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Distribution of the major ions in Lake Nasser
I. Major anions

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The completion of the Aswan High Dam in 1964 produced a permanent large impoundement; the High Dam Lake extending for 480 km, with the northern two thirds ih Egypt (Lake Nasser) and the southern third in Sudan (Lake Nubia). Seasonal and regional distribution of major anions in Lake Nasser was investigated. The irregular vertical distribution of anions might be attributed to the effects of various physico-chemical and biological factors. The increase in the rate of evaporation in August was accompanied by the maximum seasonal average temperature value. The minimum and low seasonal average values of bicarbonate in May and August accompanied by the high and maximum seasonal averages of carbonate coincided mainly with the decrease in solubility of carbonate by elevation of temperature those months. The highest evaporation rate in May and August was mainley responsible for the highest seasonal average concentractions of chloride those months. The maximum seasonal average sulphate value in April might be attributed to the increase in dissolved oxygen concentration from the high rate of photosynthesis in spring. The decrease in the regional average values of sulphate and chloride in the southern region of the lake coincided possibly with dilution by the flood waters. The highest regional average bicarbonate concentrations accompanied by the lowest regional average carbonate values in the northern area of the lake coincided in the main with the stagnation condition, where the CO_2 produced from decomposition of organic matter converted the carbonate into bicarbonate.

INTRODUCTION

Development of the river basins for conservation and better utilization of the waters for agriculture and power generation has gained importance all over the world. In the African continent, small and large dams have been erected on several rivers to assist in the development of natural resources. A few of the created man-made lakes are very large, such as Kariba Lake, High Dam Lake and Volta Lake.

The completion of the High Dam near Aswan in 1964 did not create a new lake, but instead produced a permanent impoundment of much greater size. The Aswan High Dam Lake is considered as the second largest man-made lake in the world. It extends over an area of about 480 km, with norhern-two thirds in Egypt representing Lake Nasser (Fig. 1), and southern third in Sudan (Lake Nubia).

The High Dam Lake is unique in its performance, because it is situated in pure desert where it is surrounded by rocky terrain. To the west is the great Sahara Desert and to the east is the Eastern Desert extending to the Red Sea. The yearly mean precipitation does not surpass 4 mm/year and the rate of evaporation is very high around 3000 mm/year. The only source of water is the Nile river with its inflow in the South. The outflow at Aswan is the continuation of the Nile river towards the north.

The lake has a long narrow shape with a number of side areas, called "Khors". The number of important khors is one hundred, 58 of

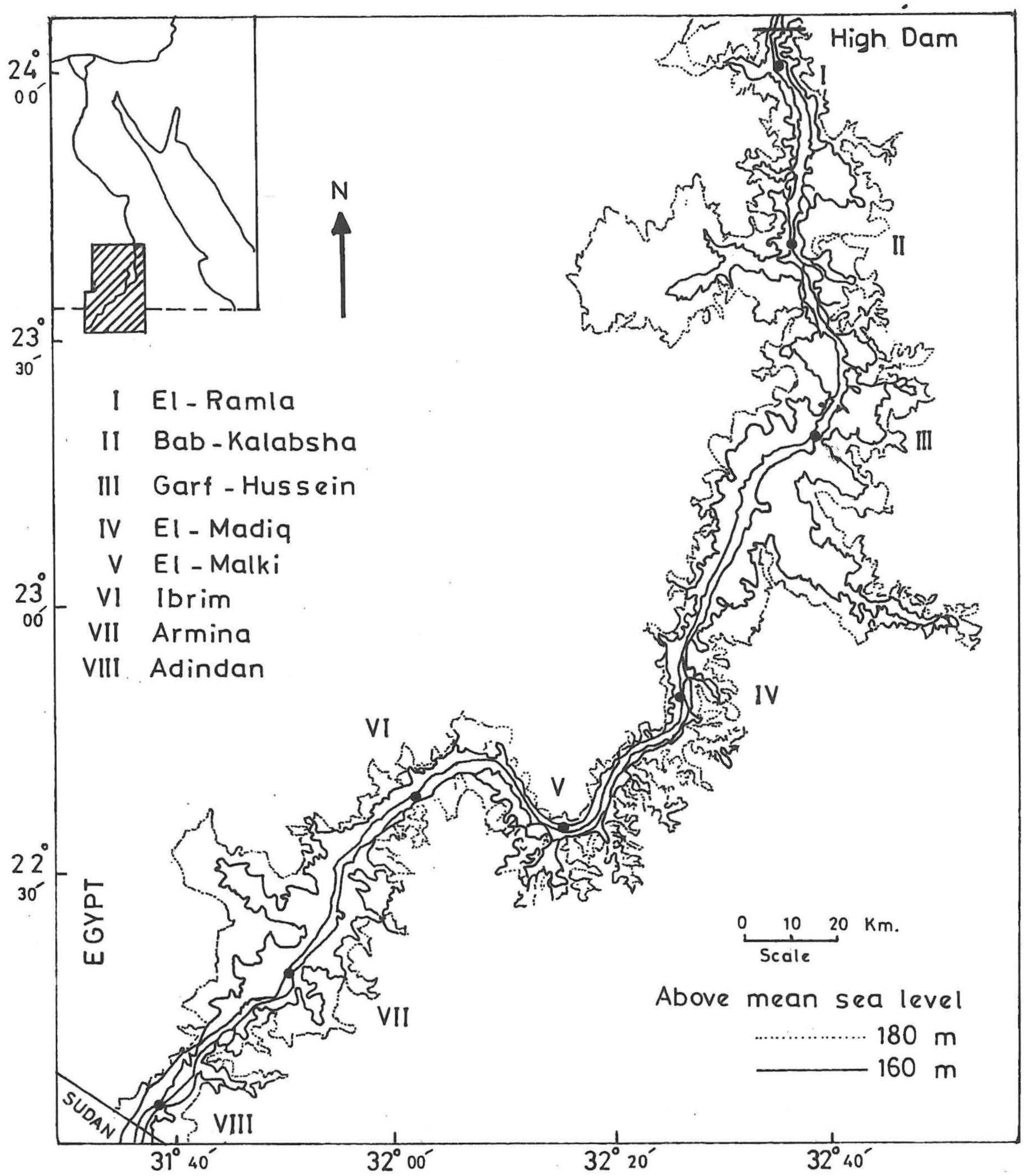

Fig. 1. Map of Lake Nasser showing position of stations.

