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EFFECT OF PHYSICO-CHEMICAL CONDITIONS ON THE DEPOSITION OF SOME ELEMENTS OF ASWAN HIGH DAM RESERVOIR WATER

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ABSTRACT

The physico-chemical parameters (pH, oxygen, temperature, electrical conductance, oxidizable organic matter as well as chemical composition, some cations and anions were measured in about 250 water samples representing 10 sites in the main channel of the Aswan High Dam Reservoir during the four seasons. 40 sediment samples as well representing the bottom sediments at the same water-sampled sites were analyzed for Na^{+}, K^{+}, Ca^{2+}, Mg^{2+} as well as Cu, Mn, Zn, P and Fe

The study indicated the effect of the measured, parometers on the deposition of the estimated elements. Colloids as well are shared in their deposition by adsorption.

INTRODUCTION

Aswan High Dam Reservoir is one of the longest man-made lakes in the world, extending in Egypt for about 300 km as Lake Nasser and further south for 180 km as Lake Nubia in Sudan. Its northsouth orientation extends from Aswan High Dam (23° 58'N and 33°15' E) to Dal Cataract in Sudan (20° 27' N and 33° 35' E). It is located in a hot, arid environment often receiving no appreciable precipitation from both sides except for wind blown sand particularly from the west. Surrounding the reservoir is a rocky terrain consisting primarily of piedmonts and peneplains of Nubian sandstone of the Nubian Facies. West of the reservoir lies the flat and sandy Sahara Desert, while the mountainous east side is known as the Eastern Desert where Aswan granites are cropping out. The bottom configuration of the reservoir is influenced by the topography of the land, the water level, the sedimentation process, which is largely controlled by the annual flood and the geologic setting of the area. The Aswan High Dam Reservoir (AHDR) with a holding capacity of about 157 x 10^9 m^3 of water is located 25 km south of the city of Aswan. Approximately 55 x 10^9 m^3 of water can be discharged annually depending upon downstream demand.

The present work aims to reveal the physico-chemical parameters of the AHDR water controlling the deposition of some chemical cations and anions as well as compounds in colloidal and mineralic forms forming the bottom sediments.

The temperature, transparency, dissolved oxygen, electrical conductance and pH values of the water were measured by mean of hydrolab equipment from surface to bottom at different depth. Oxidizable organic matter and chemical constituents were measured according to the standard methods of Anon. (1975).

The sites of measurement along the old river channel were selected regarding narrowest and widest parts, the riverine and lacustrine of the Reservoir, also the different water masses under different factors in the reservoir as flood and climatic conditions and finally both the southern and the northern ends of the reservoir (Fig. 1).

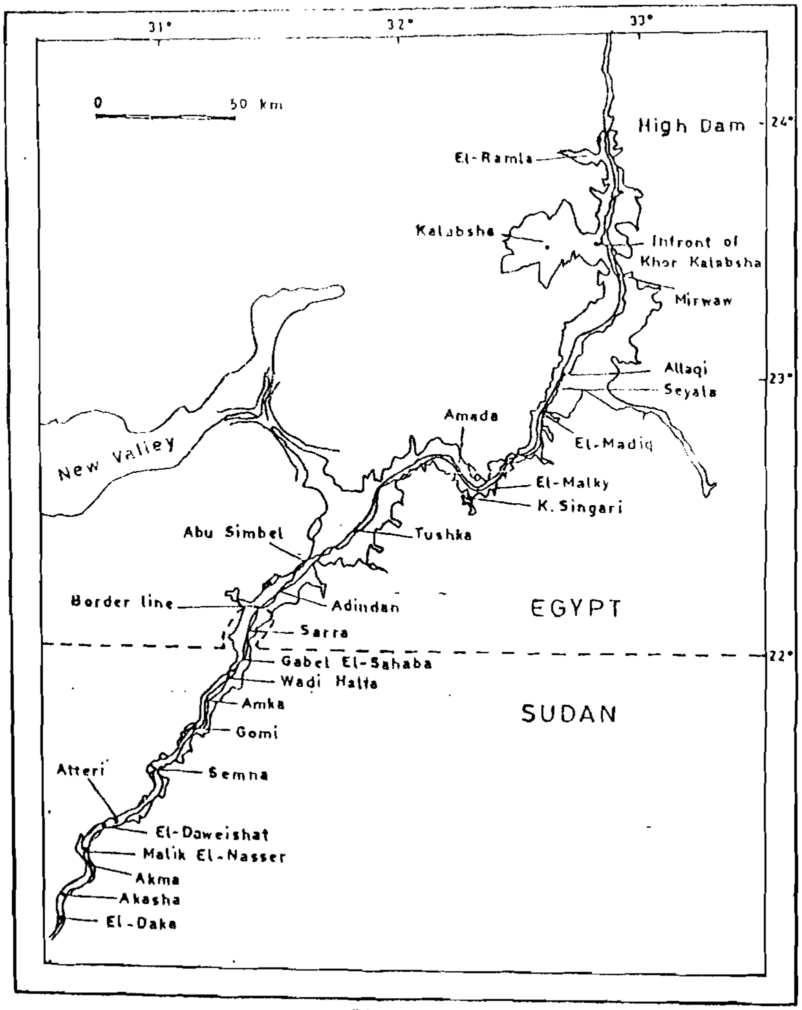

FIG. 1
Aswan High Dam Reservoir (Lake Nasser and Lake Nubia) showing sites of profiles.

