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SOME ASPECTS OF THE CHEMISTRY OF LAKE MANZALAH WATER

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ABSTRACT

Lake Manzala is brackish, shallow and divided into several basins by the scattered islets and the submerged barriers extending between the islets. The study covers the commercially fished area since the excluded parts of the lake are very shallow and marshy.

Because of the shallowness of the lake, the continuous mixing of the water by the effect of wind adds to the dissolution of atmospheric oxygen and to the nutrient exchange process leading to a more enrichment of the overlying waters. Generally, the chlorosity, hydrogen ion concentration , oxygen and nutrient contents are of low values during summer and are of higher values during the other seasons.

The contribution of Lake Manzala to the Egyptian fisheries especially mullet species, is high. Its increasing importance to the country fisheries is due to the decrease in the country fish yield caused primarily by depriving the Egyptian fishing grounds of large quantities of the fresh Nile water after the construction of the Aswan High Dam, while as for the lake, such loss is compensated by increasing amount of freshwater introduced into it through the drains and Inaniya canal.

INTRODUCTION

Lake Manzalah is situated in the North-eastern part of Egypt. It is boardered by the Suez Canal from the East, the Mediterranean Sea from the North and Damietta branch of the Nile from the West (Fig. 1). Its area is about 1275 km2 with an average depth of 1.20 m. Three fresh water canals (namely El-Ratama,El-Souffara and El-Inaniya canals) connect the lake with Damietta branch of the Nile.

The lake-sea connection is found at its North-eastern part and called "El-Gamil Opening". The Suez Canal is linked with the lake at El-Qabouti Opening which is situated few kilometers south to Port-Said.

Five main drains named El-Serw, El-Gammaliah, Bahr Hadous, Ramsis and Bahr El-Baqar, open in the South and South-eastern boarders of the lake.

Several islets are scattered in the lake. Therefore, the total area is devided into regions which are nearly separate from each other.

A dredged route for navigation extends nearly South-eastwards to connect Damietta city with El-Matariya where it proceeds North-eastwards to Port-Said. The total length of the canal is approximately 65 km. It has a width of about 8.00 m. and a depth of 2.5 m and hence the total water volume of the navigational route is 1036 x 10 m^3.

El-Wakeel & Wahby (1970) investigated the chemistry of the lake water during 1962-1963 while Wahby et al (1972) published further studies on it during 1967. The recent change in the irrigation system which followed the construction of the Aswan High Dam is noticed to be associated with an increase in the volume of drainage water. This fact urged the need to identify the different water types in their source regions and their seasonal and regional change in the lake as traced mainly by the temperature, transparency, chlorinity, inorganic phosphate,and some other chemical characteristics. Unfortunately, the water analysis for the oxygen and nitrogen determination were not possible because of some unavoidable difficulties. However, this study covers the regions which have an average depth of 1.20 m. and hoped to be useful for the hydrological as well as the fisheries purposes.

MATERIAL AND METHODS

This study is based upon the chemical analysis of surface and bottom water samples collected monthly during 1970/1971, from 20 fixed positions representing the different types of the lake waters. Each position was selected in the deepest point of the corresponding region which in any case was of not less than 75 cm. depth.

The navigational route helped to take samples at one meter interval below the water surface. Hence a section of 6 stations (1—6) was chosen to extend from

El-Gamil Opening across El-Gamil region and then South-westwardly along the route to station 8 near El-Matariya (Fig. 1).

The stations from 16 to 18 are distributed along the borders of the islets and chosen for fishing experiments which will be discussed elsewhere.

Special care was taken to collect the samples and take observations away from the shores. Ruttner sampler of one liter capacity was used to collect the samples. A standard thermometer, accurate to 0.05°C, was used to measure the water temperature. The water chlorosity was determined according to Mohr's method as described by Vogel (1953). The content of the nutrient salts and the titration alkalinity of the lake water were determined following the analytical techniques given by Harvey (1955).

The three regions of the lake, namely South-eastern, North-eastern and Western regions, suggested by El-Wakeel and Wahby (1970) were taken in consideration. They helped to follow the corresponding change in some of the chemical characteristics of their waters. Data. of the volume of drainage water flowing in the lake were derived from records of the "Irrigation Department".

Temperature Variations :

The lake water attains minimum temperature of 14.0—15.0°C during December-January. Gradual increase in these values are observed during late winter and spring. They reach the maxima during July-August (Fig. 2). The maximum values ranged from 30.0°C to 34.0°C at the beginning of August 1970. Variations in the maximum values are correlated with the shallowness of the stations during the summer season

The water in the North-western region attains 3.5°C higher than in the South eastern region and about 2.0°C higher than in the Western region. The temperature variations follow that of the air.

The majority of the phytoplankton organisms tolerate wide range of temperature. Wahby et al (1972) suggested that high water temperature in the lake increases the production of organic matter. Aleem & Samaan (1969) stated that the phytoplankton community shows a marked periodicity which is attributed to the changes in light, temperature, amount of available nutrients and salinity.

The average water temperature during February 1962, 1967 and 1970 were

16.8, 16.7 and 16.1°C respectively. But during August of the same years they were 30.5, 30.4 and 32.3°C. It is clear that the year to year temperature variations in the lake indicate no significant magnitude. This suggests the influence of temperature upon the production of organisms in the lake to be highly significant at a seasonal rather than at a year to year scale.

The transparency Variations :

By comparing Figures (3and 6), it is easy to notice that the increase in the phosphate concentration is associated with an increase in the transparency of the lake water. The maximum transparency of the water of the South-eastern region is aquired during autumn and the early winter seasons. It has an average sighting depth of 60 cm (Fig. 3). The water transparency is known to be inversely related with the abundance of the planktonic organisms and the other suspended organic and inorganic particles. There is also general tendency of the lake water to attain high values of the reactive silicate in association with low values of transparency (Fig. 3 & 5).

In the North-eastern region, the water transparency appears higher than elsewhere in the lake. During February, May and October, the average of the maximum values may reach 100 cm (Fig. 4). Low transparency values as 35 cm, are observed during July and December. But in the Western region, the water transparency varies between an average of 42 cm during December, and 25 cm during April. Obvious decrease is observed in October during which the values do not exceed 22—19 cm (Fig. 5).

The transparency values along the navigational route vary significantly according to the location and season of observations. The outflowing brackish water from the lake-sea connection which in its past history have passed over regions rich in the benthic as well as planktonic filter feeding organisms may have significantly higher transparency. Generally, the detected values in the Northern part of the canal fluctuate between 95 and 45 cm. The maxima are observed during May while the minima are attained during October

The Southern positions in the canal are covered with waters having transparency values 50 — 30 cm. The higher values are met with in October and the minima in January.

Some Characteristics of the three Water types in their "Source Regions"

The lake water type of maximum chlorosity :

This water type attains the maximum chlorosity values and the minimum inorganic phosphate content (Table I). It covers the localities of the lake-sea connection and reflects the significant influence of the sea water entering in the North-eastern region.

Complex pattern of silicate distribution is expected in the lake waters because of its shallowness. The minimum silicate content is significantly lower in the water type of maximum chlorosity than in the two other types, the "Drainage" and the "Polluted waters". This feature is associated with some increase in the transparency of the water as measured by the Secchi disc. In addition, the titration alkalinity values of this water type are lower than those of the two other types.

The polluted water type :

The type of polluted sewage water spreads mainly near El-Matariya and in the localities adjacent to the mouth of Bahr El-Baqar drain. Its sampling position was selected at the locality of El-Matariya sewage outflow. Generally, the chemical features of this type is shown in Table (1). Distinguishable association is observed between the attained minimum values of chlorosity and the exceptionally high value of inorganic phosphate.

The phosphate concentrations found during 1970-71 in the "Polluted Water" ranged from 7.64 to 5.64 ug-at/PO_4 -P/L. The transparency values vary within nearly similar range as in the water of maximum chlorosity.

The drainage water type :

This water type is manily carried into the lake through the drains. An exception is found in Bahr El-Baqar drain which receives the "Polluted Waters" from the cities of El-Sharkia Governorate in addition to the cultivated land drainage water.

Table (1) : The observed maximum and minimum values of some chemical characteristics of three different water types in their source regions in Lake Manzalah during 1970/1971.

Water type	Chlorosity gm Cl/L		PO_4 - P ug-at/L		SiO_3 - si ug-at/L	
	Max.	Min.	Max.	Min.	Max.	Min.
1 — Water of maximum Chlorosity	19.61	2.87	1.28	0.50	150	56
2 — Drainage water ..	0.57	0.44	5.32	2.26	750	266
3 — Polluted water ..	0.81	0.65	7.64	5.64	372	253
	pH		Titration alkalinity mel.equiv. /L		Transparency cm.	
	Max.	Min.	Max.	Min.	Max.	Min.
1 — Water of minimum Chlorosity	—	—	3.99	2.56	100	35
2 — Drainage water ..	7.23	6.90	4.20	2.98	50	19
3 — Polluted water ..	7.02	6.38	4.05	3.52	90	23

The drainage water is characterised by minimum chlorosity. Its inorganic phosphate concentrations range from 5.32 to 2.26 ug-at PO_4 - P/L. The reactive silicate concentrations show wide range of variation with an exceptionally high maximum values. This is usually associated with small range of transparency variation which does not exceed the maximum of 50 cm sighting depth. Its titration alkalinity ranges from 4.20 to 2.98 mel. equivalent /L. Both the drainage and polluted water types may attain low pH values which range from 7.23 to 6.38 and suggest the organic matter disintegration and accumulation of organic acids.

