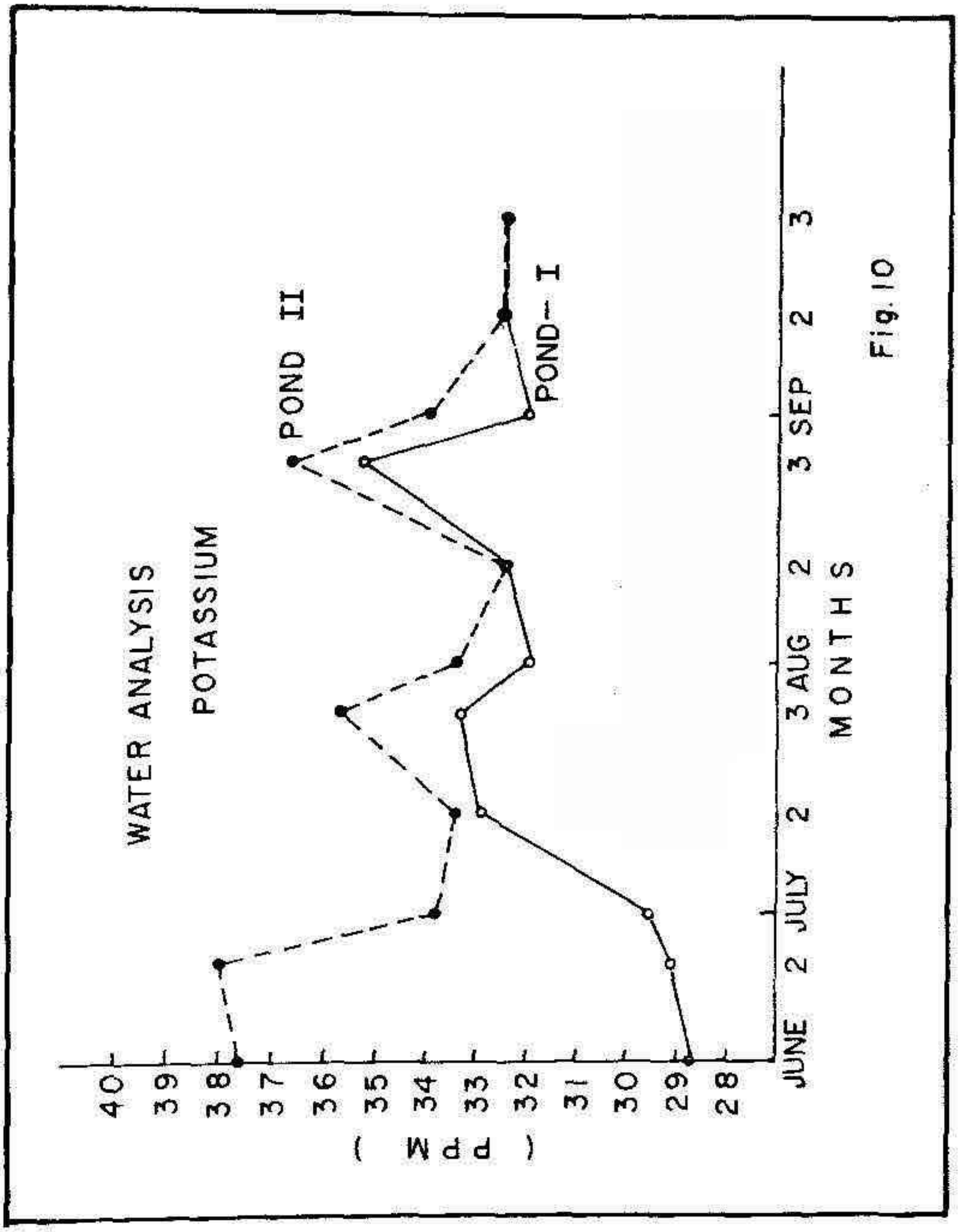

WATER ANALYSIS
POTASSIUM
POND II
POND– I
(PPM)
40
39
38
37
36
35
34
33
32
31
30
29
28
JUNE
2
JULY
2
3 AUG
2
3 SEP
2
3
MONTHS

Fig. 10

SEDIMENT ANALYSIS

(PH)

SAMPLES	POND - I	POND - II
1	6.6	6.16
2	7.46	7.18
3	6.43	8.2
4	7.33	6.46
5	6.78	7.7
6	5.46	7.4
7	5.82	7.24
8	5.46	7.25
9	6.90	6.96
10	6.4	7.85
11	7.09	8.05

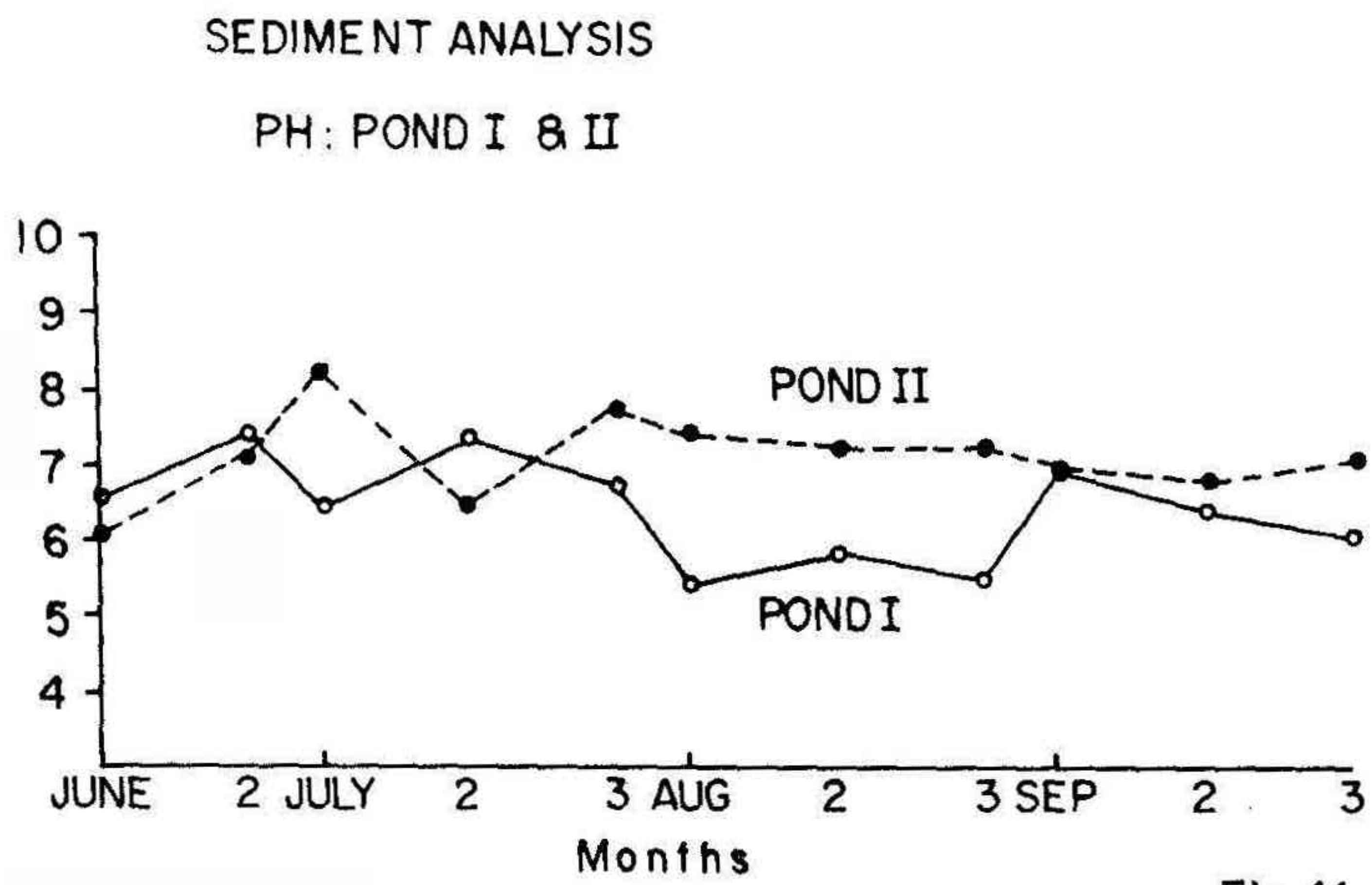

SEDIMENT ANALYSIS
PH: POND I & II
10
9
8
7
6
5
4
POND II
POND I
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 11

AVAILABLE NITROGEN IN PPM

SAMPLE	POND - I	POND - II
1	8000	3500
2	7700	2600
3	5200	2600
4	8000	3500
5	7700	2600
6	7600	3200
7	7800	2800
8	7300	3800
9	8000	2600
10	6100	3200
11	8000	3800

SEDIMENT ANALYSIS

AVAILABLE NITROGEN - %

SAMPLES	POND - I	POND - II
1	0.80%	0.35%
2	0.77%	0.26%
3	0.52%	0.26%
4	0.80%	0.35%
5	0.77%	0.26%
6	0.76%	0.32%
7	0.78%	0.28%
8	0.73%	0.38%
9	0.80%	0.26%
10	0.61%	0.32%
11	0.80%	0.38%