RESULTS AND DISCUSSION

Water Temperature

Aswan district is characterized by continental arid climate as it is a part of the great desert belt. Hot climate prevails during summer where atmospheric temperature is usually around 35°C, while during winter the temperature is comparatively as low as less than 10°C in average particularly at night. Of course such climatic conditions affect the water temperature of AHDR.

From Table 1, it is obvious that Lake Nasser is a warm monomictic one. It is with one circulation during the year and stratified during the hot months.

TABLE 1
Ranges of water temperature (C°) of Lake Nasser (1981-1983).

	WINTER	SPRING	SUMMER	AUTUMN
H.D.	21 - 18.7	18 -15.8	27.4-18.2	25 -17.1
Kalabsha	22 - 19.6	19 -16	28.4 19	26.5 -19
Allaqi	22 - 21.7	21 -16.5	31.4-19.2	28.5 -17.7
El-Madiq	22.2 - 21.5	22.5 -16.5	28.7-18.2	26.7 -19.9
Amada	21.3 - 21	26.5 -16.5	28.5-19.5	25.7 -18.5
Tushka	21.2 - 21	25 -16.5	28.2-19	26 -18.2
Abu Simble	20 - 20.3	24 -16	28.7-18.7	27.4 -18
Adindan	20 -20.2	23.5 -15.9	27.6 - 18.7	25.2 -18.2

The temperature controls the solubility of $CaCO_3$ and the metabolic rate of plants and animals. Cold waters rarely support large communities of carbonate-secreting or encrusting organisms. Consequently in summer and autumn when the water of the reservoir is warm, the activity of carbonate secreting or encrusting organisms expectingly increases that in Winter. As well the warm surface water alters the neutral point in the direction of greater hydrogen ion concentration (Mason, 1958).

Transparency

Flood water, usually brings great amounts of silt and clay, which usually result in decreasing transparency as the flood water coming from the Ethiopian high-lands.

The high load of silt in the Reservoir water is confined to Lake Nubia. Most of the silt is sedimented in Lake Nubia, while a limited amount reaches the southern part of Lake Nasser, Viz; Abu-Simble and Adindan. The transparency of Lake Nasser is reduced in spring and summer by the flourishing of phytoplankton. The transparency decreases to one meter in the north and middle thirds of the Lake where transperncy of about 4 m was recorded in winter. The extreme lowest values appear in the southern part of Lake Nasser under flood effect. Table 2 favors the inverse correlation between the deposition of the suspended matter and the transparency.

Consequently, transparency increases when the suspended products of weathering, are deposited, chiefly the mechanical, which consist essentially of tourmaline, zircon, ilmenite, magnetite, garnet, quartz, micas and feldspars as well as secondary clay minerals, altered feldspars, micas and the hydrolysates.

TABLE 2
Transparency of Lake Nasser and Lake Nubia in some selected months

	LAKE NASSER						LAKE NUBIA		
Sites	H.D.	Amada	Tushka	Adidan	Sarra	Wadi Halfa	Murshid	El De-weishat	Akasha
Distance Km/H.D.	3	200	250	290	310	360	380	410	480
February 1972	410	200	150	120	120	90	55	55	50
April 1972	220	125	90	75	180	140	100	80	35
July 1973	130	120	100	80	66	48	20	12	3
Jul/Aug 1974	125	80	65	30	20	10	8		
September/ October 74	300	57	40	37	60	50	10		

Electrical Conductance

The electrical conductivity (E.C.) is directly proportional to the amount of the suspended material (Fig. 2). The maximal values (327 µmhos) were recorded in Lake Nubia in the part lying between Murshid and ElDaka, the northward area till Sarra is characterized by an abrupt decrease in the electrical conductivity to reach 235 µmhos at Sarra. This favors that the deposition of most of the load of the suspended material is in the area south of Wadi Halfa and the main load is deposited in the part of the Lake south Murshid.