The interaction and flow of these water kinds greatly influence the chmical characteristics of the lake water in the different regions. The other factors as precipitation, evaporation and turbulence, which usually cause the stirring of bottom sediments, may affect this influence.

The Change and Distribution of the Water Characteristics

The chlorosity variations :

The volume of the drainage and fresh water inflow in the lake influences significantly, the distribution of the chemical characteristics especially the water chlorosity. The total drainage and fresh water discharge during 1963, 1967 and 1970 was about 5.858 x 10^9, 5.809 x 10^9 and 6.362 x 10^9 respectively. During January, February and March 1970, the inflow of both types of water in the lake was about 383.935, 269.389 and 506.615 million cubic meters. Gradual increase in the volume of water was observed during the period from March till September where the volume exceeded 550.000 x $10^9 m^3$/month.

The precipitation is another factor which may have a restricted influence upon the chlorosity in lake Manzalah. The rain fall usually occurs during autumn, winter and the early spring. According to the data from the Meteorological Station at Port Said, the majority of the maximum values as 10.3 mm/month are seldom observed during November and March. No rain fall occurs during late spring, summer and the early autumn seasons. Therefore the influence of precipitation is of negligible significance as compared with the other factors.

The South-eastern region contains a mixture of Bahr El-Baqar , Ramsis and Bahr Hadous drain waters. The first of them is significantly polluted with domestic wastes. Accordingly, the monthly distribution of average chlorosity shows slight variations (Fig. 6). It ranges from 0.5 to 1.0 gm/L.

In the North-eastern regions, the sea water enters through the lake-sea connection under the influence of the prevailing North-westerly winds especialy during the winter. The inflow of the other types of water in this region is also decreased significantly during the so-called "drought period" . This period extends from 10th January to 2nd February. Consequently the lake water level especially in the North-eastern region is lowered enough to permit the inflow of the sea water. However the significance of this process is recently noticed to be of neglegable magnitude than in the past years. This is shown as an increase in the average chlorosity from the range 4.17 - 3.04 gm/L during the summer, autumn and early winter months to the range 9.61 - 4.18 gm/L during the period Januray May (Fig. 7). During 1970, the maximum chlorosity values were observed near El-Gamil lake-sea connection and El-Qabouti point and reached 11.22 gm/L which then dropped to 2.91 gm/L during October.

The water in the Western region is formed mainly from the mixture of El-Gammaliah and El-Serw drain waters with the Nile water from Inaniya and El-Ratama canals. Recently, El-Souffara canal is greatly influenced by the sea water from the estuary at the end of Damietta Nile branch. Hence it may be a source of relatively high chlorosity water type. This is indicated by the distribution of chlorosity 14.50 gm/L in the mouth of the canal during February 1970.

Away from El-Souffara canal, the chlorosity of the lake water fluctuated between an average of 4.38 and 1.00 gm/L (Fig. 8). The maximum values appear during December-February. The magnitude of difference between the maxima and minima is not so high as in the North-eastern region of the lake. However, it is not as low as in its South-eastern region.

The navigational route water is influenced by the North-eastern and Western waters. Its depth which exceeds 2.5 m, have an important influence upon the magnitude and direction of the spreading volumes of the different water types.

Station I has a depth of about 3.5 m and thus significant monthly changes are observed in its water chlorosity (Fig. 9). The maximum chlorosity was found during January 1971 at about 2.5 m depth. Progressive dilution takes place from February till October. During autumn, the water of minimum chlorosity 2.89 gm/L forms the layer at 0.5 - 2.5 m depth. At the end of December and the beginning of January, the chlorosity start to increase with the decrease in the lake water level.

A general South-weasterly decrease in the Navigational route water chlorosity is noticed. The isolines across the section which extends from station I to station 4 through the shallow North-eastern region and then westwardly through the navigational route to station, 8, explains the seasonal variations of its water chlorosity (Fig. 10 A—D). Slight monthly fluctualtions are observed in the water chlorosity at stations 4 & 5. The lowest chlorosity values appear at station 6.

The influence of the increase in the drainage water is detectable during the period April-October by the monthly distribution of the water chlorosity in between stations 6 and 7 (Fig. 1).

El-Maghraby et al (1963) recorded a maximum water chlorosity of 24.73 gm/L during July 1960. Wahby et al (1972) compared the chlorosity variation during 1963 and 1967 and found significant decrease in the water chlorosity in the Western and North-eastern regions. The above mentioned chlorsity (24.73 gm/L) found during 1960 was much higher than the maximum chlorosity 13.57 gm/L in the surface water of station I near the lake sea connection during 1971. It is even significantly higher than the maximum chlorosity 19.61gm/L of the denser near bottom water at station . I. This shows the gradual and annually progressive dilution of the lake waters.

The species composition of the plant and animal organisms especially the planktonic forms and fishes is expected to suffer corresponding changes parallel to changes in the water chlorosity. However, there is a great possibility that the fresh water organisms previously considered of minor importance could dominate the lake water in the future.

The titration alkalinity and pH variations :

The titration alkalinity of the water of the south-eastern region reached 4.05 - 4.35 ml. equivalent/L during autumn and winter. The average values range from 3.27 to 3.86 ml. equivalent/L. The waters in the North-eastern region show slight monthly variations in their titrstion alkalinity values. The monthly averages fluctuate between 3.09 and 3.79 ml. equivalent/L. The minimum values are observed during January. In the Western region the titratton alkalinity vary significantly according to the locality. Low values as 2.93, 2.98 mel. equivalent /L are met with during July in stations 12 and 14, whereas exceptionally high values as 4.05 - 4.20 are found during October and December in stations 11, 14, and 15. These values are nearly similar to the values found in the south-eastern region water during the same seasons. Generally the monthly average titration alkalinity values in the Western region fluctuate from 3.32 to 3.94 ml. equivalent/L.

The monthly average pH values in the North-western region are 7.40 - 7.20. Its minimum is detected during October. The hydrogen ion concentration is exceptionally low in the stations mostly influenced by the drainage water as in station 16. In this station the pH value may be as low as 6.63 during June, but during July the pH values fluctuate between 7.24 and 6.88 in the different western localities. The low pH value may be explained by the occurance of significant decay of organic matter and the probable accumulation of organic acids.

The inorganic phosphate variations :

The phosphate content in the south -eastern lake water fluctuates between the minimum of 1.8 to 1.3 ug-at PO_4 - P/L during the spring and autumn seasons and between the maxima of 2.9 to 4.1 ug-at PO_4 - P/L during the winter and summer seasons (Fig. 6).

The North-eastern waters attain lower inorganic phosphate concentrations than the South-eastern waters. The maximum value 1.42 ug-at PO_4 - P/L was observed during December 1970 at station 30 (i.e. : El-Qabouti Zone). The average values fluctuated between 1.35 to 1.27 and 0.59 to 0.56 ug-at PO_4 - P/L. The maxima correspond to April and December while the minima correspond to the winter and late summer (Fig. 7).

The Western region waters attain slightly higher phosphate content than in the North-eastern waters. In addition, they are characterised by slight monthly variation (Fig. 8). The maximum value of 3.00 and the average of 2.10 ug-at PO_4 - P/L are found during January. Generally, a tendency of the phosphate values to decrease with the increase of the water chlorosity is observed in the different regions as indicated in Figures (6 & 8).

The monthly change of the dissolved phosphate in station I is shown in Fig. 12. This station represents the mostly influenced locality by the sea water.

The phosphate maximum is attained during December. The minima (0.50 - 0.54 ug-at PO - P/L) dominate the surface water during January-February. But these minima characterise the high chlorosity denser water at 2.0 - 3.5 m depth during the period March - October. The surface water attains a range of 0.7 - 1.2 ug-at PO_4 - P/L . It represents diluted excess lake water outflow to the sea during March-December.

Figures (13.A-D) show the distribution of inorganic phosphate in the Navigational route during January, May, October and December. The maximum concentrations are attained during May. These maxima vary in its magnitude according to the dominating type of water in the route. The water, which occupies the shallow part in between stations I and 4, attains the highest chlorosity (5.0 - 19.0 gm/L). Its phosphate concentrations are less than 2.5 ug-at PO_4 - P/L.

The average phosphate concentrations in the southern part of the route waters especially between stations 6 and 7 (Fig. 14) reach its maxima of 2.90 - 3.88 ug-at PO_4 - P/L) during February - July. The minima of 1.10 - 1.50 ug-at PO_4 - P / L dominate this part during September - November. But during May, the water at station 8 attains values of 0.57 - 1.45 gm/L and about 4.45 ug-at PO_4 - P/L.

The previous studies (during 1962/1963) show the maximum average inorganic phosphate values to vary between about 4.35, 1.23 and 0.6 ug-at PO_4 - P/L in the South -eastern, North-eastern and Western regions (El-Wakeel and Wahby, 1970).

Generally, it is clear from the above mentioned observations that the inorganic phosphate content in the water of the different localities reflect some correlation with its type and origin .