them being located on the eastern side and only 42 on the western shore. The number of these khors is expected to decrease with the progressive rise of water level in the lake, where the neighbouring khors will be diffused to from single ones.

The deepest part of the High Dam Lake is found near the High Dam, reaching approximately 85 m. The water depth of this lake decreases towards the south, reaching about 15 m at Akasha in the Sudan.

The storage of the Nile water in the High Dam reservoir started in May 1964 after the conversion of the river's course, with a water level of 106 m. a. s. l. at the end of July 1964. The lake was half full in 1969 at about 160 m. a. s. l. and the filling process has continued up to 1971. At that time, the filling process was interrupted and the water level has dropped in the following period, due to the extremely dry weather along the blue Nile. However, an increase was regained in 1973-1974 (ENTZ, 1976). During the period 1975-1980, the minimum levels of the High Dam Lake ranged from 165.6 to 173.0 and the maximum from 175.7 to 177.5 m.a.s.l. During the study period (April 1981-May 1982), the minimum water level (171.56 m. a. s. l.) was found in July, just before the start of the new flood period, which was in August. Accordingly, the lake level increased gradually from September reaching its maximum of 175.88 m. a. s. l. in November, then decreased gradually in the following months (Fig. 2). This is due to the discharge through the High Dam for agricultural demands and other needs, in addition to some amounts of water lost by evaporation. Consequently, the level of 180 m above sea level (full capacity of the lake) has not yet been reached in the lake until the period of the study. At this highest level of the High Dam Lake, the length of its shoreline, its surface area and volume will reach about 9072 km, 6276 km^2 and 157 km^3, respectively.

The High Dam Lake was subjected to relatively several studies dealing with its physicochemical characteristics. However, information on the major ions in the water of this lake is scanty. The present work has been undertaken to investigate the regional and seasonal distribution of the major anions in Lake Nasser.

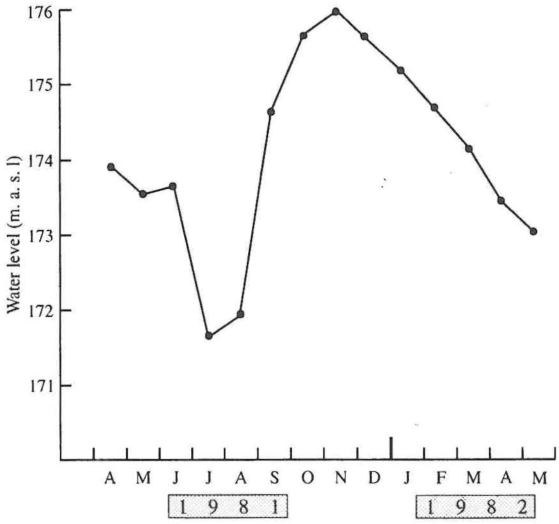

Fig. 2. Monthly variations of the daily average water levels (m. a. s. l.) in Lake Nasser during 1981-1982.

CLIMATIC CONDITIONS

Climatological data prevailing during the study period were obtained from the Meteorological Department, which has a floating station in Lake Nasser lying in front of the High Dam. Tha data recorded by this station (Table 1) reflect the climatic conditions of the nothern part of Lake Nasser. The tropic of Cancer crosses the High Dam Lake; the major part is situated within the tropics and only a small proportion in the nothern Mediterranean zone. According to HUTCHINSON (1957), Lake Nasser is classified as monomictic subtropical lake. The whole lake is subjected to a significant degree of seasonality. The daily average lowest minimum and maximum air temperature readings were recorded in February, whereas the highest minimum and maximum measurements were registered in July and June, respectively. The minimum air temperatures ranged from 11.5 to 27.0°C and the maximum from 20.4 to 38.3°C.

According to ENTZ (1976), the dominant wind direction in Lake Nasser is from N-NW

Table 1. Monthly variations of the daily average readings of the climatological conditions recorded by the Mateorological Station in Lake Nasser during 1981-1982.

Months	Temperature °C		Wind Vel.	Evaporation	Humidity
	Max.	Min.	(Knots)	(mm)	(%)
April 1981	32.9	20.2	7	16.0	30
May	35.6	22.8	7	20.9+	22–
June	38.3+	26.1	6–	19.9	24
July	38.1	27.0+	7	18.4	29
Aug.	38.2	26.4	7	20.8	26
Sep.	36.5	24.7	7	18.9	30
Oct.	35.4	23.6	6–	18.0	29
Nov.	24.4	15.1	8+	12.5	40
Dec.	24.2	13.6	7	11.5	43
Jan. 1982.	23.1	13.2	7	9.5	48+
Feb.	20.4–	11.5–	7	9.4–	43
Mar.	24.6	14.6	8+	13.7	34
April	33.1	20.1	7	15.6	32
May	34.4	22.5	7	19.6	27

N.B. The minimum values are designated by (–) and the maximum by (+).