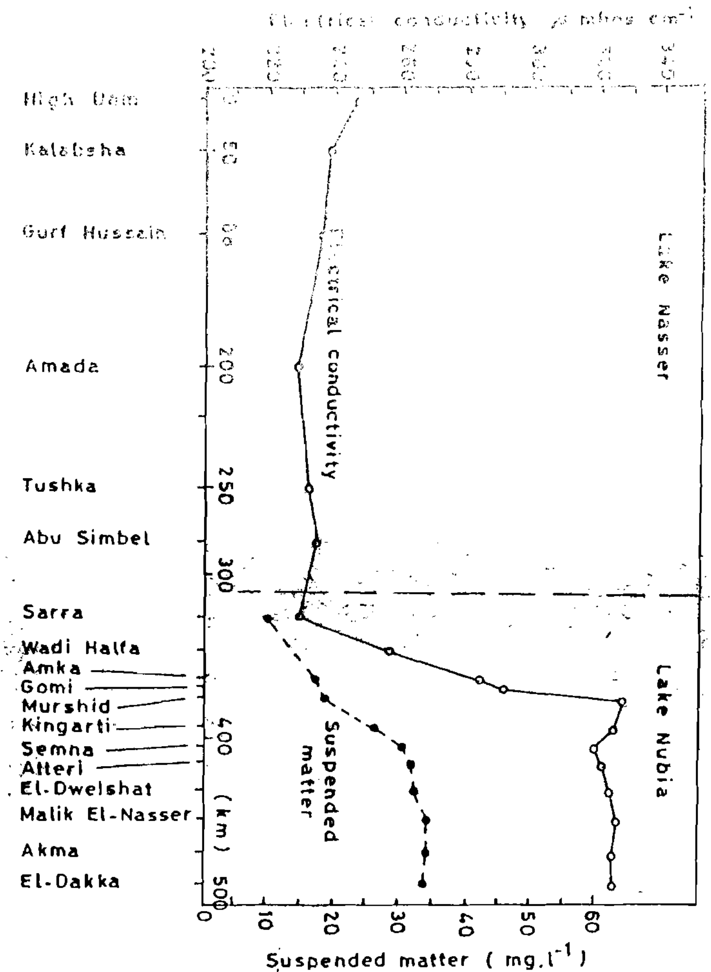

FIG. 2

Average values of electrical conductivity and suspended matter of Aswan High Dam. Reservoir.

Consequently the flood water afects the E.C. and its change depends on the level of the flood. In addition the E.C. varies with depth depending on the amount of the suspended material. This is due to that current flowing through the water, causes conductivity by salts dissolved in solution. Under the influence of an electrical field the Na^{+}, Ca^{++}, Cl^{-}, SO_4^{--} ions move, carrying electrical current through the solution. In case of mineral particles conduction is an ion-exchange process whereby ions (usually the positively changed) moving under the influence of the electric field exchange sites on the surfaces of the particles (Anon., 1972). This actually explains the sharp decrease of the electerical conductivity in Lake Nasser, since the minerals bearing Na^{+}, Ca^{++}, Mg^{++} and K^{+} are mostly deposited in Lake Nubia and the southern part of Lake Nasser.

Oxidizable Organic Matter

The oxidizable organic matter affects aquatic ecosystem by interacting with inorganic matter forming complex compounds which include in its structure the heavy metals (Visser, 1970). Such cause reaction of the oxidizable organic matter to produce H_2SO_4 (Foster, 1951). James, (1941) and Saunders, (1957), showed direct relationship of oxidizable organic matter with Mg^{++} and pH and inversal relationship with oxygen and iron.

The concentration of the oxidizable organic matter is lower in both spring and summer than in autumn and winter, since warm and longer days with sunshine are more favorable for their concentration (Gonzalves and Joshi, 1946), following the Table:-

Season	Winter	Spring	Summer	Autumn
El-Ramla	3.0	2.1	2.1	1.2
Amada	4.0	1.9	1.9	2.6
Borderline	5.0	1.1	1.1	2.8

In addition, the Oxidizable organic matter increases from the border line in the south northwards during spring and summer, while it decreases in the same trend during winter and autumn. This is due to that the decrease in organic matter is mainly referred to its sedimentation adsorbed on to suspended mater.

Hydrogen Ion Concentration

The pH of the medium is particularly significant in controlling the precipitation of hydroxides and calcium carbonate from solution, transportation of alumina and silica in solution and their ultimate redeposition (Mason, 1958).

The measured pH values were plotted in the form of isolines (Fig. 3). The pH of the surface water is always higher than the deeper water during the four seasons and the water is more alkaline in winter and spring than in summer and autumn.