The correlation between the pohosphate concentrations and the abundance the different aquatic organisms is a subject of economical importance. Salah (1961) showed that in Lake Mariut and Lake Edku, the maximum of annual average phytoplankton crop is reached during. April. Other phytoplankton growth outburst was observed during October. Both months are noticed to be characterised by the minimum dissolved inorganic phosphate in Lake Manzalah waters. Sverdrup et al (1942) concluded that the drop in either the carbon, nitrogen and phosphorus in the mineralised state in the sea waters could reasonably be supposed to indicate an equivalent incorporation into organic material. The drop in the dissolved inorganic phosphate may reach about 4.0 ug-at PO_4 - P/L in Lake Manzalah, which shows its high level of productivity. Harvey et al (1935) found that only a fraction of the phosphate removed from the water to be present in the form of plankton populations. Consequently, the actual reserve of this element in the lake is much higher than its detectable form.

The reactive silicate variations :

The reactive silicate concentrations in the South-eastern waters reacth their maxima of 365-417 ug-at SiO_3 Si/L during the autumn and winter months (Fig.3)

They drop to an average of 370 ug-at SiO_3-Si/L during the spring season. Anomalous values appear in the samples collected during the rough weather and from turbulent water.

In the North-eastern waters, the silicate concentrations fluctuates between considerably high and low values (Fig. 4). Concentrations of 715-678 ug-at SiO_3-Si/L appear during October in the water of the stations 2 and 32. Other low values of about 270 ug-at SiO_3-Si/L characterise the water at a distance of half kilometer opposite to the lake-sea connection during January and May. The waters in the shallower positions and away from the influence of the connection attained higher concentrations. The water turbulence intensify this variation.

The monthly variation of the silicate content at station I is shown in Figure (16) During October and November, the water at 1-3.5 m depth attains the maximum concentration of 613 ug-at SiO_3-Si/L . This concentration decreases gradually by time reaching 56 ug-at SiO_3-Si/L during February-June.

The average silicate concentration in the waters of the Western region fluctuates between 531 and 382 ug-at SiO_3-Si/L (Fig. 5) The minimum concentration of 339 ug-at SiO_3-Si/L is found at station 14 during January. A nearly similar minimum value is observed at station 12 during June. The maximum of 668-472 ug-at SiO_3-Si/L appears in the waters of nearly all the stations of the Western region during July and December.

The reactive silicate distribution with depth in the Navigational route (Fig. 15 A-D) shows clear variations. The minima range from 350 ug-at SiO_3-Si/L in the localities of highly diluted water to about 100 ug-at SiO_3 Si/L in the water of high chlorosity near the lake-sea connection. Anomalous values may be found at station 6. The monthly change in the silicate content of the diluted water in between stations 6 and 7, is represented in Figure (17). The variation of the detected silicate values in the bottom water layers is not highly significant as in the surface water. The low concentrations are frequently found at all depths during March-July.

The maximum silicate concentrations along the Navigational route are distinguishable during October. It ranges from 9000 to 500 ug-at SiO_3-Si/L (Fig. 15 C). The water in between stations 6 and 8 is shown in Figure (15 A) to attain

500—700 ug-at SiO_3 -Si/L during January. Some decrease is generally observed in the surface water of station I.

It is clear that the maximum silicate content in the lake water appaers during two periods (i.e. : October and January). In addition, the magnitude of this element may partially be used as a tracer of the inflowing type of water. This is also suggested by Harvey (1955) .Some difficulty may arise from the interference of temporary change in the silicate content because of the water turbulence and stirring of the sediments with its colloidal and reactive silicate forms. Hutchinson (1928) found that dilution with river waters will tend to rise the concentration of silicate. In addition, the silicon consumed by the diatoms or other organisms may return to solution after the death of the organisms. The seasonal difference between the maximum and minimum concentrations in a loclity could partially be be referred to the biological activity of the diatoms and probably other organissms.

CONCLUSIONS

The year to year variation in the average water temperature nearly follow that of the air and indicate insignificant values of about 1.0 - 2.0°C per month. But significant seasonal variations are indicated. The minimum water temperature is attained during late January while the maximum distribute during the the early August. Slight regional differences were observed in the average temppe ratur of water during July-August which do not exceed 3.5°C.

Three kinds of water are identified, according to their chemical characteristics in their Source Regions. They react and mix in the different parts of the lake. These kinds of water are :

1 — The "type of water attaining maximum chlorosity ..

2 — The "drainage water type ".

3 — The "polluted water type".

Each of these types of water attain its nearly specific chemical characteristics. Away from the Source Regions, a mixture of two or more of them, which may be subjected to other physical, chemical or biological factors, exist as a "modified kind of water". Hence, the concentration of the water chemical characteristics as related to the South-eastern, North-eastern, and Western rgion of the lake as well as in the Navigational Canal may be useful.

Seasonal fluctuations of the chlorosity and nutrient salts in every region water are clearly observed.

Since 1960, the annual dilution of the lake waters increased progressively with the icrease in the inflowing "Drainage Water". The variation in its average chlorosity show a future trend to facilitate the dominance of the drain and fresh water flora and fauna in the lake.

Significant influence of the Northern deep section of the Navigational route upon the increase in the salt content of the lake waters is oberved. The chlorosity of the lake waters increase with the increase of the sinking denser "maximum chlorosity water kind " from the sea water origin, in the deep nothern part of the route. This kind of water flow southwardly and mix with the waters in the adjacent regions through the turbulence and the other physical processes.

During 1970—71, the chlorosity maximum concentrations in the Southeastern North-eastern, Western and Navigational Canal waters were 1.01, 11.22, 4.38 and 19.61 gm Cl/L successively. The inorganic phosphate concentrations in the lake waters fluctuate between 7.64 and 0.50 ug-at PO_4 -P/L. The reactive silicate concentrations range from about 900 to 56 ug-at SiO_3 -Si/L.

The titration alkalinity are found to vary from 4.20 to 2.56 ml. equivalent/L.

The pH values may be found as low as .02 - 6.38.
The transparency of water in the differnt localities range from about 100 cm to 19 cm.

The range of variation of the dissolved inorganic phosphate and silicate is significant and suggest high productivity of the lake waters. The actual reserve of the nutrient salts appear to be much higher than their detectable amounts. In addition, the correlation between the different characteristics of waters need further study of their elements complex behaviour. This study may facilitate the future construction of mathematical expressions especialy concerning its water chemistry. It also help to improove the management of the lake fisheries.

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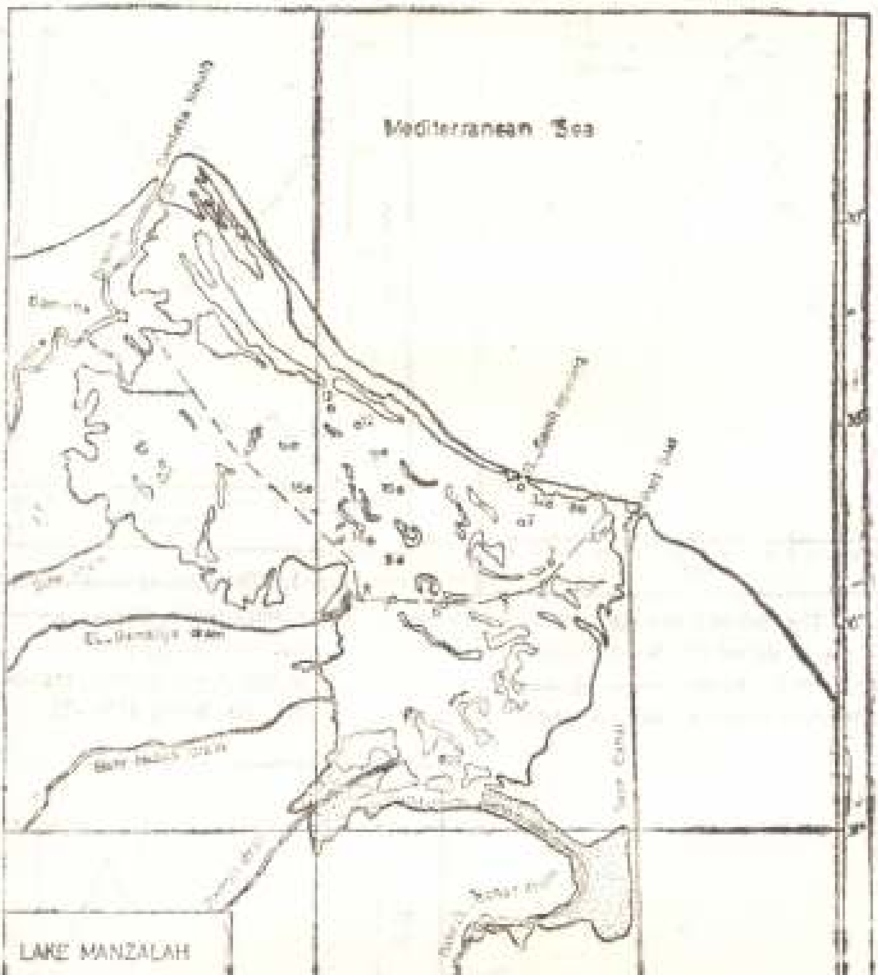

Fig. 1. The sampling position and the section taken along the artificial navigational route (dashed line) in Lake Manzalah. (Note : The stations 17—27 were enlisted for fishing experiments and hence out of scope of this work).