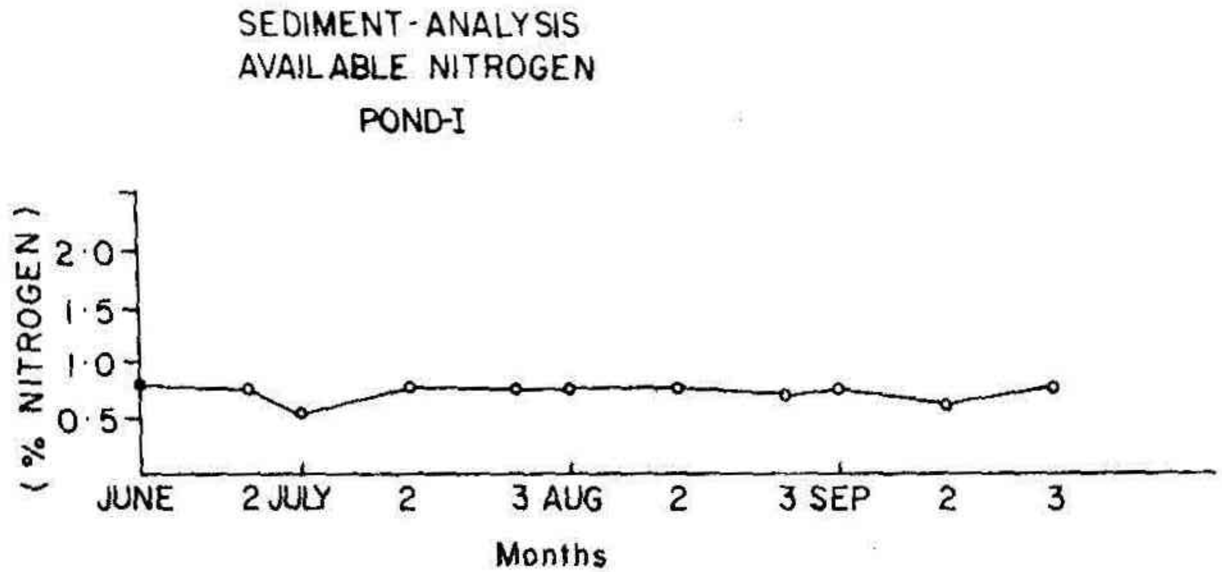

SEDIMENT - ANALYSIS
AVAILABLE NITROGEN
POND-I
(% NITROGEN)
2·0
1·5
1·0
0·5
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 12

The seasonal distribution of available phosphorus (Fig 9) showed minimum fluctuations during the monsoon. The maxima were exhibited by the two ponds during the fag end of monsoon and another minimum followed during the post monsoon.

If all the water properties available potassium exhibited maximum fluctuations especially during the monsoon. The maximum of 38 ppm occured during the onset of monsson in Pond II and two other maxima were also observed by peak monsoon, where as in Pond I the minimum occur during the onset of monsoon. Except for the latter, the distribution pattern of available potassium in both the ponds were more or less similar.

Considering the analytical properties of the bottom sediments in the investigational ponds, the comparable nature of the ponds was again observed. The seasonal distribution patterns are given in figures 11 to 17. The pH distribution in Pond II showed a maximum during July, and during fag end of monsoon and post monsoon the sediments appeared to be neutral. Unlike the above, the sediments in Pond I were mostly acidic during peak monsoon. A uniform trend is maintained in Pond I (Fig 12) as far as the distribution of available nitrogen is concerned.

WATER ANALYSIS

AVAILABLE POTASSIUM Mg/at/litre

SAMPLE	POND - I	POND - II
1	73.49	96.18
2	74.69	97.39
3	75.90	86.64
4	84.24	85.44
5	85.44	91.40
6	81.86	85.44
7	83.06	83.06
8	90.20	96.18
9	81.86	84.24
10	83.06	83.06
11	83.06	83.06

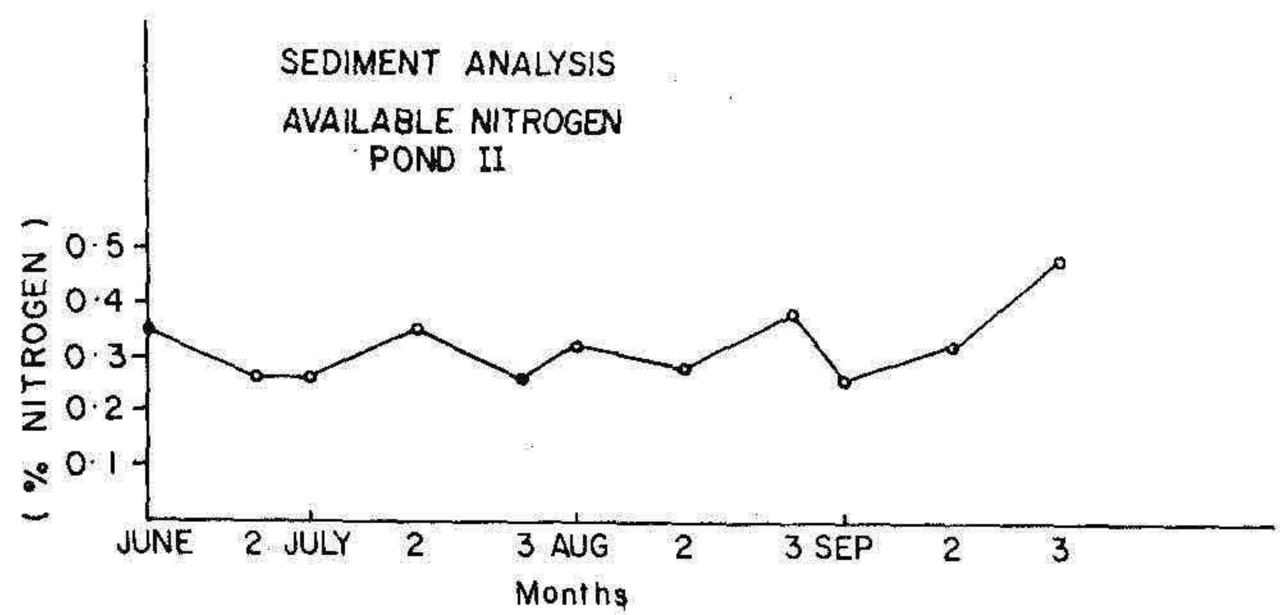

SEDIMENT ANALYSIS
AVAILABLE NITROGEN
POND II
(% NITROGEN)
0·5
0·4
0·3
0·2
0·1
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 13

SEDIMENT ANALYSIS

AVAILABLE POTASSIUM IN (PPM)

SAMPLES	POND - I	POND - II
1	32.93	8.67
2	24.07	7.27
3	38.07	29.20
4	37.60	27.80
5	36.67	27.33
6	32.47	27.33
7	24.07	20.27
8	23.60	11.46
9	32.47	34.33
10	32.47	33.4
11	32.93	33.4

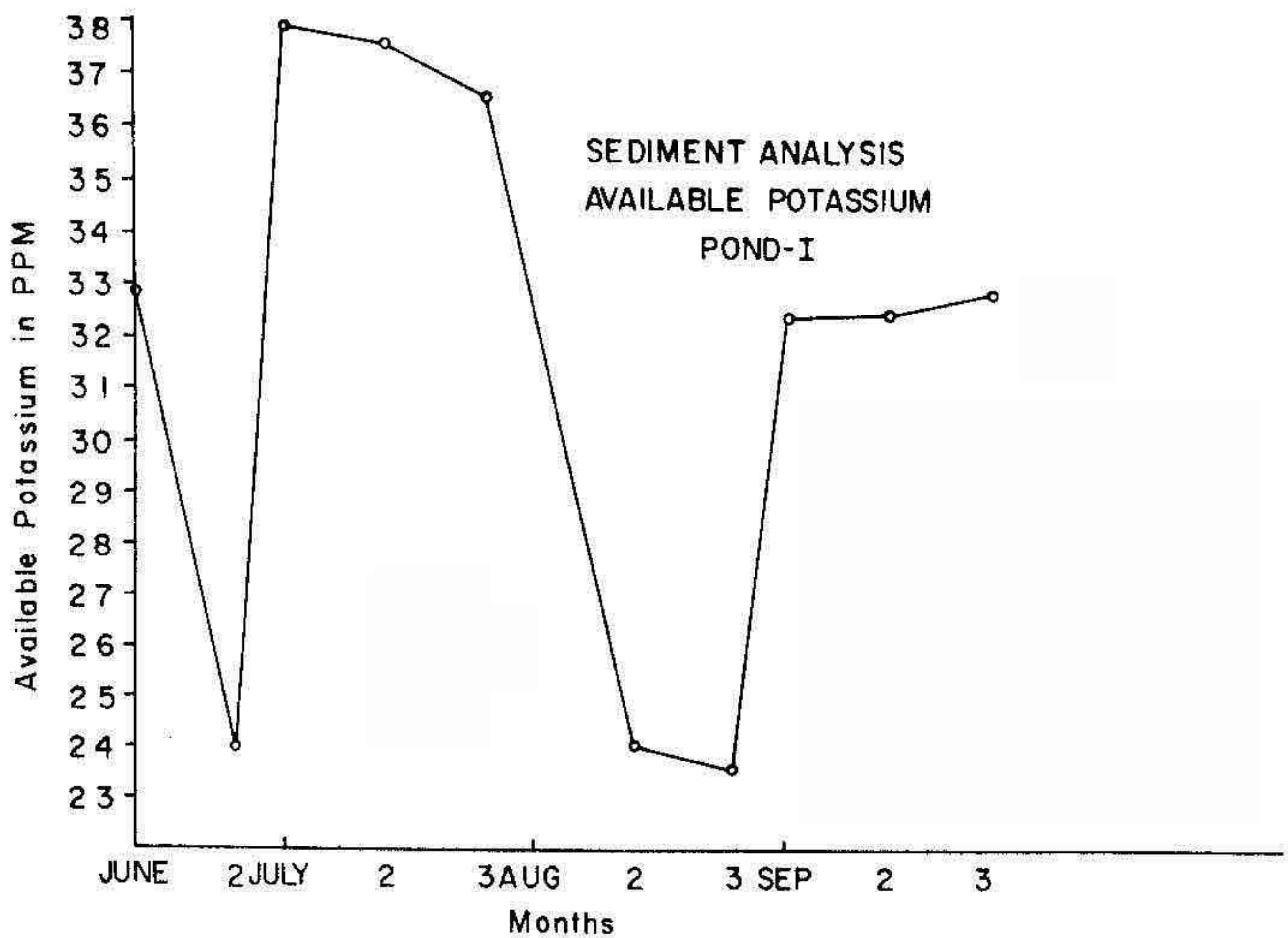

SEDIMENT ANALYSIS
AVAILABLE POTASSIUM
POND-I
Available Potassium in PPM
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig.14