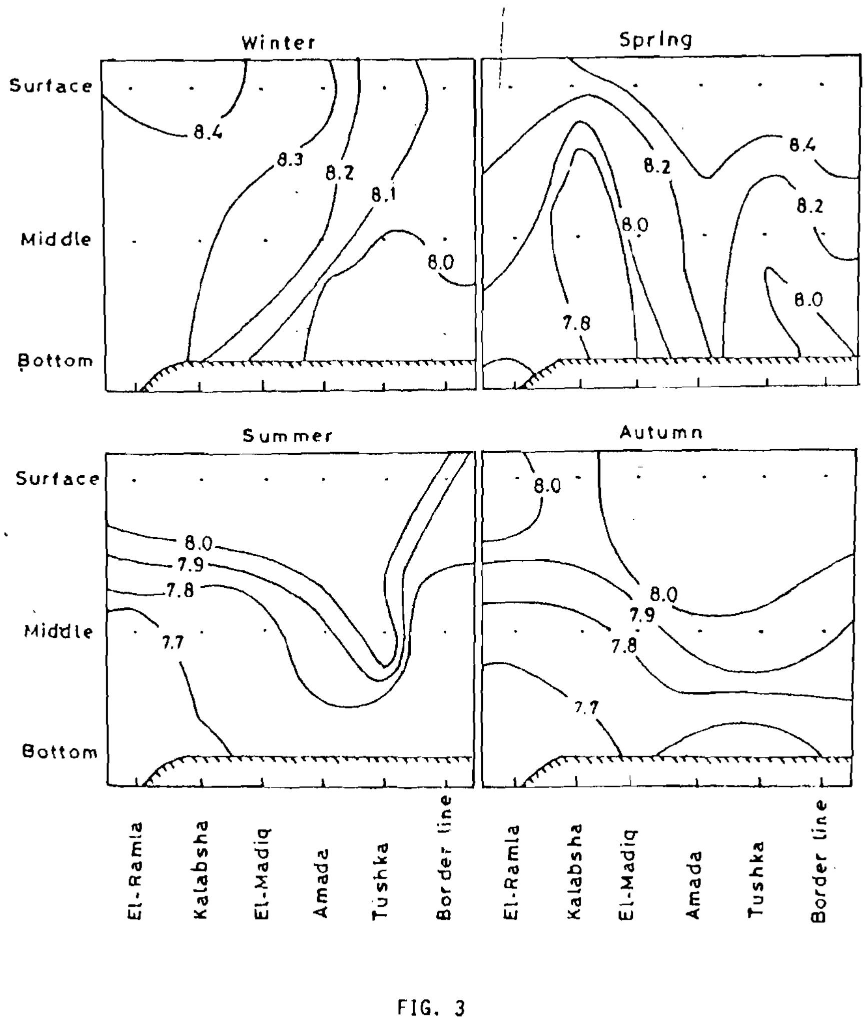

FIG. 3
Iso-lines of the pH values of Lake Nasser water.

The pH values of water in winter increase from south to north. The highest pH value is recorded at El-Ramla and Kalabsha.

In the same time, the pH of the surface and bottom water decreases in spring from south to north and was lower in the northern region in comparison to other southern localities. In summer, the pH value of the surface water is constant at all profiles (>8.2), while in autumn, the pH shows stratification from bottom (<7.7) to surface (>8.0).

Dissolved Oxygen

Since Lake Nasser is eutrophic (Latif, 1974) deep and shallow waters exhibit thermal stratification, therefore, formation of an oxygen depleted bottom layer naturally ensures in the hot seasons. In winter, when the Lake is nearly homothermal the water is oxygenated from the surface to the bottom (Table 3). In spring, due to the plankton blooming, the difference in oxygen concentration between the surface and bottom becomes wider. As the Lake water begins to stratify thermally, the concentration of oxygen decreases in the bottom water layer whereby a non-oxygenated bottom layer becomes well-established in summer (Fig. 4). The thickness of the oxygenated layer, i.e. epilimnion, increases in thickness southwards from the High Dam to the border line. This is in agreement with the ideas of Hutchinson (1957), Welch (1952) Seiwell and Seiwell (1958), Gaterman (1975) and Ruttner (1952).

With the destruction of thermal stratification in the southern most part of Lake Nasser, with the incoming flood, the water column becomes oxygenated. This besides, the increased thickness of the upper oxygenated layer in autumn will ultimately result in the complete oxygenation of the Lake in the cold season and particularly in winter (Fig. 4).

According to the classfication suggested by Perelman (1968) to the epigenetic processes in the supergene zone based on the typemorphic elements and compounds of the gaseous migration, the High Dam reservoir water can be divided to 2 media:

a- Oxidized medium (the oxygenated layer), in which iron, manganese, copper, vanadium, sulphur etc. are present in highly oxydized forms (Fe^{3+}, Mn^{4+}, Cu^{2+}, V^{5+}, S^{6+}... etc.). Since the oxygenated layer is always alkaline (pH >8), so the Eh slightly exceeds zero, usually Eh> 0.15 mV.

b- Reduced medium with free H_2S(the non-oxygenated layer) in which there is no free oxygen and other strong oxidizing agents. A lot of H_2S with occasional methan and CO_2 are present. Iron and many other heavy metals do not migrate as weakly soluble sulphides are formed. The type morphic compounds are H_2S and occasionally CO_2. This medium is characterized by alkaline conditions (pH>7), Eh value is almost less than zero (from -0.5 to 0.6 mV).