(83.3% of windy days), blowing along the main channel or towards the lake center in the khors of the western side and towards the shore in the opposite eastern khors. The wind velocity ranged from 6 knots in June and October to 8 knots in March and November.

No rainfall occurred during the period of study. The lake region is generally rainless, with negligible occasions. The sky is clear, cloudless during most of the year.

Evaporation from the surface of the lake seems to be one of the most important features. Losses by evaporation in impoundments are generally high and those of the Aswan High Dam basin are enormous (RZOSKA, 1976). The rate or evaporation ranged from 9.4 to 20.9 mm in February 1982 and May 1981, respectively. The high values of evaporation during June-October coincided with the considerable rise of temperature during this period.

The percentages of relative humidity fluctuated between 22% in May 1981 and 48% in January. Relative humidity gave, in general, higher values in late autumn and winter, whereas in summer, the values were lower.

MATERIAL AND METHODS

Water spamles were collected from Lake Nasser, using a hydrobiological research vessel. Sampling was carried out seasonally in April, August, November 1981 and February 1982, representing spring, summer, autumn and winter, respectively. In addition, water samples were collected in May 1982 to represent late spring. Eight stations were selected along the whole length of the lake to represent different regions. These locations, starting from the High Dam in the north towards the south; i. e. from station I to VIII, are El-Ramla, Bab-Kalabsha, Garf-Hussein, El-Madiq, El-Malki, Ibrim, Armina and Adindan. These stations are about 10, 44, 88, 143, 177, 220, 260 and 296 km south of the High Dam, respectively (Fig. 1). Water samples were collected at several depths at each station, using reversing Nansen water sampler.

Water temperature was recorded at the time of sampling, using standard reversing protected thermometers. The major anions were determined according to American Public Health Association (1975). The chloride values were determined by the argentometric method. The bicarbonate and carbonate contents were calculated from the titrimetric determination of alkalinity. The sulphate was determined by the turbidimetric method.

The statistical results were produced on the IBM-AT microcomputer, employing the statistical analyses module of the second generation data base management system "FOCUS". All statistics were computed from the average values (averages of all depths at each station). The correlation coefficients were calculated between each pair of the major constituents, as well as between total cations and anions. The correlation matrices were constructed from the resulting correlation coefficients. Different levels of significance were obtained from the Table of MURDOCH and BARNES (1970.) The relationship between the major constituents were represented in the form of "correlation constellation".

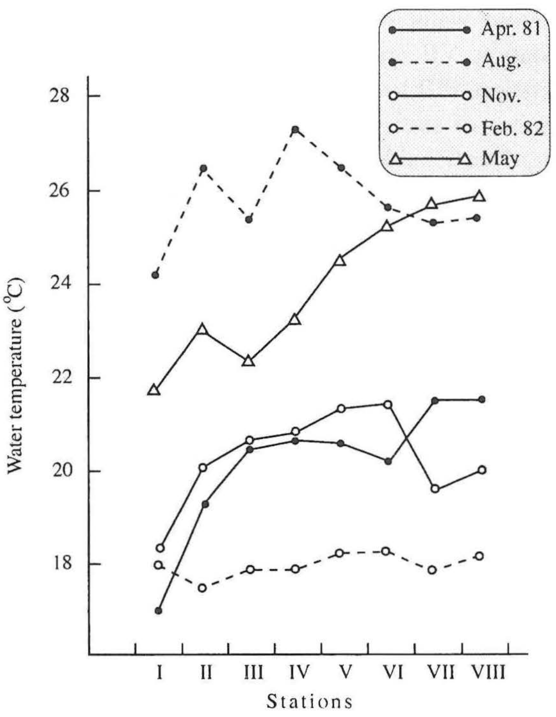

Fig. 3. Variations of the average values of water temperature (°C) in Lake Nasser during 1981-1982.

RESULTS

Water temperature

Distribution of temperature generally showed a decrease with depth. The temperature differences between the surface and bottom readings were generally lower in November and February than in April, August and May. The vertical readings ranged from 16.5°C at 20 m depth of station I in April to 31.0°C at the surface of station VIII in May. The average values (averages of all depths at each station) showed noticeable local variations, ranging from 17.0°C at station I in April to 27.3°C at station IV in August (Fig. 3). The seasonal average values (averages of all stations in each season) gave a maximum in August and a minimum in February (Fig. 8).

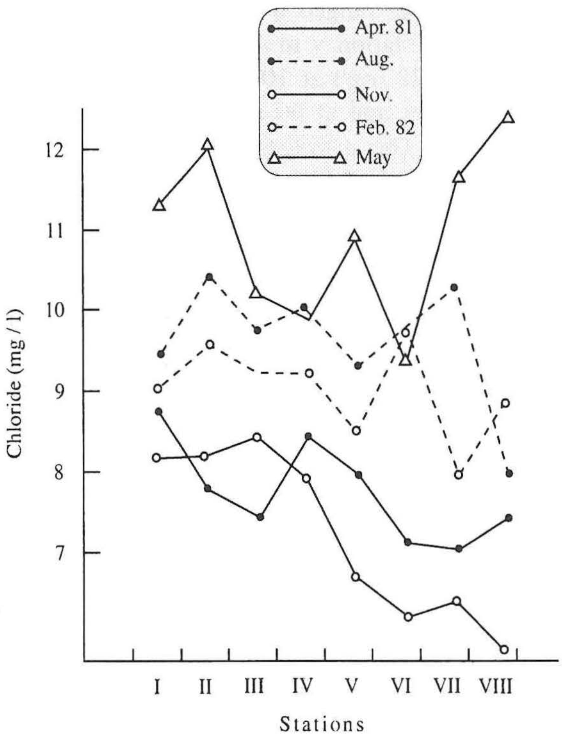

Fig. 4. Variations of the average of chloride in Lake Nasser during 1981-1982.