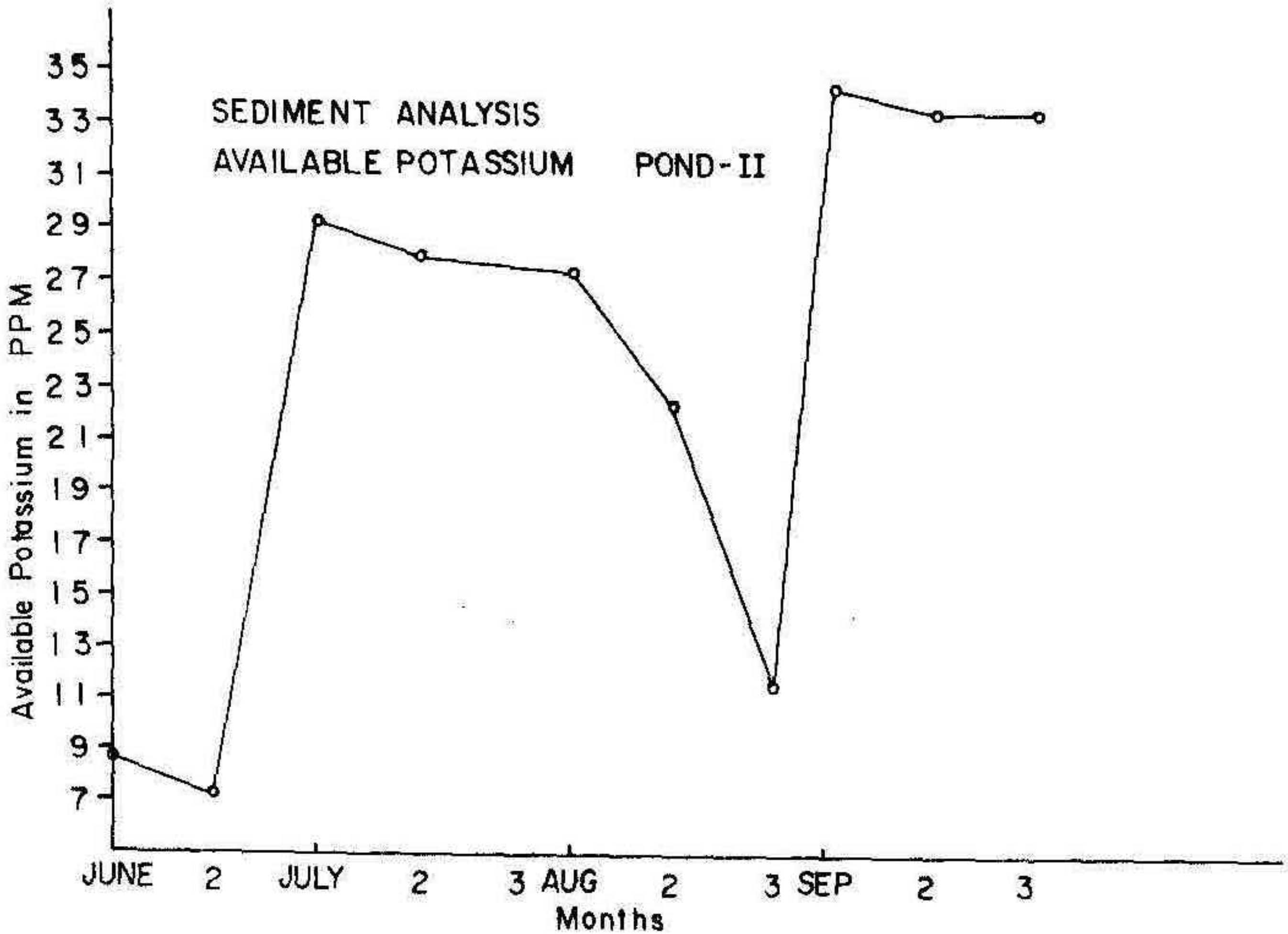

SEDIMENT ANALYSIS
AVAILABLE POTASSIUM POND-II
Available Potassium in PPM
35
33
31
29
27
25
23
21
19
17
15
13
11
9
7
JUNE
2
JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 15

SEDIMENT ANALYSIS -

AVAILABLE PHOSPHORUS IN (PPM)

SAMPLES	POND - I	POND - II
1.	12.31	6.07
2.	13.35	10.23
3.	14.38	9.19
4.	12.31	7.11
5.	13.35	6.07
6.	13.35	6.30
7.	12.31	6.23
8.	12.31	6.07
9.	15.43	9.19
10.	16.47	9.19
11.	25.84	14.39

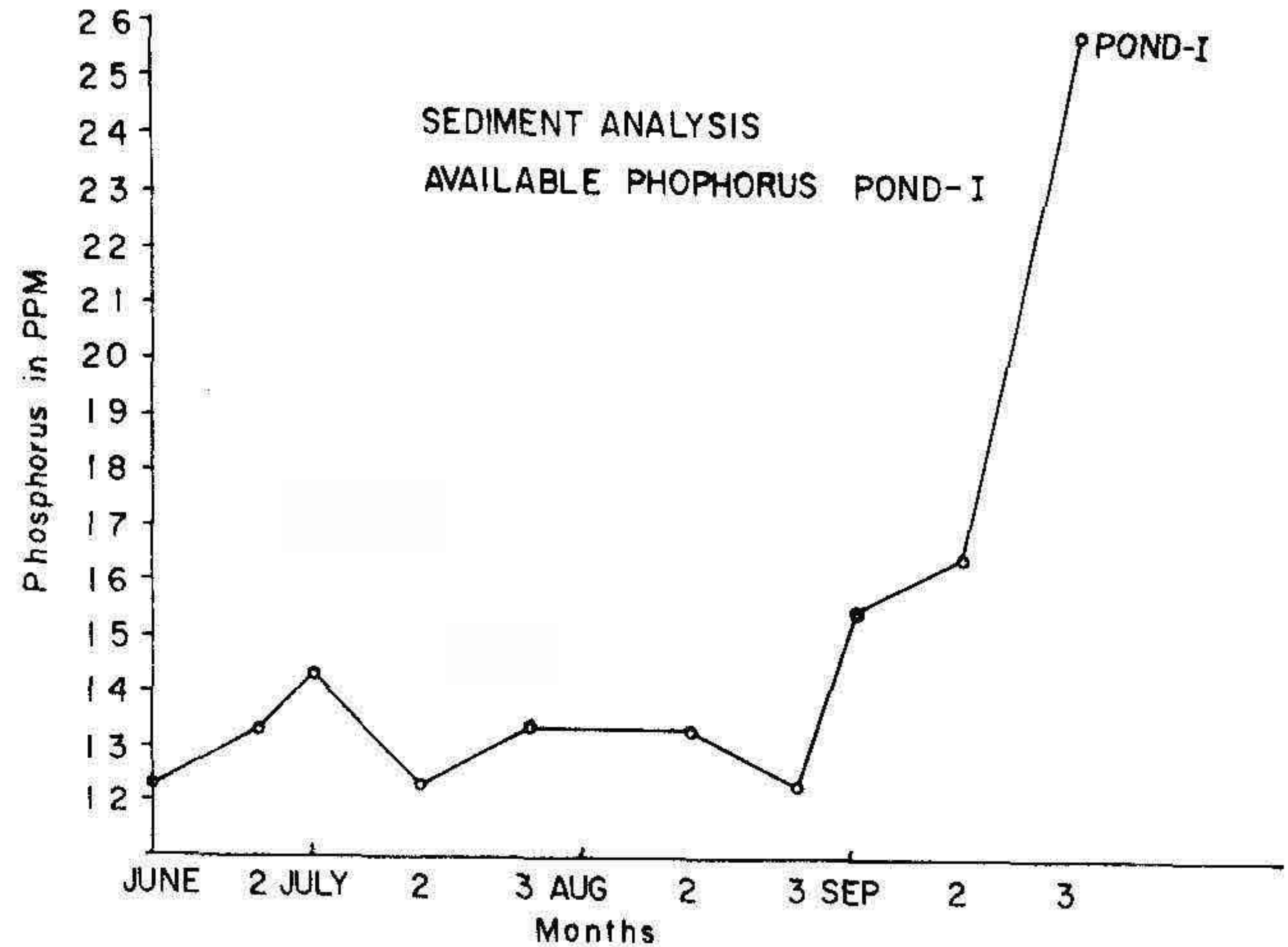

SEDIMENT ANALYSIS
AVAILABLE PHOPHORUS POND-I
POND-I
Phosphorus in PPM
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
JUNE
2 JULY
2
3 AUG
2
3 SEP
2
3
Months