TABLE 3

Seasonal variation of oxygen concentration at the surface, 10m, 25m, and 50m. depth of Lake Nasser in different localities

Locality / Seasons	H.D.	Kalabsha	Allaqi	El-Madiq	Amada	Tushk	Borderline
			WINTER				
Surface	7	7.5	9.7	8.4	11.3	8.8	8.8
10m depth	6.8	5.6	8.9	8.3	9.2	8.2	8.6
25m depth	6.6	5.6	8.6	8.4	8.1	8.1	8.4
50m depth	5.6	5.2	7.9	7.2	8.2	7.0	7.8
			SPRING				
Surface	8.4	10.1	9.2	10.15	11.6	11.4	8.9
10m depth	7.2	9.5	8.6	8.85	8.65	8.6	7.0
25m depth	5.85	6.6	6.3	6.2	7.2	6.4	7.75
50m depth	5.2	5.35	6.2	5.0	6.15	5.75	5.6
			SUMMER				
Surface	5.5	8.57	7.65	6.65	8.5	9.3	6.1
10m depth	0.3	5.1	7.05	2.9	2.95	3.89	5.9
25m depth	0.0	0.0	0.3	0.0	0.0	0.1	0.8
50m depth	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			AUTUMN				
Surface	8.1	8.1	9	8.1	6.7	7.47	7.4
10m depth	5.6	6.5	5.5	5.83	4.8	6.53	6.9
25m depth	5.1	1.8	4.3	3.1	4.6	5.73	6.73
50m depth	0.0	0.0	0.0	0.0	2.45	0.0	2.8

The oxidation reduction conditions of fresh water in open bodies can be characterized by the oxidation-reduction index rH_2 which can be found from the following equation (Voznaya, 1983):-

$$rH_2 = Eh/0.029 + 2pH$$

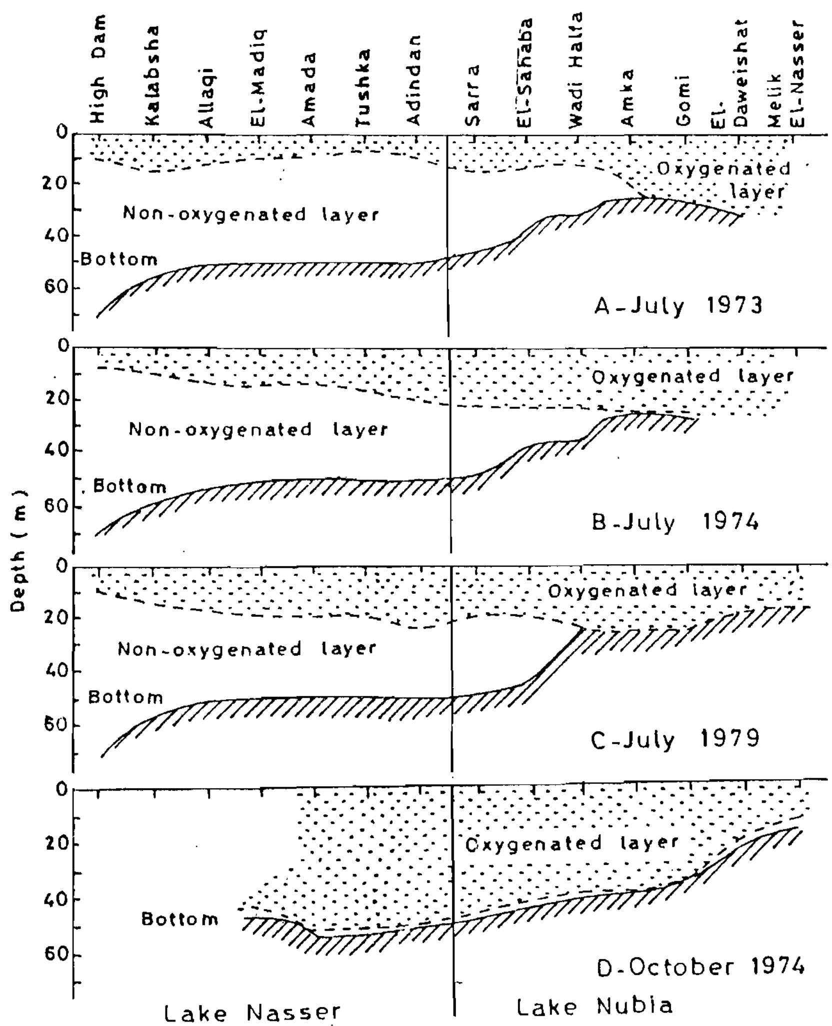

FIG. 4
Depth (m) of oxygenated upper layer of Lake Nasser and Lake Nubia in different months.