Chloride

The vertical values of chloride had generally irregular distribution. The concentrations varied from 6.13 mg/l in November in the boottom water of stations VI, at 10 m depth of station VII and in the whole water colum of station VIII to 13.67 mg/l in May in the bottom water of station VIII. The average values showed noticeable local variations, ranging from 6.13 to 12.39 mg/l station VIII in November and May, respectively (Fig. 4). The averages in May at most stations were higher than in the other seasons, leading to the maximum seasonal average value of 11.02 mg/l that month. In November, the averages were lower at the majority of locations, as indicated by the lowest seasonal average value of 7.47 mg/l that month (Fig. 8). The regional average values (averages of all seasons at each station) showed irregular fluctuations along the lake, ranging from 8.60 mg/l at station VI to 9.69 mg/l at station II (Fig. 9). The average concentration of chloride for Lake Nasser during the study period was 9.08 mg/l (Fig. 10).

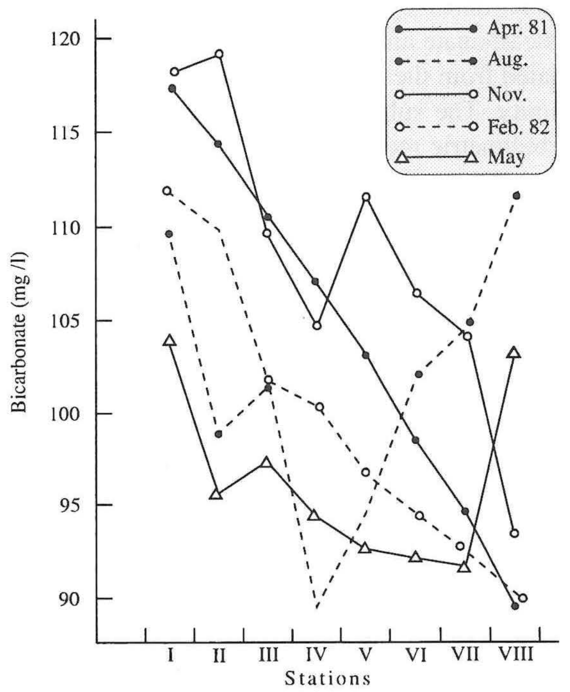

Fig. 5. Variations of the average values of bicarbonate in Lake Nasser during 1981-1982.

Bicarbonate

It showed irregular vertical variations. The vertical values ranged from 72 mg/l at 5 and 1 m depths of station V in August in May, respectively, to 122 mg/l at 10 m depth of station II in November and at 40 m depth of station VI in August. The averages were lower at most stations in May and higher at some locations in November, as shown from the seasonal minimum (96.42 mg/l) and maximum (108.35 mg/l) averages found in May and November, respectively (Fig. 8). The average values ranged from 89.67 mg/l at station VIII in April to 119.14 mg/l at station II in November (Fig. 5). The regional average values fluctuated between 97.57 mg/l at station VII and 112. 14 mg/l at station I (Fig. 9). The average concentration of bicarbonate calculated for Lake Nasser was 102.08 mg/l (Fig. 10).

Carbonate

The vertical distribution of carbonate was irregular, although a decrease with depth has frequently occurred. Carbonate disappeared from the whole water column in November at stations I and VIII, as well as at station VIII in August. Depletion of carbonate has generally

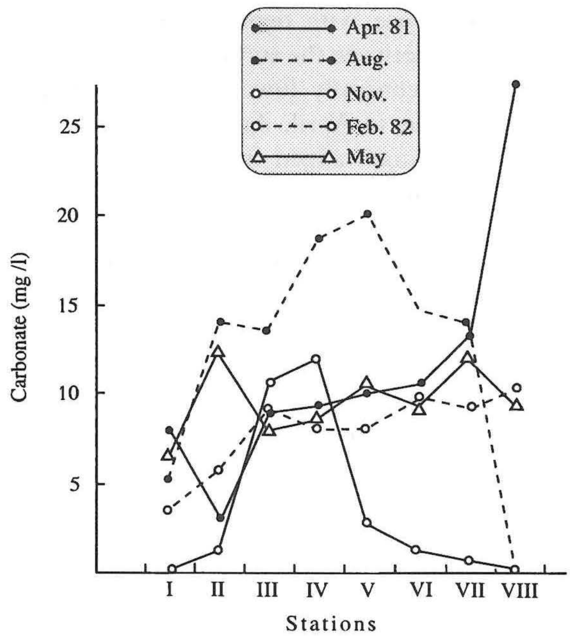

Fig. 6. Variations of the average values of carbonate in Lake Nasser during 1981-1982.

occurred in the lower water column in several seasons. The values fluctuated between 4 mg/l in several samples and 48 mg/l at 1 m depth of station V in August. The average values showed considerable local and seasonal variations, ranging from 0.57 mg/l at station VII in November to 27.33 mg/l at station VIII in April (Fig. 6). Lower average values were observed in November at several stations and depletion occurred at stations I and VIII, leading to the minimum seasonal average value that month (3.24 mg/l). The highest average values, however, were found at most stations in August, as indicated from the maximum seasonal average value of 12.55 mg/l that month (Fig. 8). The regional average concentrations varied from 4.7 to 11.07 mg/l at stations I and IV, respectively (Fig. 9). The average carbonate value for Lake Nasser was 8.91 mg/l (Fig. 10).