Fig. 16

SEDIMENT ANALYSIS
AVAILABLE PHOSPHORUS POND - II

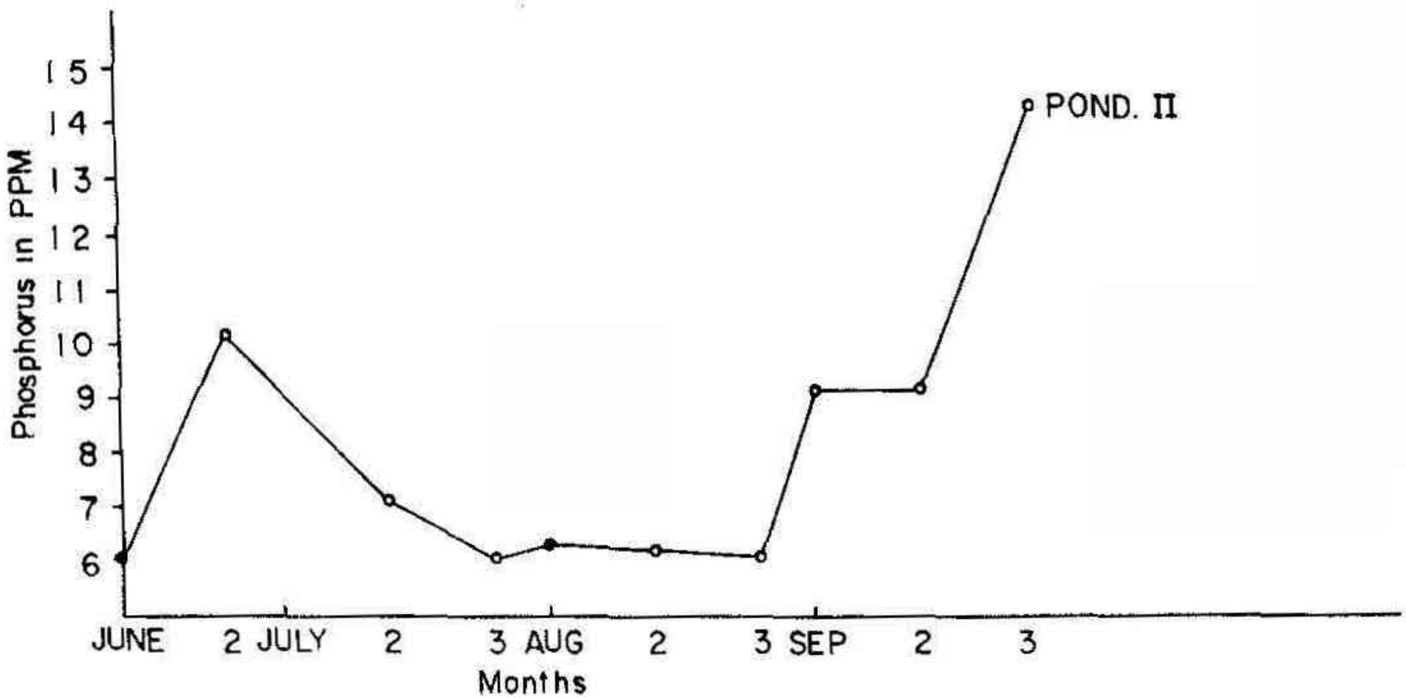


Fig. 17

N-P-K RATIOS IN WATER IN POND - I

SAMPLES	NITROGEN	PHOSPHORUS	POTASSIUM
1	38	1	147
2	49	1	155
3	43	1	158
4	24	1	158
5	18	1	189
6	16	1	170
7	19	1	166
8	6	1	61
9	37	1	545
10	32	1	461
11	174	1	461

N-P-K RATIOS IN WATER IN POND - II

SAMPLES	NITROGEN	PHOSPHORUS	POTASSIUM
1	24	1	169
2	35	1	145
3	11	1	117
4	26	1	131
5	12	1	172
6	15	1	150
7	23	1	156
8	28	1	169
9	48	1	421
10	25	1	260
11	82	1	251

N-P-K RATIOS IN SEDIMENT ANALYSIS IN POND - I

SAMPLES	NITROGEN	PHOSPHORUS	POTASSIUM
1	650	1	3
2	577	1	2
3	566	1	3
4	650	1	3
5	577	1	3
6	570	1	3
7	633	1	2
8	593	1	2
9	515	1	2
10	370	1	2
11	310	1	1

N-P-K RATIOS IN

SEDIMENT ANALYSIS IN POND - II

SAMPLES	NITROGEN	PHOSPHORUS	POTASSIUM
1	576	1	2
2	254	1	1
3	283	1	3
4	492	1	4
5	428	1	5
6	508	1	4
7	450	1	3
8	626	1	4
9	283	1	4
10	348	1	4
11	264	1	2

Any seasonal change could be observed in Pond II only where 4 maxima are exhibited (fig 13). In general, the quantity of available nitrogen was much lower in Pond II compared to Pond I.

A similar trend is exhibited by the available phosphorus also, in the sediments, (Fig 16 and 17). The maximum available phosphorus of 26 ppm was in Pond I whereas in Pond II, the maximum was only 14.5 ppm. The seasonal fluctuations also were comparable in the ponds during the actual monsoon periods, although lesser values were exhibited in Pond II.

The contrast between the two ponds were much more clear as far as the available potassium in the sediments are concerned. The maximum of 38 ppm in Pond I occured during the onset of monsoon fig (14 - 15). Where as in Pond II this maximum was only 29 during the same date. A decreasing trend by the progress of monsoon was observed in both the pond and another maximum during September could be observed.

Monthly variations in phytoplankton biomass at the two culture phonds have been observed, during the period of investigation. Cyclo tella striatta, stephanopyxis palmariana, Gyrosigma balticum, Pleurosigma formossum, Nitzchia longissima, Chaetoceras subtilis, Navicula monilifera Amphora ovalis, Diploneris didyma, Licmophora juergengil, Bacillaria paradoxa, Pinnularia ambigua, Scenedesmis occured commonly throughout the period of investigation. The diatoms formed the major components of the phytolanktons during this periods.

A few zoo plankton species were also observed. During June Nitzchia clostrium, is the predominent species in both the ponds. (1,50,000 cells/litre) in all the months during monsoon and post monsoon (fig 18). The biomass of Stephanopysis palmariana was minimum during this months in both ponds. Other dominant species was Cyclostella striatta. During July Nitzchia clostrium was again abundant in both the ponds (fig 19). But during the peak monsoon Cyclostella striatta (fig 20) dominated. During post monsoon period, Thalassiosira subtilis, Bacillaria paradoxa are mostly abundant in both the ponds are more or less similar in monsoon and post monsoon periods. Considerable changes in the species have been noted, during the monsoon and post monsoon in phytoplankton biomass. But in zoo plankton biomass, minimum amount of species have been noted and not much variation in zoo plankton biomass was observed zoo plankton was moderately abundant during the previous months also and exhibited

PLANKTON ANALYSIS

No. of cells/litre

POND - I

S.No.	MONTH	SPECIES NAME	No. of cells/ Litre
1.	JUNE	Stephanophyxis Palmariana	28,000/litre
2.		Cyclotella striatta	60,000/litre
3.		Gyrosigma balticum	24,000/Litre
4.		Pleurosigma formosum	16,000/litre
5.		Nitzchia clostrium	1,50,000/litre
6.		Nitzchia longissigma	60,000/litre
7.		Chaetoceros subtilis	6,00,000/litre
		copepods	3,000/litre
	JULY		
1.		Stephanopyxis palmariana	42,000/litre
2.		Cyclotella striatta	80,000/litre
3.		Cyrosigma balticum	22,000/litre
4.		Pleurosigma formosum	21,000/litre
5.		Nitzhcia clostrium	1,30,000/litre
6.		Nitzhia longissima	49,000/litre
7.		Chaetoceras subtilis	7,20,000/litre
8.		Navicula monilifera	3,50,000/litre
		copepods	3,000/litre
	AUGUST		
1.		Stephanopyxis palmariana	38,000/litre
2.		Thalassiosira subtilis	8,00,000/litre

.....2.

-2-

S.No.	MONTH	SPECIES NAME	No. of cells/ Litre
3.		Cyclostella striatta	65,000/litre
4.		Bacillaria paradoxa	1,56,000/litre
5.		Amphora ovalis	28,000/litre
6.		Diploneris didyma	1,80,000/litre
7.		Ceratium gravitum	4,00,000/litre
8.		Nitzchia clostrium	2,60,000/litre
	SEPTEMPER	copepods	3,00 /litre
1.		Licmophora juergensii	12,000/litre
2.		Cyclo tella striatta	45,000/litre
3.		Navicula gracilis	56,000/litre
4.		Navicula monilifera	56,000/litre
5.		Amphora ovalis	30,000/litre
6.		Pleurosigma formosum	13,000/litre
7.		Cyrosigma balticum	19,000/litre
8.		Bacillaria paradoxa	1,48,000/litre
9.		Nitzchia navicularis	12,000/litre
10.		Nitzchia clostrium	4,80,000/litre
11.		Nitzchia seriata	48,000/litre
12.		Pinnularia ambiguna	45,000/litre
13.		Scenedesmus acuminatus	45,000/litre
		copepods	3,00 /litre