The oxidation-reduction potential Eh can be calculated for the given conditions from the Nernst formula and using the pH of water and the coefficient of its saturation with oxygen (rH_2).

Eh (for t° = 25°C) = Eo - 0.058 pH + 0.0145 log PO_2 (Voznaya, 1983) where Fo is the normal oxygen electrode potential.

The value Eo for oxygen is the function of the pH of the medium, hence the strong oxidizing power of oxygen shows up only in an acid medium.

From the pH patterns of Lake Nasser water, it can be deduced that power of oxygen is generally low, since the oxygenated layer is alkaline (pH>8). However, regarding the variation in thickness of the oxygenated layer seasonally it can be stated that the oxidizing power of oxygen in Lake Nasser is the highest in winter and the least in summer through spring and autumn.

However, the well established non-oxigenated layer in summer and autumn suggests a reduced bottom water which is slightly alkaline. Such medium favors the deposition of iron and manganese as well as some other heavy metals in the form of sulphides.

Chemical Composion Of Water

The major cations and anions concentration (mgl^{-1}) (Elewa, 1980) in Lake water varies in the following ranges:-

a- Cations:-

Na^+	7.6 - 27.8	Ca^{2+}	14.29 - 27.5
K^+	0.6 - 8	Mg^{2+}	3.16 - 13.47

b- Anions:-

HCO_3^-	110.79 - 203.36	SiO_2^{3-}	10 - 35
CO_3^{2-}	0 - 22.2	PO_4^{3-}	0.11- 0.338
Cl^-	3.46 - 9.88	S^{2-}	0- 400
SO_4^{2-}	2 - 14	NO_3^-	0.667- 1.267

To characterize the intensity of aqueous migration of elements, Perelman (1968) introduced the aqueous migration coefficient (K_x), which can be computed according to the following equation:

$$K_x = m \times 100 / a\, n_x$$

Where; m_x: content the element x in water (mg/1)
n_x : content of the element x in sediments (%)
a : mineralic residuals of water (mg/l).

K_x values of Ca, Na, Mg, K and Si in the water of the reservoir at several sites were calculated (Table 4). The average content of the elements in the lithosphere given by Vinogradov (1962) is taken to represent n_x, since the catchment area of the Nile River occupies large territories of the central Africa where the various known rock units of the Arabo-Nubian shield are outcropping. According to the descending order of the values of K_x given the mentioned elements can be arranged in the following series: Na, Ca, Mg, K, Si. Perelman (ibid) considered Na, Ca and Mg strongly migrated elements in both oxidized and reduced conditions (K_x 10-10) while K and Si are moderately migrated elements (K_x5 - 0.5).

TABLE 4
Aqueous migration coefficient (K_x) of some elements in Aswan High Dam Reservoir water.

Stations	Km. H.D.	Na	Ca	Mg	K	Si
H.D.	3	5.39	5.73	2.97	1.5	0.048
Kalabsha	60	5.13	5.12	2.97	1.46	0.03
Tushka	250	5.69	4.49	2.50	1.63	0.039
Abu-simble	280	5.69	4.49	2.50	1.51	0.021
Sarra	310	21.47	4.76	2.53		0.02
Wadi Halfa	360	6.37	4.77	2.96		0.024
Amka	365	5.05	3.77	2.55		0.022
Gomi	372	7.5	4.52	2.52		0.03
Murshid	375	8.0	4.0	1.79		0.037
Kignarti	390	8.14	3.26	2.28		0.037
Semnar	400	8.36	3.53	3.38		0.033
Atteri	430	8.5	3.53	3.3		0.04
Daweishate	440	8.74	3.44	2.42		0.032
Malik El-Nasser	450	4.35	3.34	2.56		0.033
Okma	470	8.06	4.47	2.44		0.3
El-Daka	480	7.69	3.34	2.35		0.03

The average contents of some elements of the lanthanides calculated from the data of Sherif et al. (1981) shows relatively appreciable values dissolved in water. The hydroxides of these elements are stronger bases than aluminum hydroxides. They, therefore, remains partly in solution during the weathering and the formation of hydrolyzated. Such remain are carried out down in the carbonate sediments because they replace calcium (Rankama and Sahama, 1950). In addition these lanthanides form ionic solutions during weathering with a moderatly high degree high of ease (following table).

The minimum and the mean contents of some rare Earth metals in water of Aswan High Dam Reservoir. (ppb).