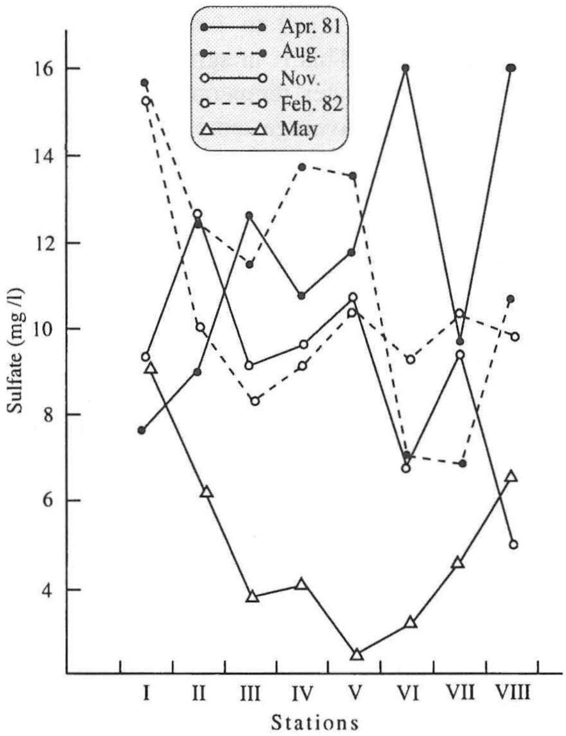

Fig. 7. Variations of the average values of sulphate in Lake Nasser during 1981-1982.

Sulphate

The concentrations showed irregular vertical variations, ranging from 0.80 mg/l at 5 m depth of station V in May to 34.73 mg/l at the bottom of station I in August. The average values generally showed remarkable local and seasonal variations, fluctuating between 2.53 mg/l at station V in May and 16.14 mg/l at station VI in April (Fig. 7). Lower averages were observed at most stations in May, as shown from the minimum seasonal average value of 5.14

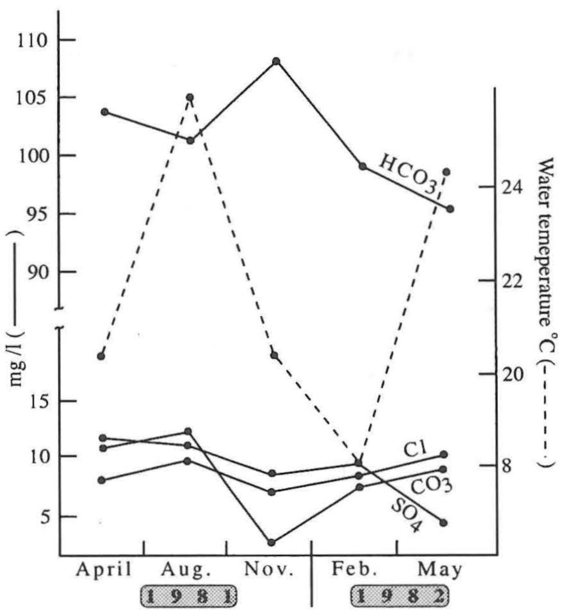

Fig. 8. Seasonal average values of water temperature (°C) and anions in Lake Nasser during 1981-1982.

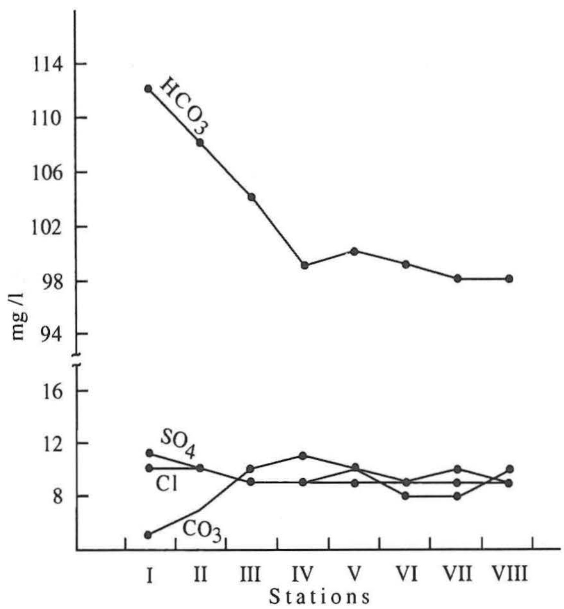

Fig. 9. Regional average values of anions in Lake Nasser during 1981-1982.

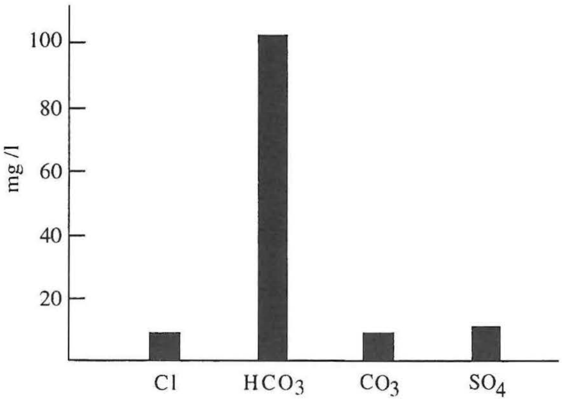

Fig. 10. Mean annual values of anions in Lake Nasser.

mg/l that month. The maximum seasonal average value reached 11.66 mg/l in April (Fig. 8). The regional averages fluctuated between 8.17 mg/l at station VII and 11.48 mg/l at station I (Fig. 9). The average value of sulphate calculated for Lake Nasser was 9.52 mg/l (Fig. 10).

DISCUSSION

According to WELCH (1935), all waters in nature contain dissolved solids. As might be expected, the quality and quantity of these solids vary remarkably in different waters; they also differ in the same water, due to certain factors including season and location. The major constituents are those ions that in principal select which organisms may occur in the water (GOLTERMAN, 1975). Major elements are necessary constituents of the living matter of organisms and in case of aquatic animals a proportion of them comes from the food (BEADLE, 1981). The loss of an ion can result from factors, such as ionexchange, plant or animal uptake and selective precipitation (MUIR and JOHNSON, 1978).