PLANKTON ANALYSIS

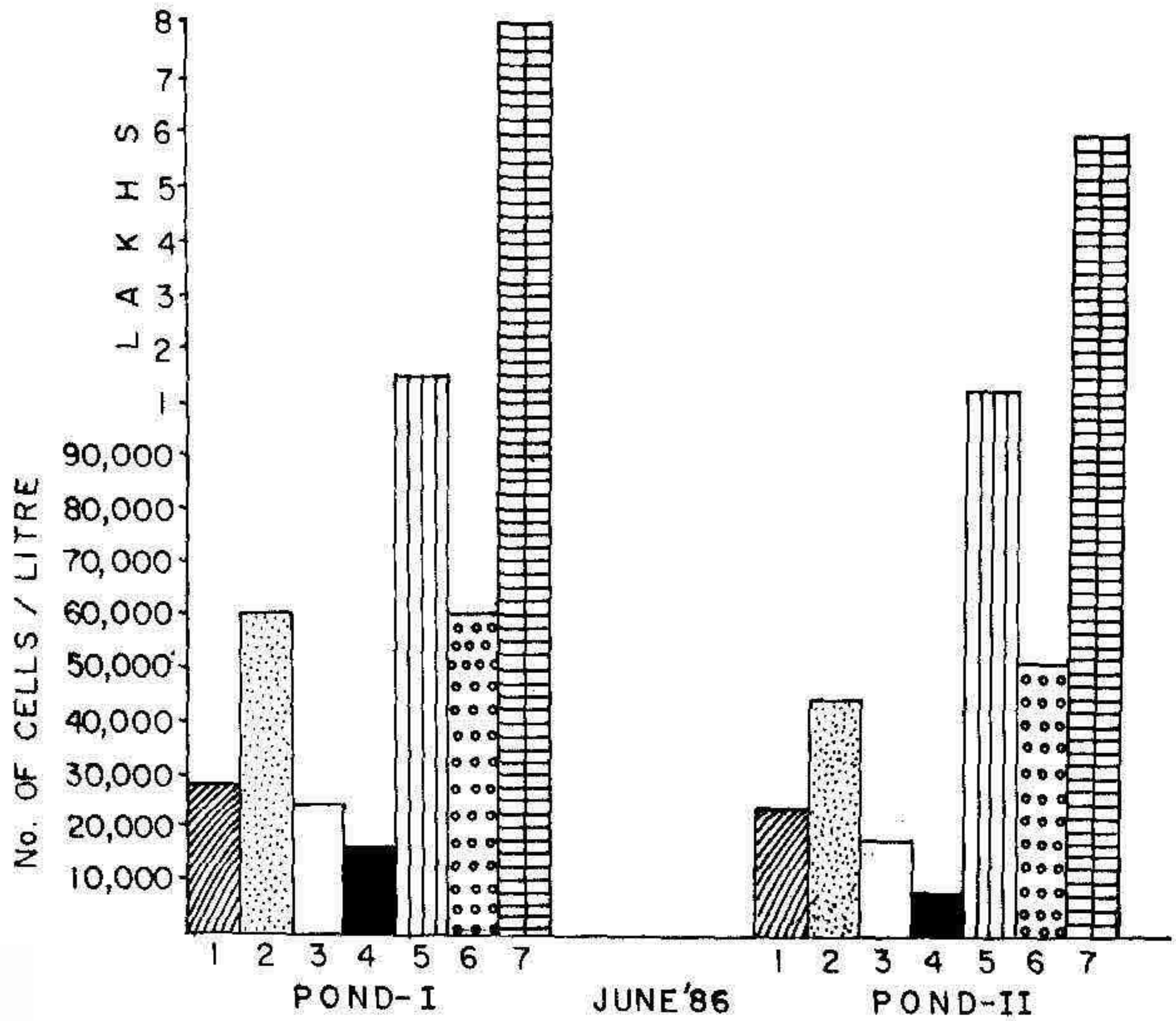
POND - II

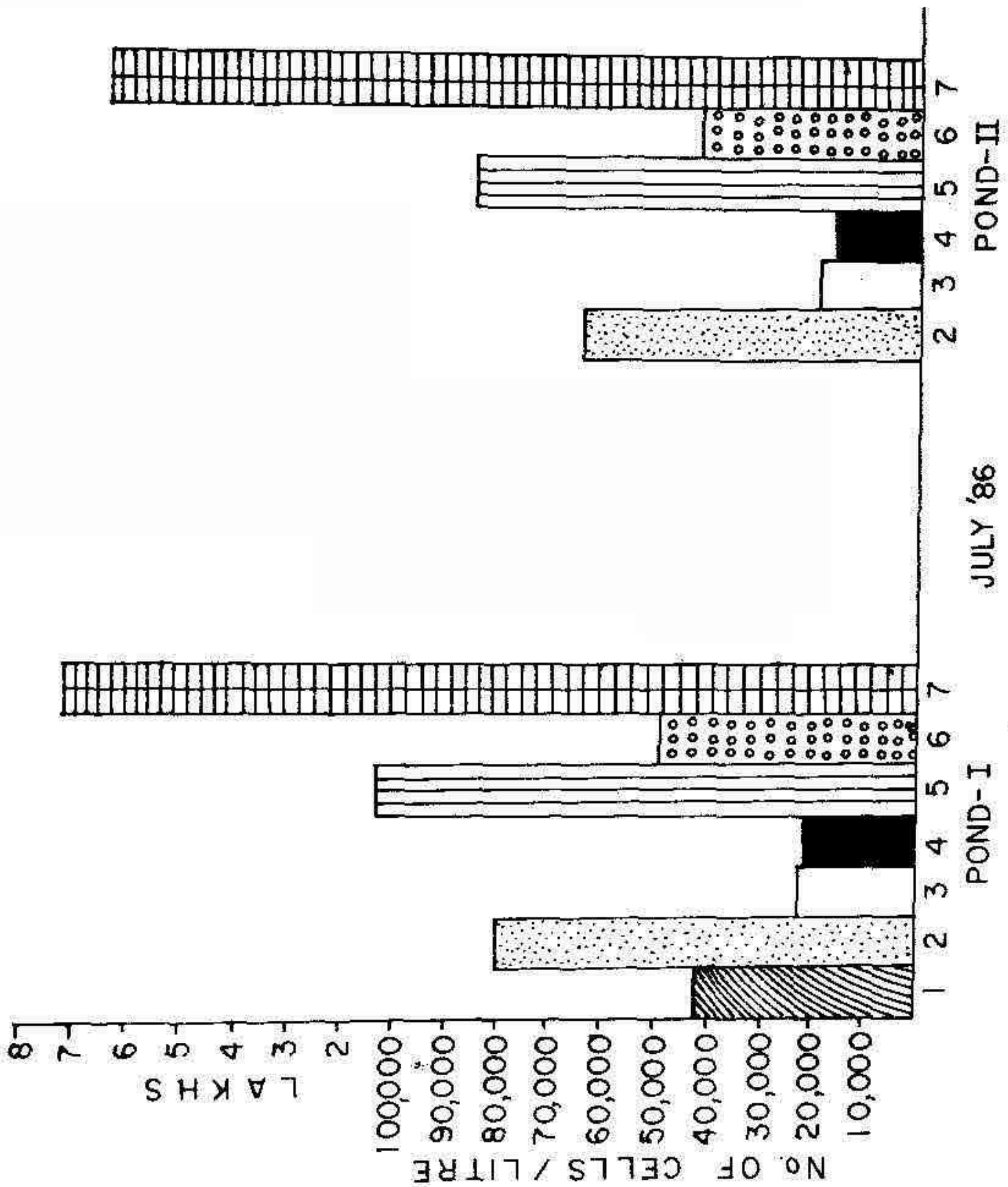
S.No.	MONTH	SPECIES	No. of cells/ Litre
1.	JUNE	Stephanopyxis palmariana	24,000/litre
2.		Cyclotella striatta	45,000/litre
3.		Gyrosigma balticum	18,000/litre
4.		Pleurosigma formosum	8,000 /litre
5.		Nitzchia clostrium	1,30,800/litre
6.		Nitzchia longissima	52,000/litre
7.		Chaetoceros subtilis	6,00,000/litre
		copepods	2,00 /litre
	JULY		
1.		Cyclotella striatta	64,000/litre
2.		Gyrosigma balticum	19,000/litre
3.		Pleurosigma formosum	16,000/litre
4.		Nitzchia clostrium	85,000/litre
5.		Nitzchia longissima	42,000/litre
6.		Chaetoceros subtilis	6,50,000/litre
		copepods	2,00 /litre
	AUGUST		
1.		Stephanopyxis palmariana	32,000/litre
2.		Thalassiosira subtilis	6,50,000/litre
3.		Cyclo tella striatta	62,000/litre