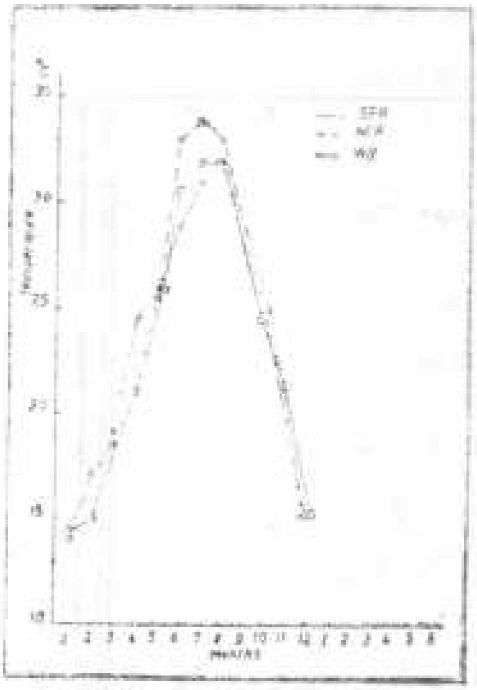

Fig. 2. The monthly average temperature in waters of South eastern (.......), North (— — —) and Western (———) Regions water.

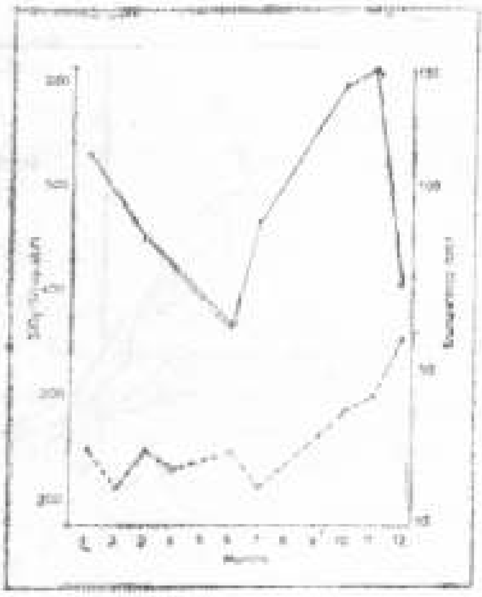

Fig. 3. The monthly variations in the average reactiv esilicate (———) and transparency values (— — —) in the South eastern regions of the lake during 1970—71.

Fig. 4. The monthly variations in the average reactive silicate (— —) in the North eastern regions of the lake during 1970—71.

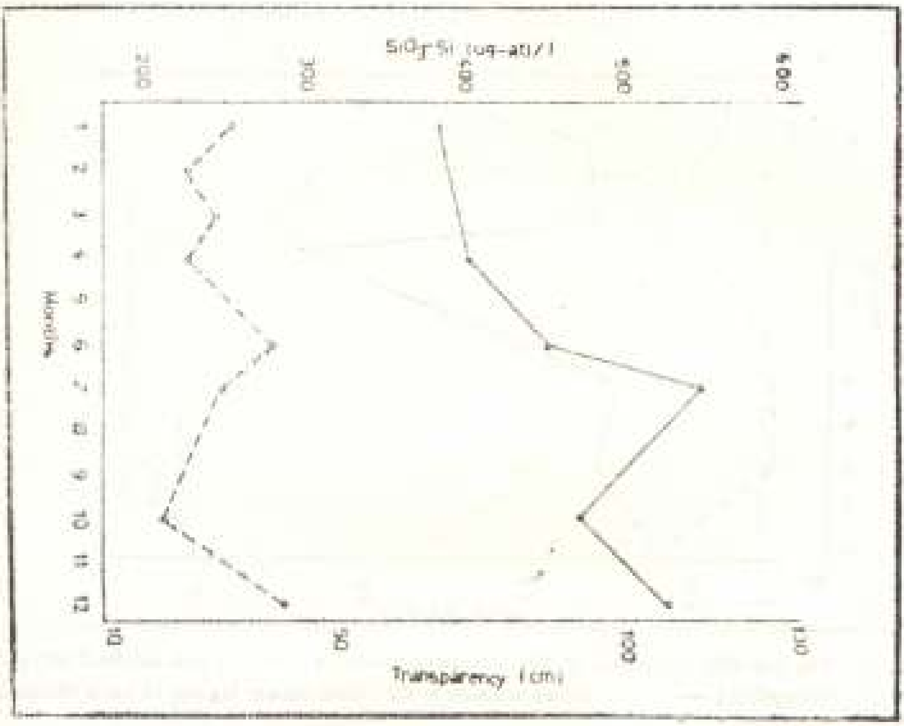

Fig. 5. The monthly variations in the average reactive silicate (——) and transparency values (— — --) in the Western regions of the lake during 1970 -71

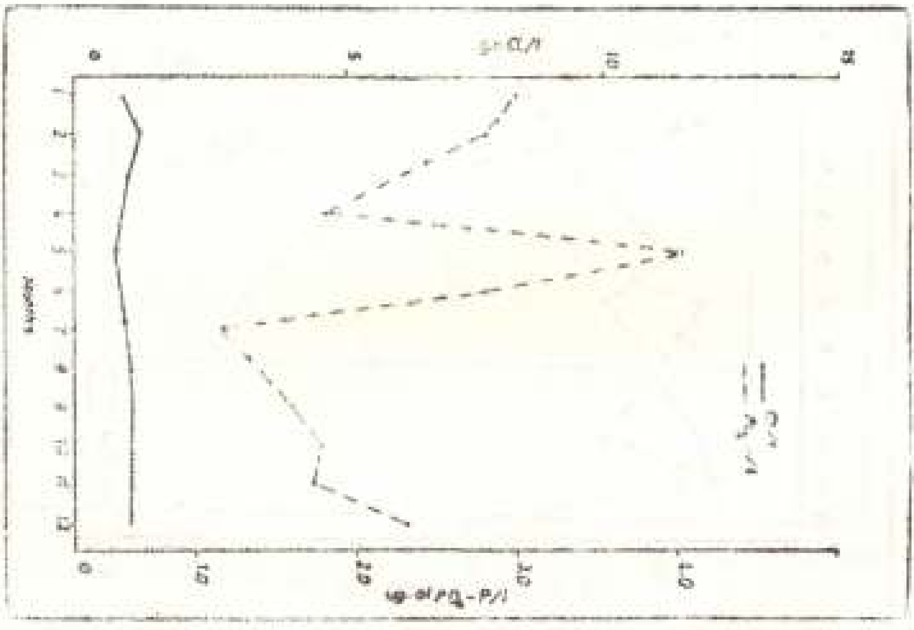

Fig. 6. The monthly variations in the average chlorosity (......) and inorganic phosphate (— — —) concentrations in the South eastern regions of Lake Manzalah.

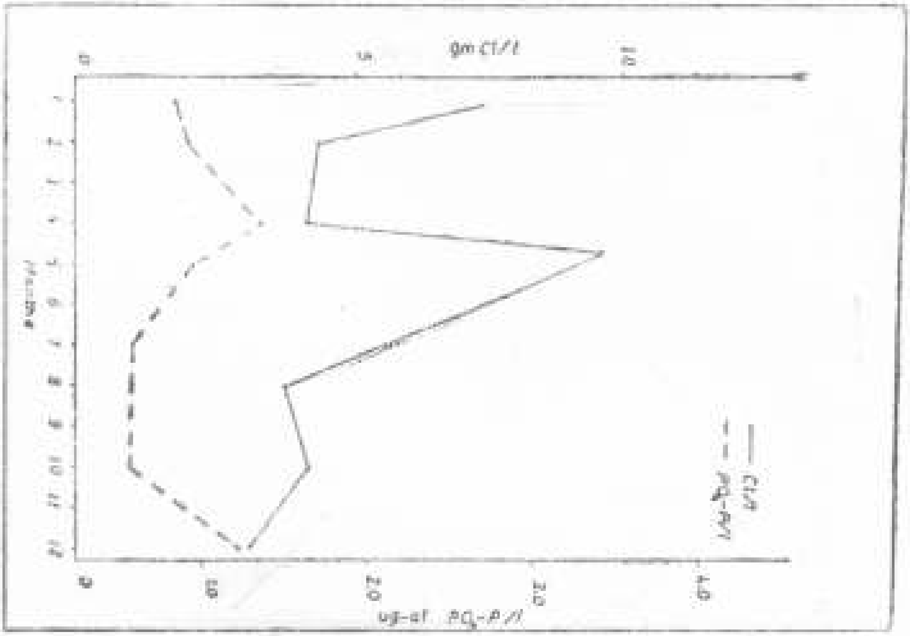

Fig. 7. The monthly variations in the average chlorosity (——) and disolved inorganic phosphate (— concentrations in the North eastern regions of Lake Manzalah.