Water Temperature Variations

A positive correlation was found between chorophyll *a* and temperature. This is an expected result, as the rate of photosynthetic activity and concurrent algal growth are temperature dependent (WETZEL, 1975).

DENNY (1972) pointed out that the vertical temperature profile is often used as a guide to the interpretation of the hydromechanics of a lake, but can sometimes be missleading. The general trend of the vertical water temperature distribution in Lake Nasser was the decrease with depth, which was explained by SAAD (1978) to be due to the heating effect of the sun on the surface water and the transference of heat throughout the water column by mixing process. The vertical temperature values in May and August showed a distinct thermal stratification. According to DENNY (1972), physical stratification is usually accompanied by chemical stratification, where stability or permanence had been achieved.

ENTZ (1976) pointed out that the course of temperature of the whole water mass in the High Dam Lake is mainly influenced by the seasons. There is a rapid increase of the air temperature from April to June, followed by that of the water. This is in agreement with the present data of water temperature, illustrating that the seasonal average temperature value in May was higher than that in April (Fig. 8). The maximum seasonal average water temperature in August (Fig. 8) was accompanied by a high evaporation value that month (Table 1).

Chloride Variations

According to GOLDMAN (1966), chloride is considered as a micronutrient for algae. GOLDMAN and HORNE (1983) reported that chloride ion si required by photosynthesizing cells for the photolysis of water to release oxygen, for ATP formation and for certain phosporylation reactions.

Based on the annual average values (Fig. 10), chloride occupied the third order in abundance among the anions in Lake Nasser. This is in agrement with all similar data for the fresh water lakes of the world, as has been stated by COLE (1983).

The irregular vertical distribution of chloride might be attributed to the effect of various physico-chemical and biological factors. As in case of sodium (SAAD and GOMA, in press), the chloride values in the upper water layer in August (20 m depth) were, in general, noticeably higher than in the bottom waters as a result of elevation of water temperature that month and the existence of thermal stratificatoin. However, no significant correlation was found between chloride and sodium (Table 2). ENTZ (1980) pointed out that a white crust of salt, composed mainly of sodium chloride, was formed by the extremely high rate of evaporation and by capillarity effect close to the shore of Lake Nasser.

In November, the minimum seasonal average chloride value (Fig. 8) resulted from the effect of dilution by the flood waters containing low salt content and reaching its maximum level that month (Fig. 2). The maximum seasonal average concentration in May (Fig. 8) coincided mainly with the increase in the rate of evaporation by elevation of temperature, as indicated by the maximum evaporation by elevation of temperature, as indicated by the maximum evaporation that month (Table 1). According to ZAFAR (1964) and MORGAN and KALK (1970), evaporation leads to the concentration of the anions, especially chlorides in the surface water.

The regional between each major anion and the rest of anions and all cations in Lake Nasser is given in the correlation matrix (Table 2) and the significant correlations of the anions are represented in Fig. 11, in the form of "correlation constellation". Chloride was high negatively correlated with calcium (p) and suphate ($p = 0.05$). It was positively correlated with carbonate ($p = 0.02$). No significant correlation apeared betweeen chloride and each of sodium, magnesium, potassium and bicarbonate.

Bicarbonate and Carbonate Variotions

It is preferable to discuss bicarbonate and carbonate side by side, due to their close relationship. According to PARK *et al.* (1969), composition of alkalinity in fresh water is variable depending on the chemical composition of the water. Alkalinity is customarily expressed in terms of equivalent bicarbonate or carbonate, although other ions could contribute to it.

Based on the annual average values, bicarbonate represented the most abundant anion in Lake Nasser, whereas carbonate was the least abundant anion. The annual average concentration of bicarbonate was considerably higher than the sum of annual averages of the other anions (Fig. 10).

Table 2. Correlation matrix of major cations and anions for Lake Nasser (n = 40)

	Na	Mg	Ca	K	Cl	HCO_3	CO_3	SO_4
Na	1.0000							
Mg	0.5130	1.0000						
Ca	–0.1117	–0.1841	1.0000					
K	0.9712	0.4637	–0.1674	1.0000				
Cl	–0.0943	0.1239	–0.6715	–0.0158	1.0000			
HCO_3	0.4140	0.4881	0.4188	0.3208	–0.2371	1.0000		
CO_3	0.3085	0.0153	–0.5908	0.3408	0.3403	–0.6057	1.0000	
SO_4	0.5649	0.4096	0.1541	0.4902	–0.2987	0.2187	0.1926	1.0000

Any value $r \geq 0.5043$ is significant at the > 99.9% level ($p < 0.001$)
Any value $r \geq 0.4057$ is significant at the 99.9% level ($p = 0.001$)
Any value $r \geq 0.3694$ is significant at the 99% level ($p = 0.01$)
Any value $r \geq 0.3145$ is significant at the 98% level ($p = 0.02$)
Any value $r \geq 0.2660$ is significant at the 95% level ($p = 0.05$)