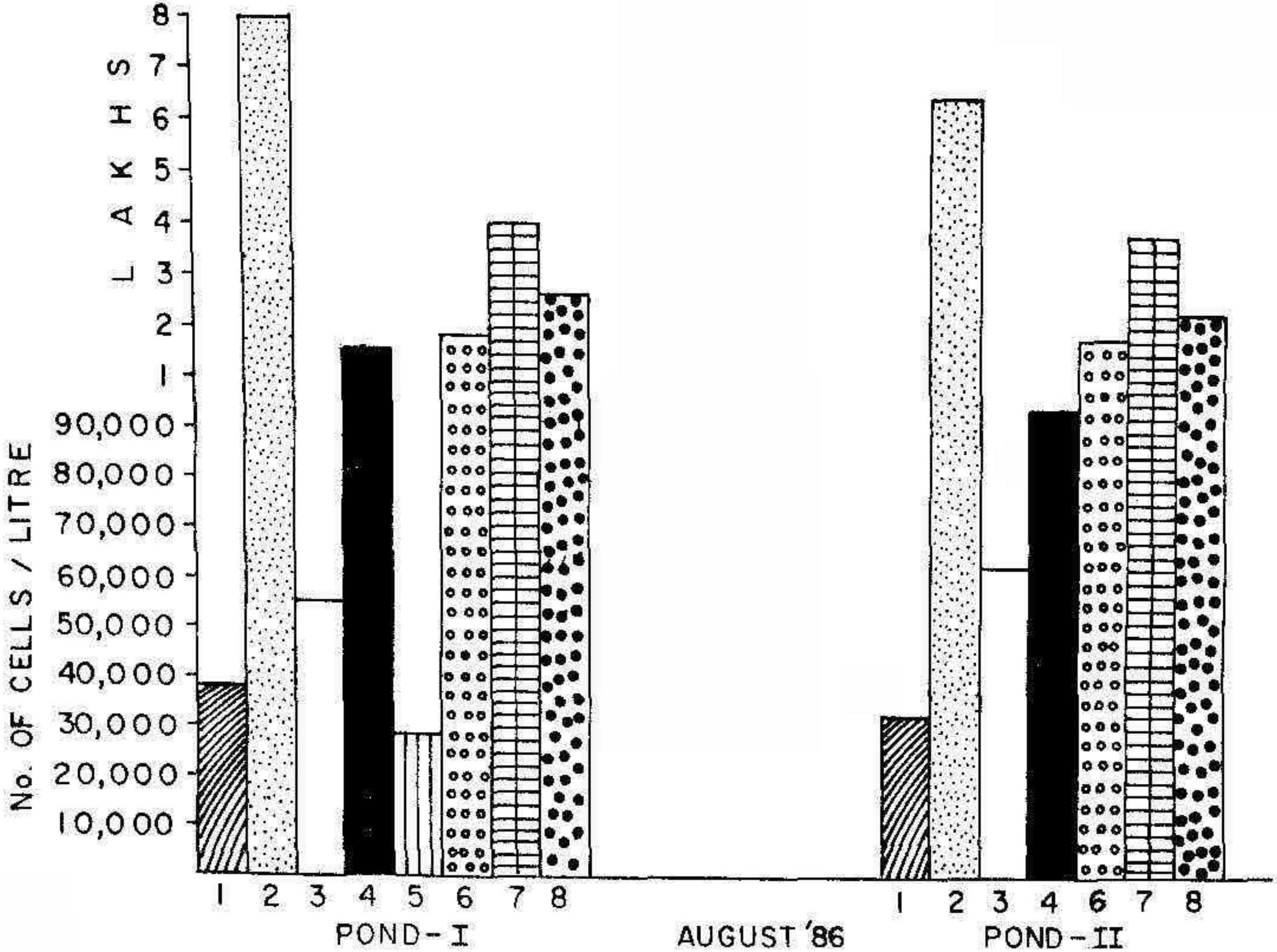
.....2

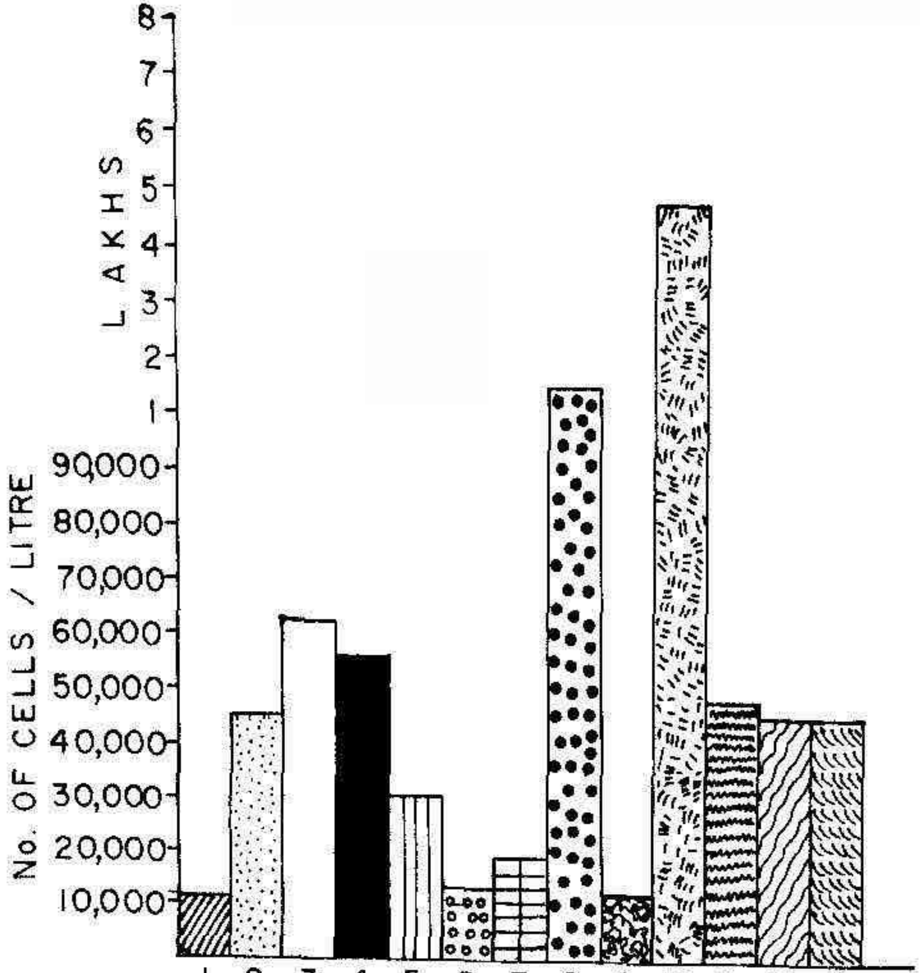
-2-

S.No.	MONTH	SPECIES	NO. OF CELLS/ LITRE
4.		Bacillaria paradoxa	1,35,000/litre
5.		Diploneris didyma	1,65,000/litre
6.		Ceratium gravidum	3,80,000/litre
7.		Nitzchia clostrium	2,25,000/litre
	SEPTEMBER	copepods	2,000/litre
1.		Licmophora juergensii	8,000/litre
2.		Cyclostella striatta	32,000/litre
3.		Naviculla gracilis	48,000/litre
4.		Naviculla monilifera	42,000/litre
5.		Amphora ovalis	20,000/litre
6.		Pleurosigma formosum	7,000/litre
7.		Gyrosigma balticum	11,000/litre
8.		Bacillaria paradoxa	1,28,000/litre
9.		Nitzchia navicularis	4,000/litre
10.		Nitzchia clostrium	3,70,000/litre
11.		Nitzchia seriata	35,000/litre
12.		Pinnularia ambigua	35,000/litre
13.		Scenedesmus acuminatus	60,000/litre
		copepods	2,000/litre


No. OF CELLS / LITRE
L A K H S
8
7
6
5
4
3
2
1
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
1 2 3 4 5 6 7
POND-I
JUNE'86
1 2 3 4 5 6 7
POND-II


No. OF CELLS / LITRE
LAKHS
8
7
6
5
4
3
2
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
1 2 3 4 5 6 7
POND-I
JULY '86
2 3 4 5 6 7
POND-II


LAKHS
8
7
6
5
4
3
2
1
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
No. OF CELLS / LITRE
1 2 3 4 5 6 7 8
POND-I
AUGUST '86
1 2 3 4 6 7 8
POND-II


LAKHS
8
7
6
5
4
3
2
1
No. OF CELLS / LITRE
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
1 2 3 4 5 6 7 8 9 10 11 12 13
POND-I SEP.'86