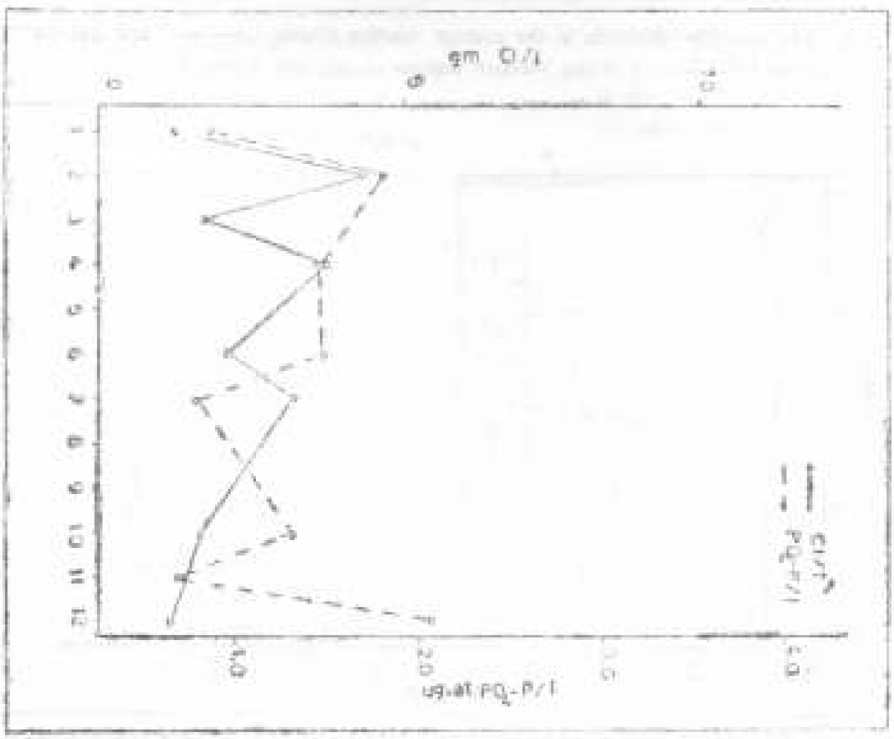

Fig. 8. The monthly variations in the average chlorosity (——) and dissolved inrganic phosphate (— — —) concentrations in the Western regions of Lake Manzalah.

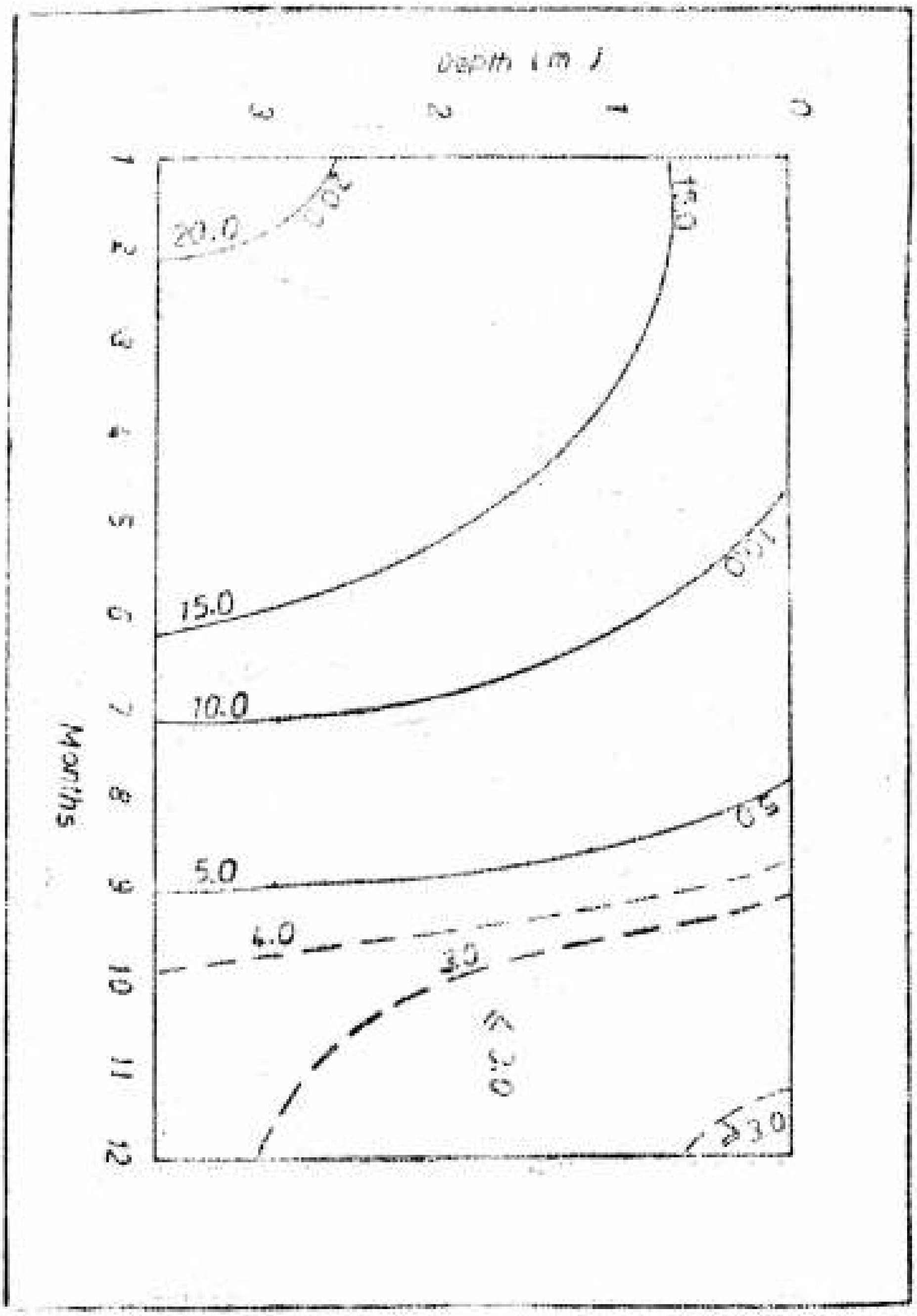

Fig. 9. Isopleth diagram showing the change in the average chlorosity (gm. Cl/L) in the water column 0—3.5 m, from month to month in station I, during 1970—71.

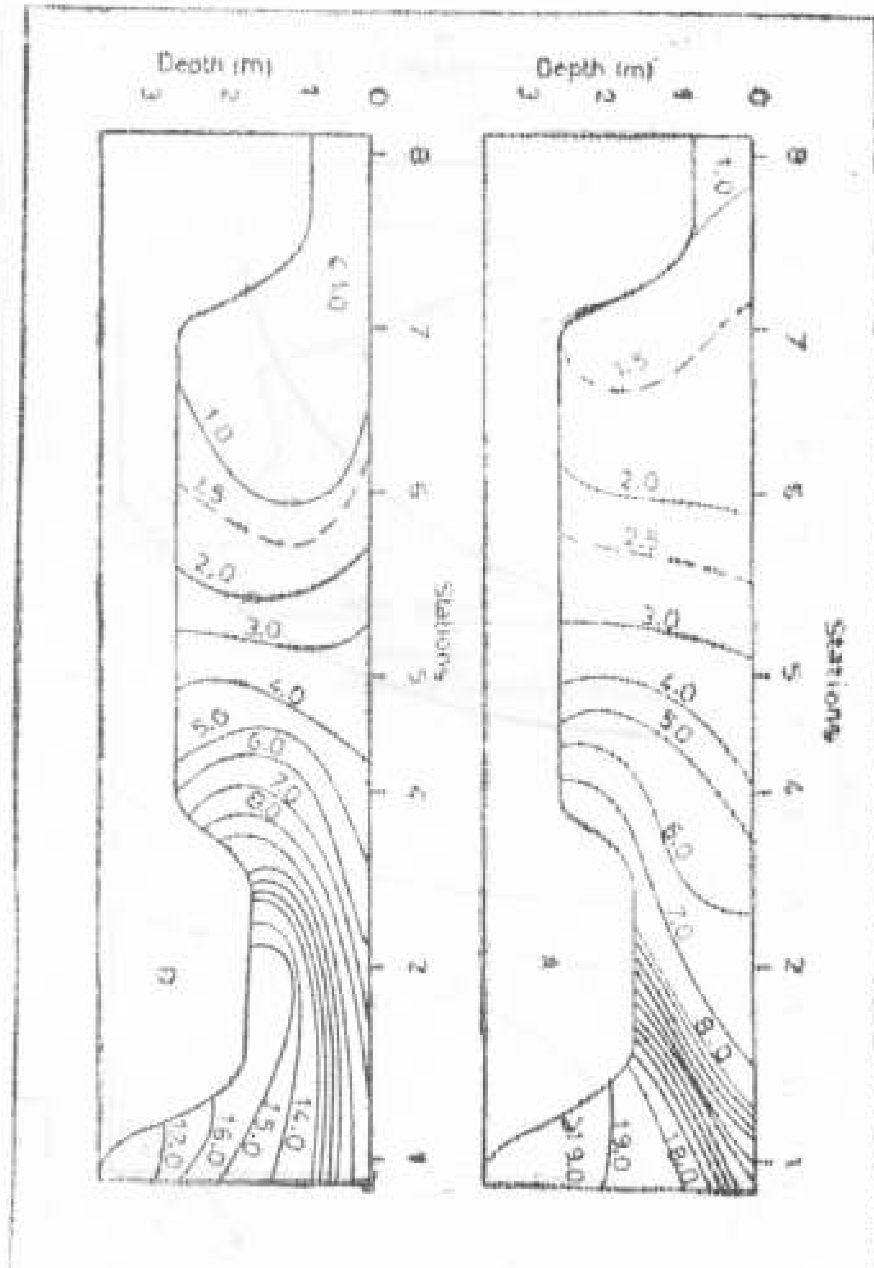

Fig. 10. The distrbution of the average chlorosity isolines across the section taken from station 1 to station 8 through the navigational canal during (A) January, 1971, (B) May, 1970,