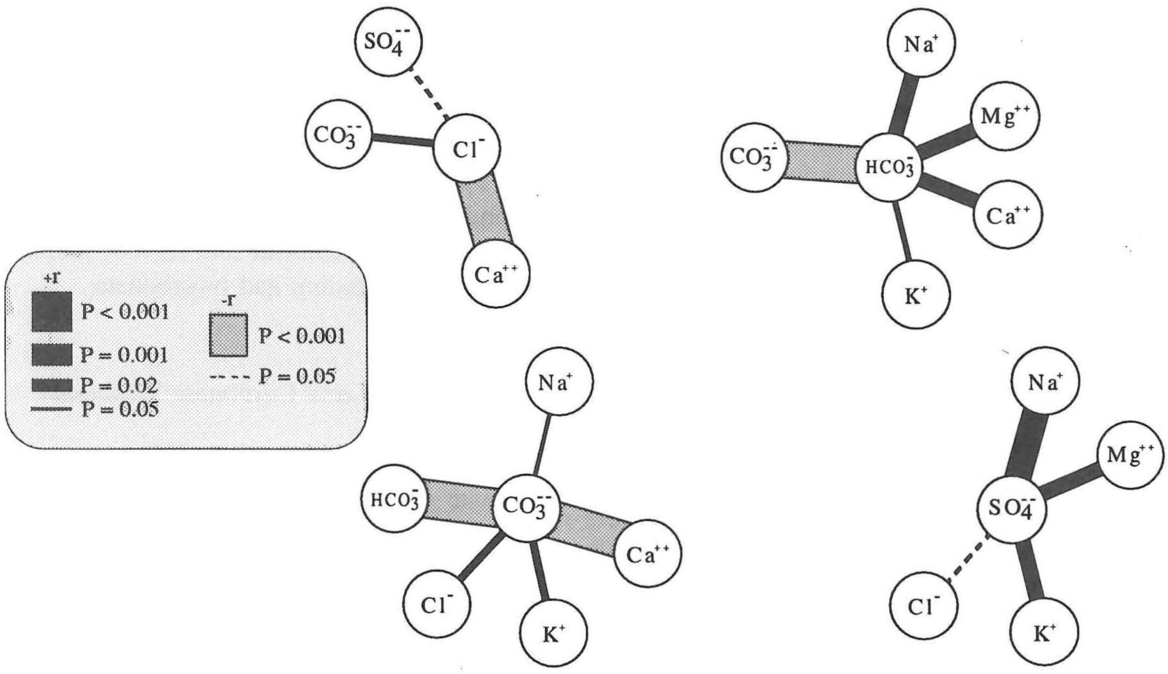

Fig. 11. Correlation constellation for each major anion and other major elements in Lake Nasser during 1981-1982.

The vertical distribution of bicarbonate was irregular with obvious indication of an increase in concentrations in the lower water column. This can be attributed to solution of the deposited calcium carbonate in sufficient supply of CO_2 resulting from the processes of decomposition of organic matter (NESSIM, 1972). MUNAWAR (1970) found the same condition in fresh water ponds in India. This is supported by the absence and very low values of carbonate in the bottom water layers of the lake. However, the low bicarbonate values in the surface water layers resulted from its conversion into carbonate, due to the utilization of the half-bound carbon dioxide by phytoplankton in the euophotic zone. Disappearance of carbonate and its low concentrations in certain water samples reflect the abundance of carbon dioxide.

The minimum seasonal average value of bicarbonate in May (Fig. 8) is attributed to the abundance of phytoplankton in spring and consequently the increase in the rate of utilization of the half-bound carbon dioxide for the photosynthetic process. According to RAVEN (1970), many species of algae have been reported to be capable of utilizing bicarbonate or carbonate as source of inorganic carbon for photosynthesis. On the other hand, SREENIVASAN (1970) pointed out that photosynthesis intensifies dissolved oxygen and carbonate and decreases carbon dioxide and bicarbonate. The minimum seasonal average value of carbonate (Fig. 8) in November, the end of the flood period as indicated by the highest water level (Fig. 2), can be related to the increase, in water turbidity from the suspended load in the floodwater, which decreased the depth of the photosynthetic zone and consequently lowered the rate of photosynthesis (NESSIM, 1972). Accordingly, considerable amounts of carbonates have been converted into bicarbonates in abundance of carbon dioxide. This evidence is supported by the maximum seasonal average value of bicarbonate that month (Fig. 8). The maximum seasonal average value of carbonate in August, accompanied by relatively low seasonal average value of bicarbonate (Fig. 8) coincided mainly with the decrease in solubility of carbonate by elevation of temperature.

The highest regional average values of bicarbonate at stations I and II were accompanied by the lowest regional averages of carbonate

(Fig. 9). This coincided in the main with the position of these two stations in the most stagnant area of the lake, where carbon dioxide is produced as one of the products from decomposition of the descending planktonic organisims, a process activated by elevation of water temperature. The accumulated carbon dioxide in the hypolimnion and in the upper water layer after being distributed by water movements converts the carbonate into bicarbonate. The possible abundance of carbon dioxide near the High Dam might result from the relative decrease in the rate of photosynthetic activity, due to the remarkable decrease in phytoplantkon populations, as indicated by the increase in transprency of the water in this stagnant area. According to ENTZ and LATIF (1974), the transparency of the lake water near the High Dam was very high and the phytoplankton density was very low.

The seasonal average bicarbonate: chloride ratio ranged from 8.8 in May to 14.6 in November (Table 3). These are correlated with the minimum and maximum seasonal bicarbonate averages in these months, respectively (Fig. 8). The seasonal variations of the average carbonate: chloride ratio varied from 0.4 in November to 1.4 in April. These are related to the minimum and relatively high seasonal carbonate averages in these months, respectively (Fig. 8).

and bicarbonate (p). It was positively correlated with potassium and chloride (p = 0.02). However, there was no significant correlation between carbonate and each of magnesium and sulphate.

Sulphate Variations

The importance of sulphate in African inland waters was pointed out by BEAUCHAMP (1953), who suggested that sulphate deficiency may be a factor affecting the growth of phytoplankton. GOLDMAN (1966) reported that sulphate is considered as s micronutrient for algae.