La	Ce	Nd	Sm	Fu	Tb	Tm	Yb	Lu
0.1 - 290	4.31 - 119.04	11.9 - 175	0.25 - 8.75	0.42 - 1.25	0.01 -8.33	0.01 - 0.37	0.85 - 3.35	0.5 - 4.72
212.29	38.68	68.35	3.47	1.47	3.55	0.18	1.37	1.68

Major Cations

K^+ content in water decreases from the surface downwards to the bottom water in the 4 seasons (Fig. 5) while there is no certain trend to control the content of Na^+ in water. The effect of pH of water on their deposition is not noticeable. The low content of K^+ in the water in contact with the bottom sediments is due to its adsorption onto the clay minerals. Realy, during their cycle sodium and potassium, follow different courses.

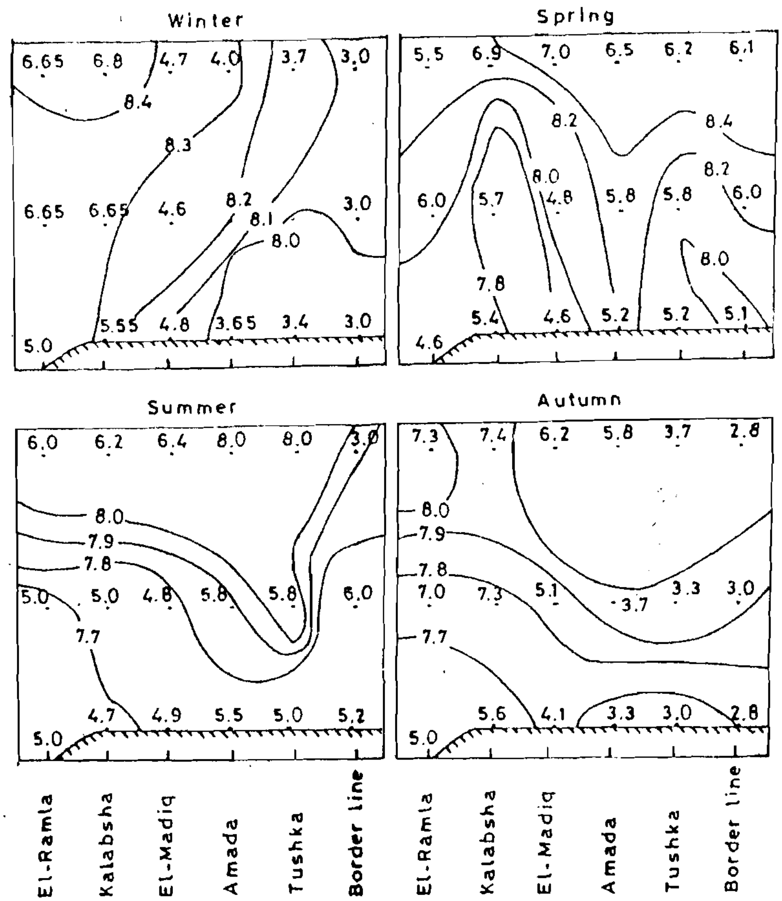

FIG. 5

Potassium ion content (mgl^{-1}) in water of Lake Nasser plotted on pH seasonal map.

The distribution of Ca^{+} content in water is controlled by the hydrogen ion concentration. The water of pH less than 7.8 which is the lime stone fence (Krumbein and Garrels, 1952) contain more Ca^{+} than in the more alkaline water (Fig. 6). Accordingly the surface water contains comparatively less Ca^{++} content since its pH values are more than 7.8. Moreover, in summer and autumn the activity of carbonate/secreting or encrusting organisms increases causing deposition of organic calcite.

Mg^{++} in the reservoir water does not show certain regulation in its abundance and distribution.