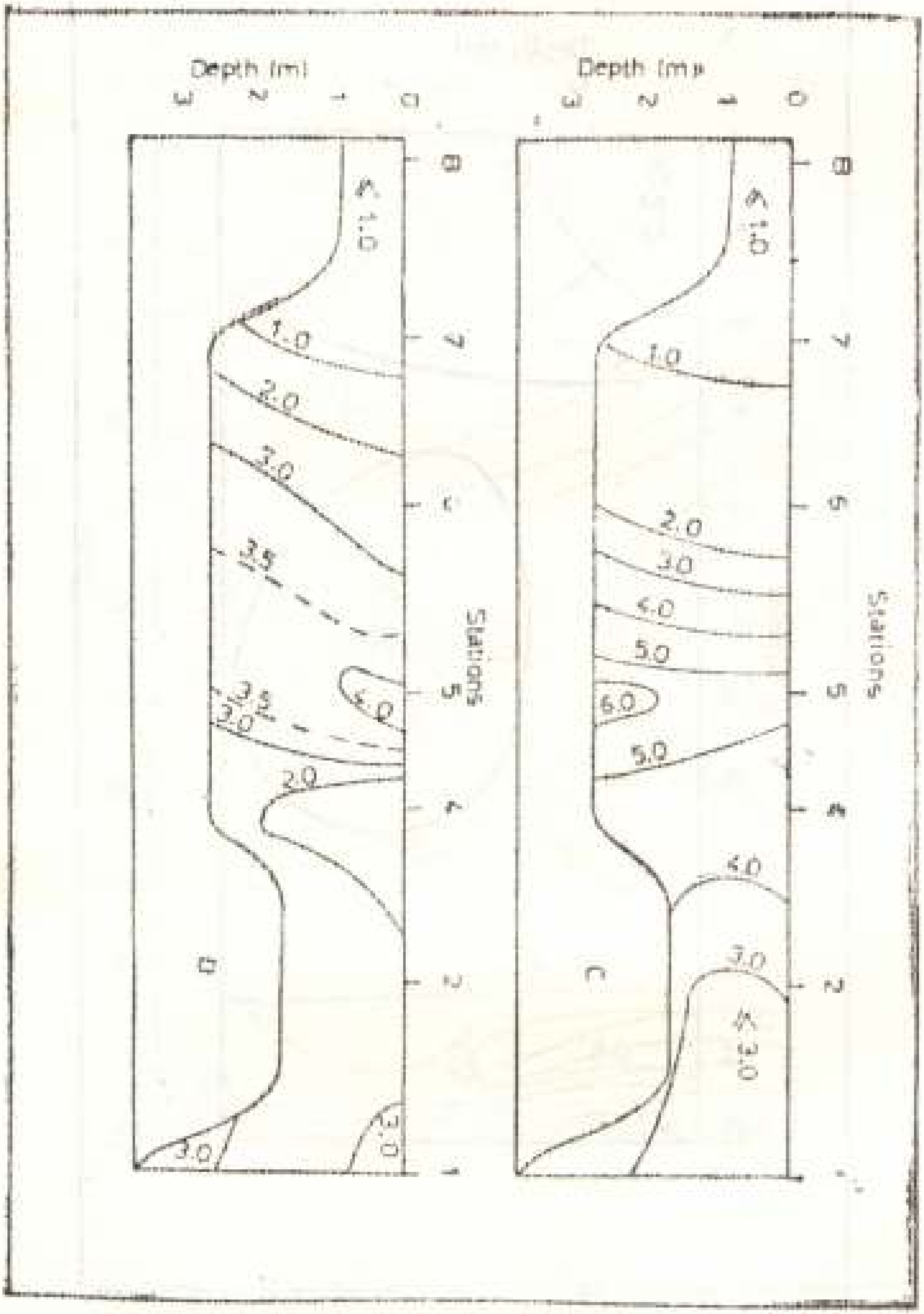

Fig 10. (C) October 1970 and (D) December, 1970.

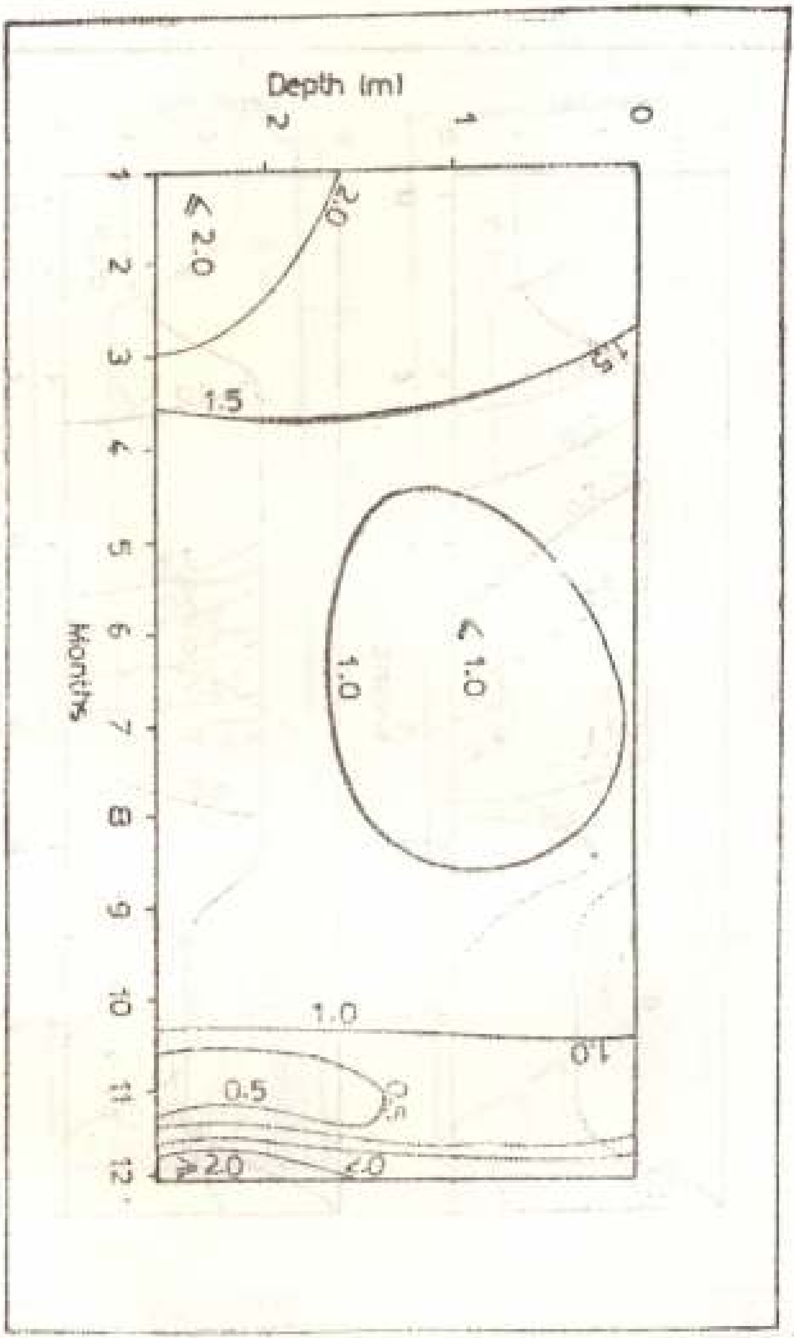

Fig. 11. Isopleth diagram showing the change in the average cholrosity (gm. Cl / L) in the water column 0—2.5 m, in a position midway between station 5 and 6, from month to month during 1970—71.

LAKE FISHERIES

Lake fish production and its importance

Lake Manzala is one of the major sources of fish production in Egypt. Estimates based on the fisheries statistics of the country for the years 1962—1968 show an increasing percentage of the lake production relative to the annual fish yield of Egypt (Table 2). It varies between about 20% in 1962 and 53% in 1967. However, it is to be noticed that the production of inland waters, lagoons and Lake Borollos is not included in the Reports of Statistics of Fisheries in A.R.E. The same should be taken into consideration when studying the importance of Lake Manzala for mullet fishery (p. 44 & Table 5). Moreover, it was found necessary for comparison to add to the total country fish production during 1962—1964 (Table2), 2000 metric tons which is nearly the utmost annual production of Lake Quarun during 1965—1968.

Table 2 — The percentage of fish production of Lake Manzala and the other sources in Egypt during 1962—1968.

Year	Total** discharged Nile water x 10^9 m³	Total country fish production (tons)	% of fish production			Total production of Lake Manzala (tons)	Discharged+ water into Lake Manzala x 10^9 m³
			Red & Mediterranean Seas	Lake Manzala	Other lakes		
1962	42.9	94159	65.7	20.2	13.0	19396	5.63
1963	42.9	91740	62.6	21.2	16.2	19410	5.96
1964	52.9	81233	54.3	26.9	18.8	21862	6.06
1965	18.0	72543	54.4	26.3	19.1	19186	6.11
1966	traces	62461	43.4	40.2	16.4	25129	6.28
1967	traces	51161	36.2	52.9	10.9	26649	5.81
1968	—	52049	44.1	47.6	8.3	24757	5.20

** (Data provided by the Delta Barrage Directorate, Ministry of Public Works, "after Halim *et alii*, 1967").

+ (Data provided by both El-Sharkiya and Eastern of Dakahliya Irrigation Directorates, Ministry of Public Works).