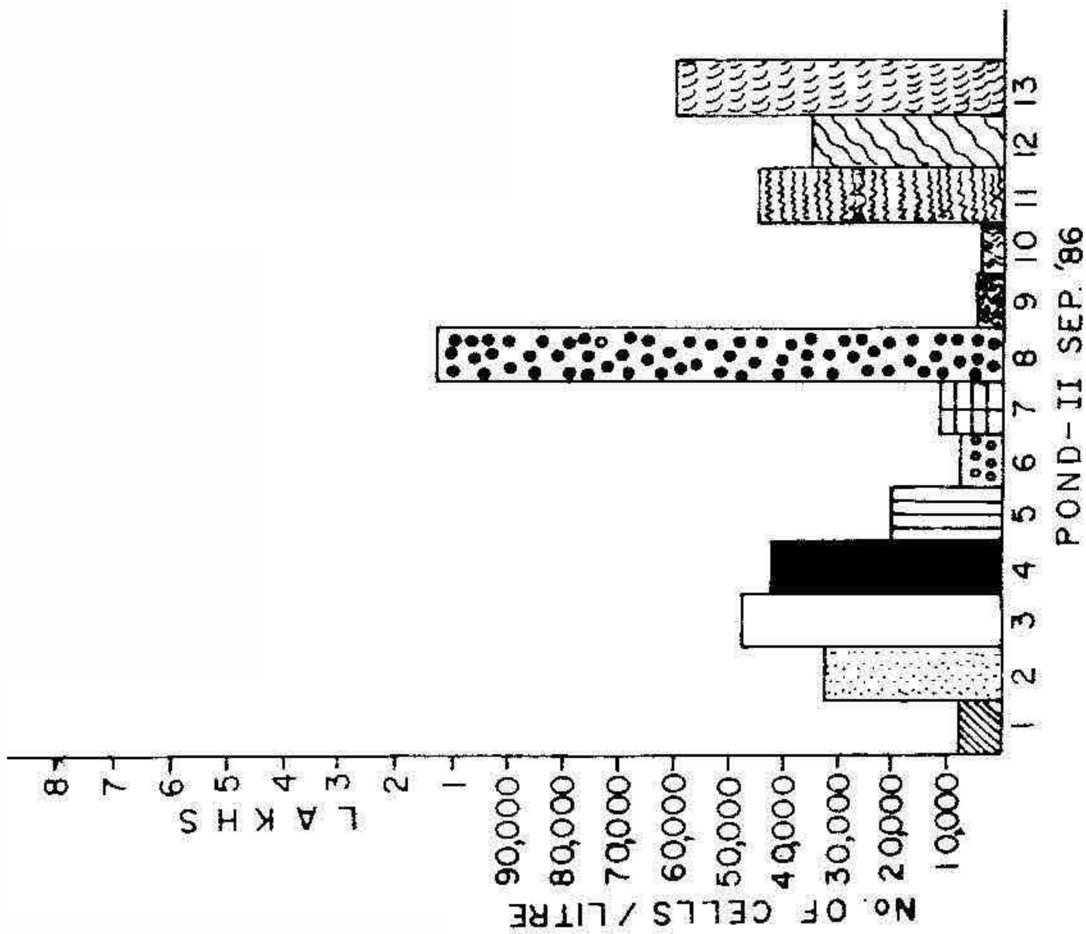
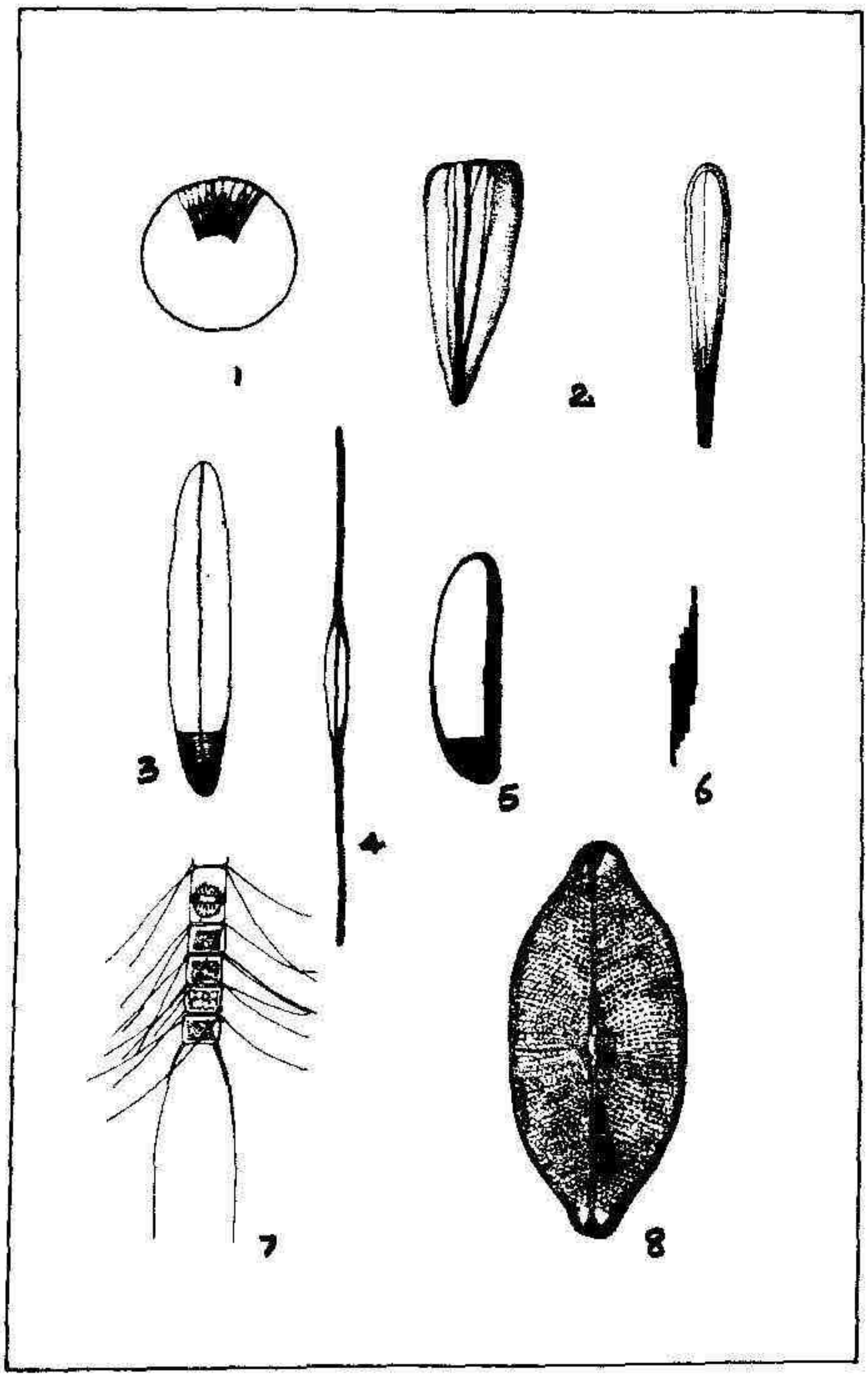

No. OF CELLS / LITRE
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
1
2
3
4
5
6
7
8
LAKHS
1 2 3 4 5 6 7 8 9 10 11 12 13
POND-II SEP. '86

PLATE - I

1. *Cyclotella striata*
2. *Licmophora juergensii*
3. *Navicula gracilis*
4. *Nitzchia longissma*
5. *Amphora ovalis*
6. *Bacillaria paradoxa*
7. *Chaetoceros subtilis*
8. *Navicula monilifara*


1
2
3
4
5
6
7
8

P L A T E - II

9. Diploneris didyma
10. Pinnularia ambigua
11. Gyrosigma balticum
12. Nitzchia navicularis
13. Stephanopyxis palmariana
14. Ceratium gravidum

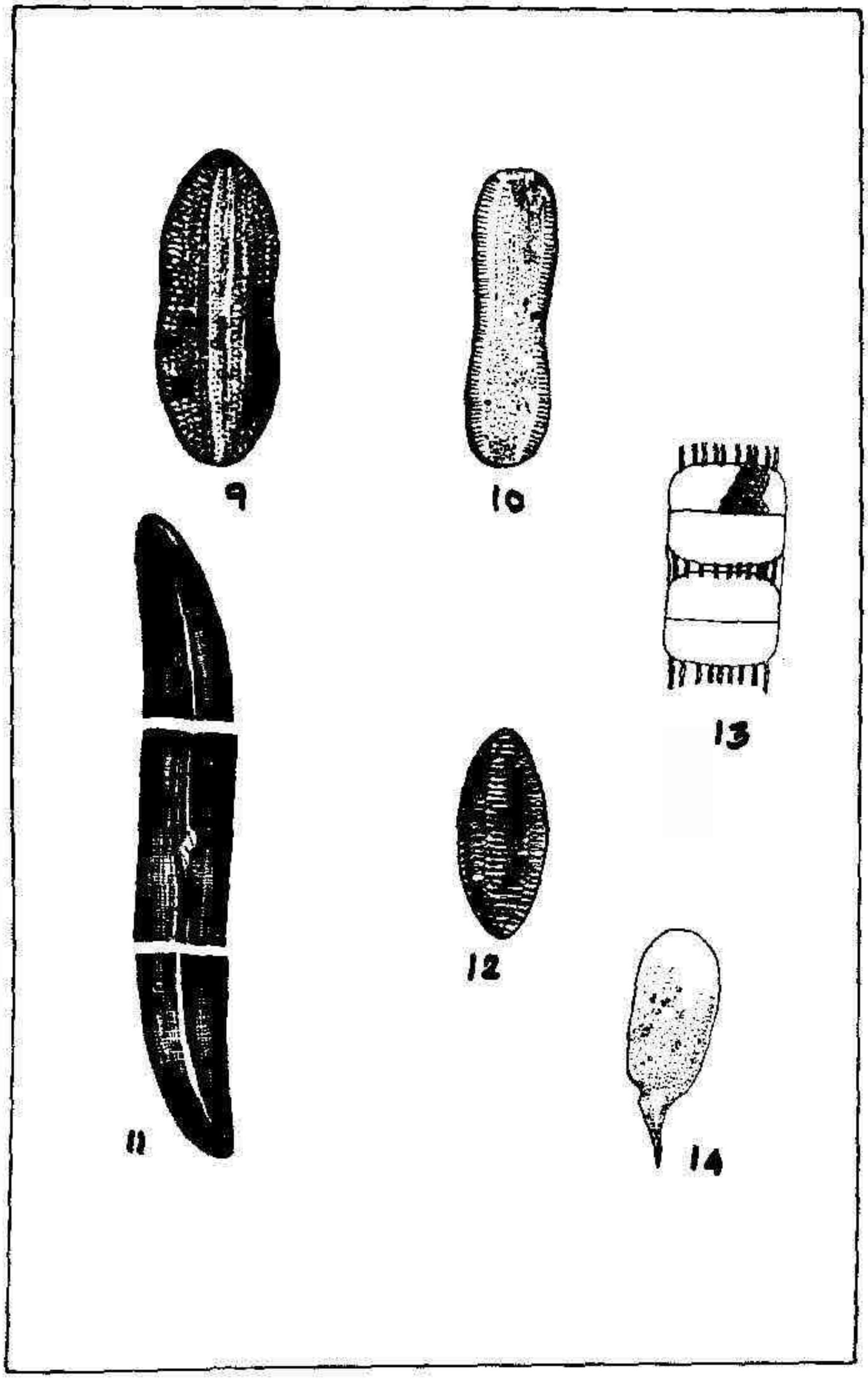

9
10
11
12
13
14

PLATE - III

15. Pleurosigma formosum

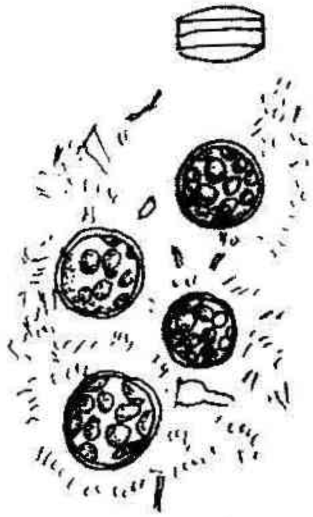
16. Nitzchia clostrium

17. Thalassiosira subtilis

18. Scenedesmus acuminatus

15

16



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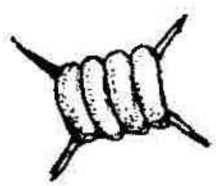