Based on the annual means (Fig. 10), sulphate occupies the second order in abundance among the anions in Lake Nasser. This may be due to the high input of sulphate to the Nile waters.

The irregularity in the vertical values of sulphate might be attributed to the effects of different physico-chemical and biological factors. Relatively lower sulphate concentrations were generally observed in the bottom water layer in August, as well as in the bottom of certain stations in the other months. SALEH (1976) attributed this aspect to the activities of the sulphate-reducing bacteria, which reduce some of the sulphate ions to hydrogen sulphide.

Table 3. Variations of the seasonal average bicarbonate, carbonate, and sulphate: chloride ratios in Lake Nasser during 1981-82.

	April	Aug.	Nov.	Feb.	May
		1981		1982	
HCO_3 : Cl	13.1	10.5	14.6+	10.9	8.8–
CO_3 : Cl	1.4+	1.3	0.4–	0.9	0.9
SO_4 : Cl	1.5+	1.2	1.2	1.1	0.5–

The minimum values are designated by (–) and the maximum by (+)

Bicarbonate was observed to be highly negatively correlated with carbonate (p). It was positively correlated with sodium, magnesium and calcium (p = 0.001) and potassium (p = 0.02). However, there was no significant correlation between bicarbonate and each of chloride and sulphate. The carbonate was found to be highly negatively correlated with calcium

The maximum seasonal average sulphate value obtained in April (Fig. 8) coincided possibly with the abundance of phytoplankton in spring and consequently the increase in the dissolved oxygen concentrations resulting from the high rate of photosynthesis. However, GOLDMAN (1966) stated that the positive correlations between chlorophyll *a* and sulphate are more difficult to explain. The minimum seasonal average sulphate value in May might be attributed to the marked rise in water temperature (Fig. 8) in presence of blooms of plankton. The decay of the descending plankton increased by elevation of temperature. The microbiological oxidation of this organic material causes the reduction of sulphate to sulphide resulting in the loss of sulphate. SALEH (1976) concluded that the bottom sediments of Lake Nasser were colloidal and black, indicating the presence of metal sulphides mixed with decaying organic matter.

The abundance of suspended load in the southern region of the lake might be mainly responsible for the decrease in sulphate content, as indicated by the lowest regional average concetrations at stations VI and VII. Sulphate is lowered to critical levels by adsorption on mineral particles (COLE, 1983).

The seasonal average sulphate: chloride ratio ranged from 0.5 to 1.5 in May and April respectively (Table 3). These coincided with the minimum and maximum seasonal average sulphate values (Fig. 8).

Sulphate was found to be highly positively correlated with sodium (p). It was also positively correlated with magnesium and potassium ($p = 0.001$), but negatively correlated with chloride ($p = 0.05$), However, there was no significant correlation between sulphate and each of calcium, bicarbonate and carbonate.

CONCLUSIONS

The decrease in temperature with depth was the general trend of the vertical temperature distribution. A distinct thermal stratification appeared in May and August. Based on the annual average concentrations of anions, bicarbonate occupied the first order in abundance, follwed by sulphate, chloride and carbonate. The annual average concentrations of bicarbonate was considerably higher than the sum of annual averages of the other anions. Disappearance of carbonate and its low values in certain water samples reflect the abundance of carbon dioxide. The relatively low sulphate concentrations generally found in bottom water samples are related to activities of the sulphate-reducing bacteria. The abundance of suspended load in the southern region of Lake Nasser decrease the sulphate content due to its adsorption on the mineral particles.

Chloride was highly negatively correlated with calcium and sulphate and positively correlated with carbonate. Bicarbonate was highly negatively correlated with carbonate and positively correlated with sodium, magnesium, calcium and potassium. The carbonate was found to bi highly negatively correlated with calcium and positively correlated with potassium and sodium, sulphate was positively correlated with sodium, magnesium, and potassium.

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Raspodjela glavnih iona u jezeru Nasser
I. Glavni anioni

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KRATKI SADRŽAJ

Završetkom izgradnje Asuanske visoke brane godine 1964. izazvalo je trajno ograđivanje vode. Jezero visoke brane proteže se 480 km, dvije trećine sjevernog dijela nalazi se u Egiptu (jezero Nasser) a južna trećina u Sudanu (jezero Nubia). Istraživana je sezonska i regionalna

raspodjela glavnih aniona u jezeru Nasser. Nepravilna okomita raspodjela aniona mogla bi biti posljedica djelovanja raznih fizičko-kemijskih i bioloških čimbenika. Pojačano isparavanje u kolovozu javilo se istovremeno s maksimalnom prosječnom sezonskom temperaturom. Minimalne i niske sezonske prosječne vrijednosti bikarbonata u svibnju i kolovozu popraćene visokim i maksimalnim sezonskim prosječnim vrijednostima karbonata javljaju se istovremeno sa smanjenjem topljivosti karbonata uslijed povišenja temperature u tim mjesecima. Vrlo jako isparavanje u svibnju i kolovozu uglavnom je bilo uzrok vrlo visokim koncentracijama klorida u tim mjesecima. Maksimalna srednja sezonska vrijednost sulfata u travnju može se pripisati povišenoj koncentraciji otopljenog kisika uslijed snažne fotosinteze u proljetnom periodu. Opadanje regionalnih prosječnih vrijednosti sulfata i klorida u južnom dijelu jezera moguće se javljala istovremeno s razrjeđenjem poplavnim vodama. Vrlo visoke regionalne prosječne koncentracije bikarbonata popraćene vrlo niskim prosječnim vrijednostima karbonata u sjevernom dijelu jezera javlja se istovremeno sa uvjetima stagnacije kada je CO_2, nastao raspadanjem organske materije, pretvorio karbonat u bikarbonat.