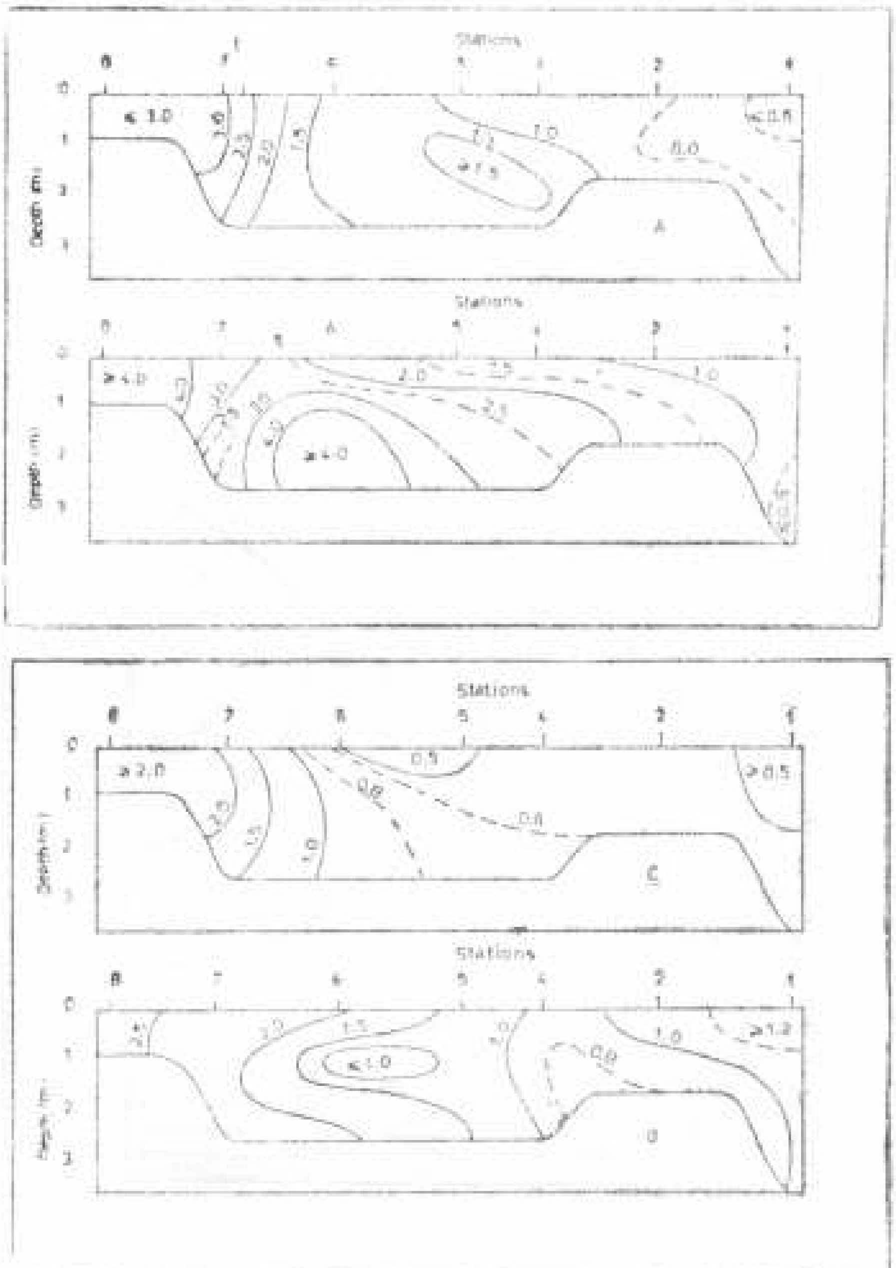

Fig. 13· The distribution of the average inorganic phosphate (ug-at PO_4 -P/L) isolines at the section taken from station I to station 8 through the navigational canal during (A) January 1971, (B) May 1970, (C) October 1970 and (D) December 1970.

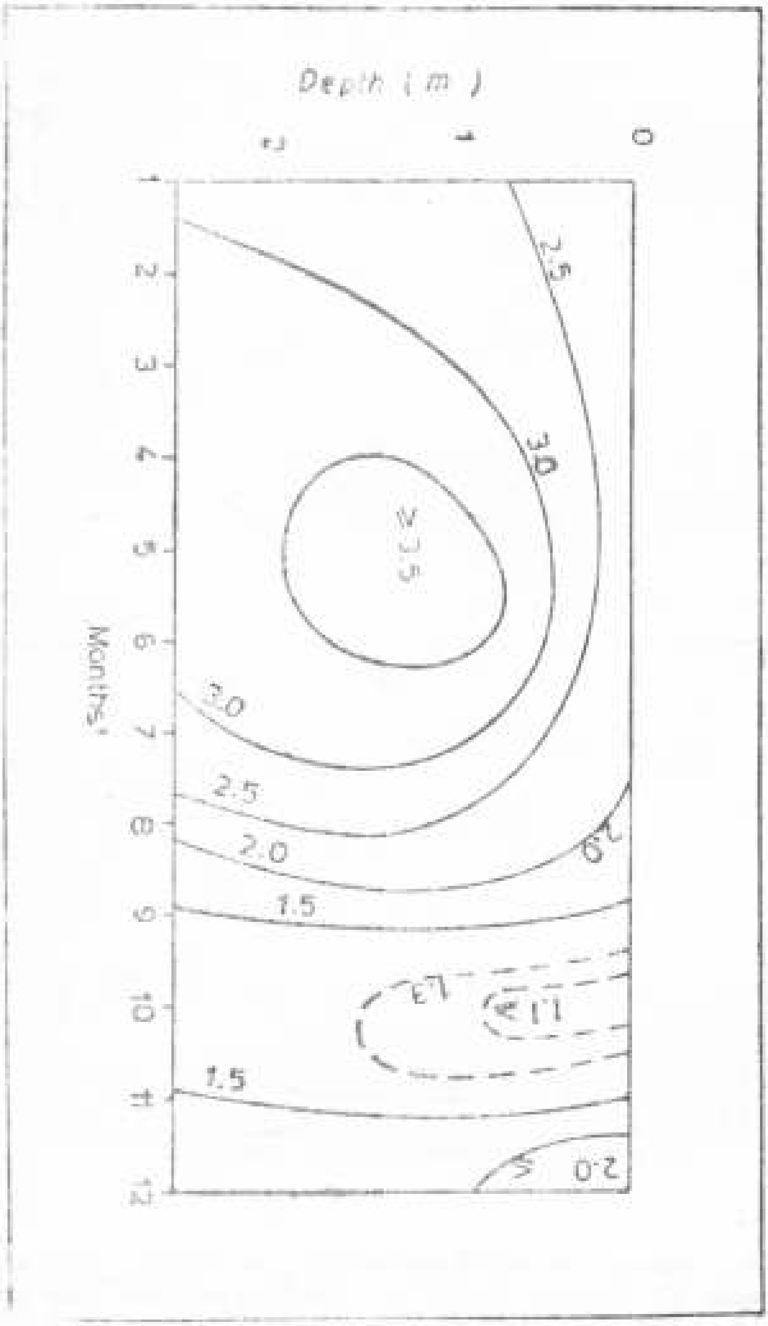

Fig. 14. Isopleth diagram showing the change in the average inorganic phosphate concentrtaion (ug-at. PO_4-P/L) in the water column 0—2.5 m, from month to month in a position midway between station 5 and 6 during 1970—71.