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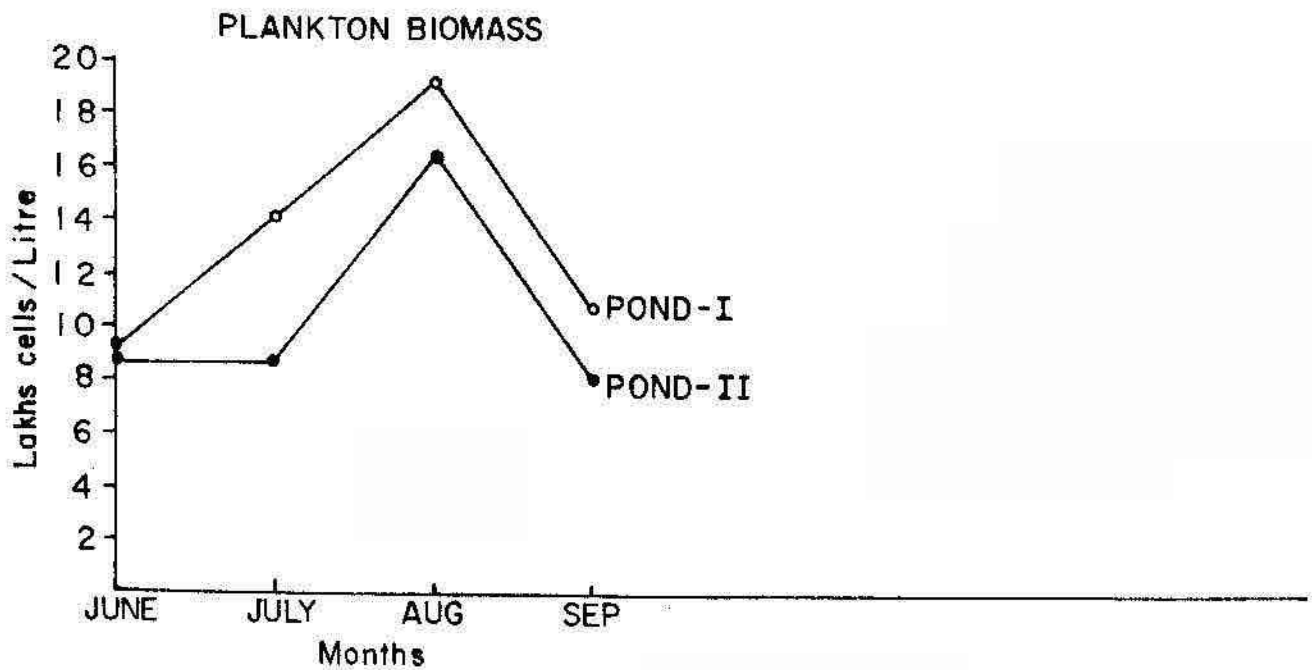
PLANKTON BIOMASS
Lakhs cells / Litre
20
18
16
14
12
10
8
6
4
2
JUNE
JULY
AUG
SEP
Months
POND-I
POND-II

Fig. 23

maximum values of *Chaetoceras subtilis* which was third in abundance during this month.

By the end of monsoon and the beginning of post monsoon (September) a noticeable change was observed in the time distribution pattern of plankton biomass (Fig. 21). A hitherto unobserved species *Bacillaria paradoxa* was observed in good quantities during late August and early September in both the ponds, and by the end of September five more hitherto unnoticed species were also existent in both the ponds (Fig 21 - 22). One contrast between the ponds was the controversial abundance in the biomass of this species *Nitzhia clostrium*. In general a decreasing trend in the total plankton biomass was observed during the monsoon.

Discussion

Boyd (1984) while discussing water quality in relation to fish production in Aquaculture scheme has stated that the ability of water to produce plankton depends on many factors, but, the most important is usually the availability of inorganic nutrients like carbon, oxygen, hydrogen, phosphorus, nitrogen, potassium etc. Out of this, phosphorus is most often the element regulating phytoplankton growth in ponds. In the present case the seasonal variation of phosphorus is noticeable although not drastic with a maximum during the late monsoon (August). The comparison of the distribution patterns of the above nutrients and total plankton biomass shows that the maximum biomass of plankton corresponds to the maximum available phosphorus during the investigational period.

Banerjea (1963) has put forward a similar conclusion that in laboratory and field experiments, the plankton concentration of the water can be increased considerably by artificially raising the available phosphorus of the soil. In the present case the soil phosphorus showed high fluctuations in Pond I. It was conspicuosuly higher in Pond I than in Pond II which feature is again reflected in the total plankton biomass atleast during the monsoon. The mechanisum of exchange of nutrients between sediments and overlying water although complicated, reveal that the phosphorus content of the overlying water bears and inverse relation with that present in the bottom soil. This feature could be observed in the present case also, especially during the monsoon and post monsoon. A similar conclusion has been put forward by Dinesh Babu (1985) while he discussed the calcium exchange between sediments and water in some culture ponds.

OSUGI et. al. (1932), sited in Kowaguchi, 1950 and Lu and Chung (1964) have studied the solubilities of various phosphate minerals at different pH values and observed that solubilities of most phosphates increased under alkaline conditions. Considering the pH variations and available phosphorus concentration of the overlying water in the present case it can be observed. High phosphorus contents during the late monsoon, and post monsoon periods, corresponded to the alkaline waters especially in Pond II but in Pond I the feature was not very clear. As already mentioned, the area of Pond II is much lesser than that of Pond I. As has been stated by Govind (1959) the rich rain waters of south west monsoon appear to influence the production of plankton duriring the peak mansoon. Gopinathan (1972) has also arrived at a similar conclusion. Drastic variations in temperature were not conspicuous but, in general the low temperature during the post monsoon especially in Pond I seems to be more favourable for production.

Falkowski (1980) has stated that there is a positive relatiionship between phytoplankton and nutrient enrichment in natural waters.

Sumitra Vijayaraghavan (1973) while discussing a comperative account of soil, water relationship in three tropical ponds has stated that the productivity of the Pond need not necessarily depend upon the total Nitrogen content present in the soil. In the present case the fluctuations in the available nitrogen in the pond soil were not much during the investigational period. Not much correlation was observed between the phosphorus and Nitrogen contents in the soil, although the former author postulates an inverse relation between phosphate and nitrogen and direct relation between pH and phosphate.

Concentration changes in Nitrate are the net effect of nitrification, Nitrate reduction, and assimilation, and Nitrate reduction is quantitatively more important than nitrification. In the present investigation the fluctuations in the nitrate and nitriate in the pond waters were remarkable although the fluctuations in the available Nitrogen in the sediments were low. During active monsoon in general, the nitrate concentrations were low in both the ponds, but the planktonic abundance was high during monsoon. Moreover, the only variations in planktonic abundance between active and pre monsoon and post monsoon was in the increase in the variety of species.

Motzkin et. al. (1982) have studied the interaction between nutrients load fish activity and developing phytoplankton in a stocked fish pond, and on unstocked sea water controlled pond, wherein they received the same nutrient load from a common inflow when the stocked fish pond received an extra nutrients especially Nitro en, and they have stated that this was responsible for the higher standing crop of phytoplakton. In the Narakkal culture ponds the nitrate contents were high during onset of monsoon, and low during peak monsoon, but the plankton abundance was more during monsoon. Probably the assimilation ofthe available Nitrogen by the plankton during monsoon has resulted in the lower values during late monsoon.

As is the case with Nitrogen and phosphorus the amounts of available potassium was always higher in Pond I in the sediments as well as in the overlying waters. The amounts in the sediments were much higher than in the overlying water. As such the fertility of Pond I appears to be much higher than Pond II but a correlation between the available potassium and the plankton biomass appears to be much ill defined that the other nutrients.

An examination of the N-P-K. ratios in the sediments reveals that the sediments always contain high amount of available Nitrogen where as the available potassium was much low. Throughout the investigational period the ratio between phosphorus and potassium were more or less constant and the integrated ration (N:P:K) did not varying much. Dinesh Babu (1985) while discussing exchange of sediments and water in culture pond has observed that the soil Nitrogen con ent did not show much variations during the period May to September, which agrees with the present observations also. Except for a lesser amount of nutrients in general the ratios in both the ponds were comparable. But the ratios in the overlying waters showed much variation than that in the sediments. The potassium content in the water were much higher than the sediments. Except for the peak monsoon periods the the ratios between the three nutrients were more or less the same. Again the ratios during monsoon were comparable to each other but this feature was not so conspicuous in Pond II wherein general the nutrient contents were low.

Summary

The present investigations pertained to a short term study of the available forms of Nitrogen, Phosphorus and potassium in the sediments and the overlying waters in two culture ponds at Narakkal, in relation to the plankton biomass existing in the ponds. The available forms of Nitrogen in the sediments and overlying water showed that the sediments always contain much higher amounts than the overlying water. The available Nitrogen did not show much variations monthwise but the fluctuations in potassium content were highly conspicuous. The available phosphorus was much more higher in the overlying water than in the sediments.

Acidic soil dominated in Pond I but the water pH was mostly in the alkaline range. The high amounts of available Nitrogen during the onset of monsoon showed a decreasing trend towards the peak of the season which was accompanied by a noticeable increase in the plankton biomass and the decrease in the Nitrogen and phosphorus content during this period has been attributed due to the consumption by the plankton. A decrease in the biomass during post monsoon coincided with a notable increase in the phosphorus nutrient contents. The correlation between the available potassium and plankton biomass was not very significant. The available potassium was always conspicuously higher than the other nutrients in the overlying water. The N-P-K ratios in the sediments and overlying waters were more or less of a steady nature when the sediments and water are considered individually.

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