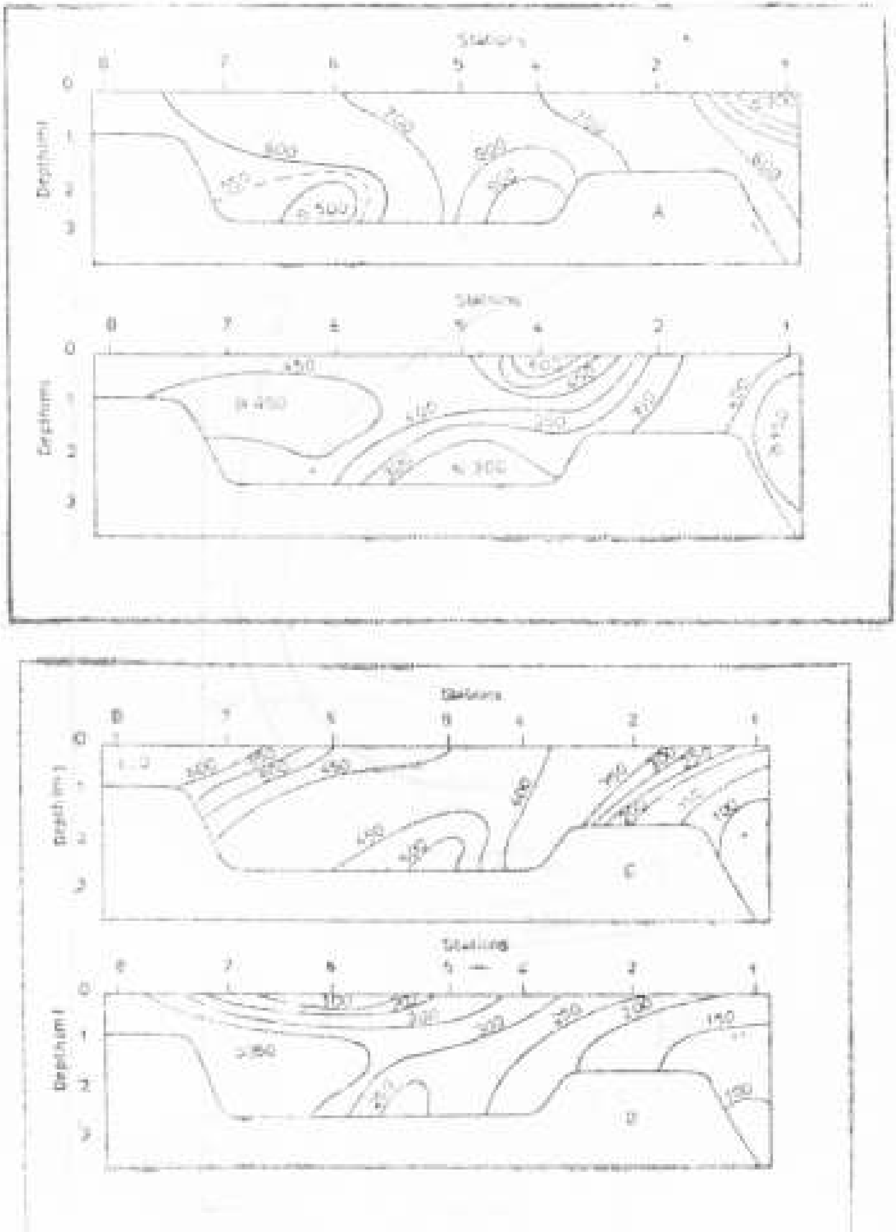

Fig. 15. The distribution of the average reactive silicate (µg-at SiO_3 Si/L) isolines across the section taken inbetween station 1 and 8 through the navigational route during (A) January 1971, (B) May 1970, (C) October 1970, and December 1970.

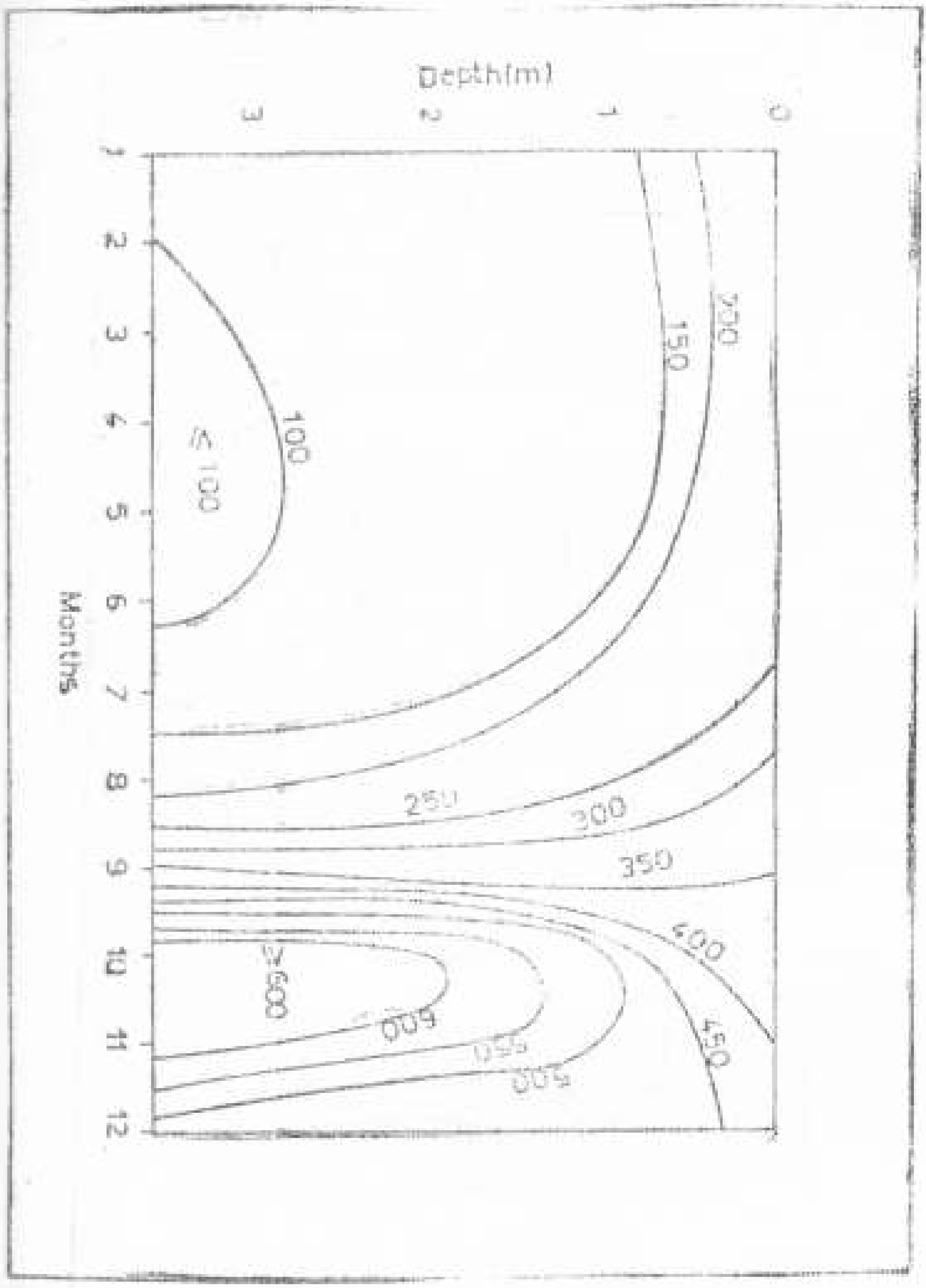

Fig. 16. Isopleth diagram showing the average reactive silicate (µg-at SiO_3 -Si/L) in the water column 0—3·5 m, from month to month in station I during 1970—71.

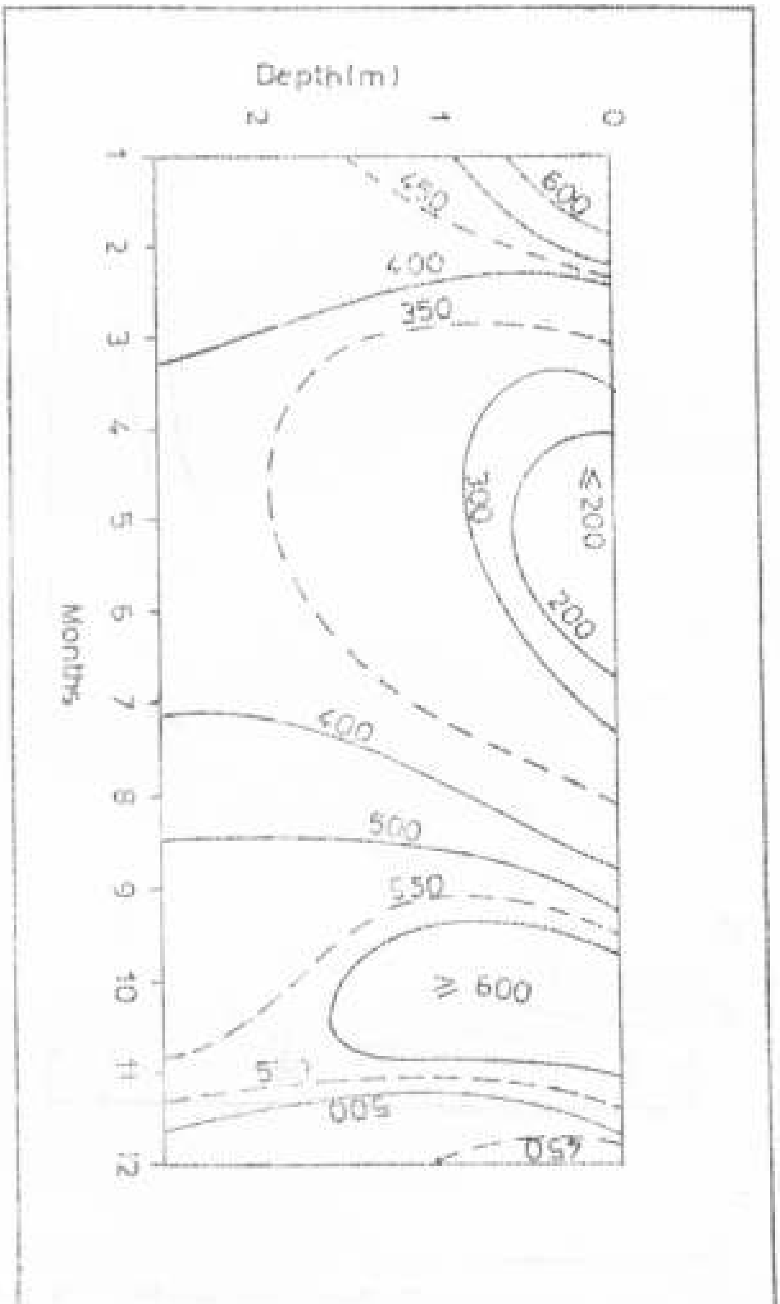

Fig. 17. Isopleth diagram showing the average reactive silicate (ug-at SiO_3 -Si/L) in the water column 0—2.5 m, from month to month in a position midway between station 5 and 6 during 1970—71.