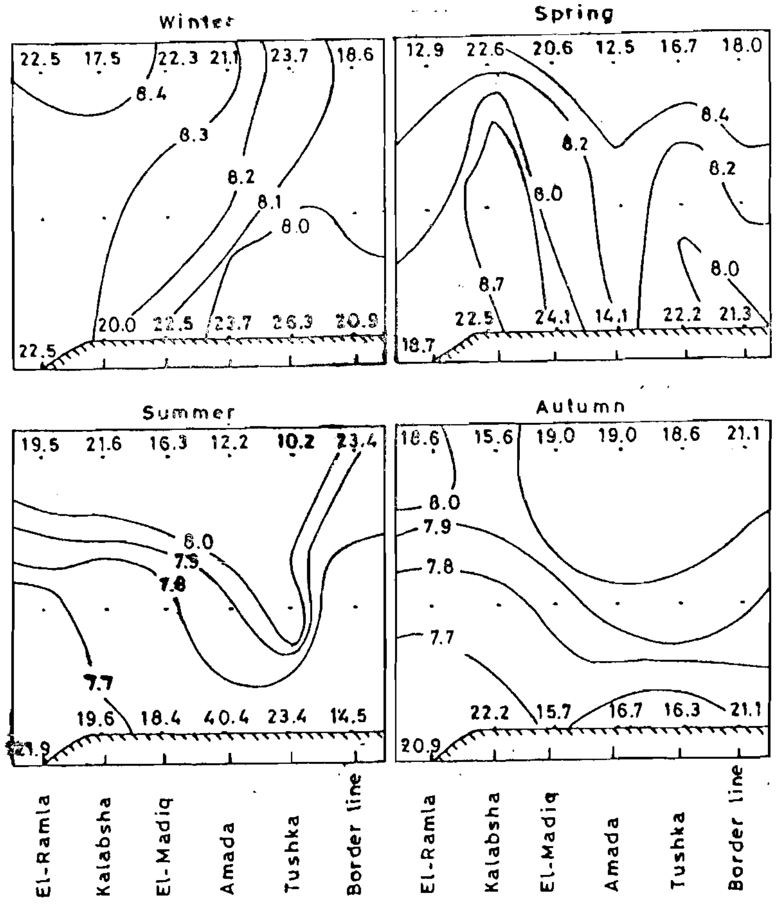

FIG. 6
Calcium ion content (mgl^{-1}) in water Lake Nasser
plotted on pH seasonal map.

Major Anions

Silicate distribution in Lake Nasser water indicates that the northern part of the Lake had more silicate than the southern one. However the variation in content of silicate of the surface and bottom waters is fluctuating and does not show certain trend either seasonally or from one year to another.

The sulphate concentration for the surface, middle and bottom layers of water column, in different seasons is mostly less than 10 mgl^{-1}. Sulphide ions are not detected from the Lake water during the winter and the early spring. This is due to the whole oxygenated water column. The sulphides appear in summer and autumn and confined to the deep non-oxygenated layer of the lake and the khors. The rise in the sulphide concentration was very sharp on approaching the bottom of the Lake and the khors, particularly in the 0.5 - 10.0 cm just above the bottom sediment. The presence of the sulphides nearby the bottom sediments favours the deposition of the heavy metals as sulphides in summer in the form of black colloidal or granualar material mixed with dead organisms. A significant correlation was found (Saleh, 1976) between H_2S concentration, average bacterial count and most probable numbers of the sulphate reducing bacteria; following the table:

Sulphide concentration (mgl^{-1}) in Lake Nasser

Month	September		October	
Depth (m.)	H.D.	El-Ramla	H. D.	El-Ramla
40	0.1	0.0	0.05	0.0
60	0.35	0.0	0.558	0.15
80	1.01	0.55	0.382	0.53
90	292.20		0.598	343.84
			400.0	

The H_2S formed in the hypolimnion layer is likely to diffuse slowly towards the oxygenated uper layers as well as Fe^{2+} ions. Two possibilities may take place; either the Fe^{2+} ions combine with H_2S to form insoluble metal sulphides FeS, precipitate to the bottom, or the gas is oxidized to sulphur.

The phosphates are comparatively concentrated in the bottom relative to the surface water. In addition, the orthophosphate concentration in water appears to be function of time as it is more enriched in the water of period 1976/1977 relative to that of 1970/1971. In turn the spatial variation shows that orthophosphate concentration is lowest at the northern third of the Lake (Following table):

Average value of orthophosphate concentration (mg/l) of Lake Nasser in the surface and bottom water.

Station Layer	H. D.	Kal.	All.	El-Madiq	Amada	Tush.	Adi	Ave.
A. 1976/1977								
Surface	0.130	0.153	0.15	0.25	0.11	0.138	0.235	0.167
Bottom	0.338	0.295	0.31	0.298	0.20	0.20	0.33	0.282
B. 1970/1971								
Surface	0.075	0.066	0.95	0.125	0.136	0.104	0.13	0.104
Bottom	0.256	0.288	0.268	0.368	0.514	0.682	0.228	0.372

The detailed study of the spatial behaviour of the dissolved solides and the chemical constituents in water of the High Dam Lake favors the following characteristics (Fig. 7):

1- The values of the total dissolved solids as well as the chemical constituents show abrupt decrease at Amka and Gami located 365 Km south of the High Dam. The part of the Lake characterized by high values is that which shows an initial stage of a delta formation.

2- SiO_2^{3-}, HCO_3^-, Ca^{2+} and Mg^{2+} contents increase from Wadi Halfa northwards, meanwhile Na^+ content decreases. Cl^- content practically does not show fluctuation in this part of the Reservoir.

According to the classification suggested by Perelman (1968) to the epigenetic processes in the supergene zone, water of the High Dam Reservoir can be considered as alkaline bicarbonate-calcite ($pH > 8.5$) medium where the typemorphic ions are Ca^{2+} and HCO_3^-.

Chemical Composition Of Bottom Sediments

Knowledge of the distribution patterns of the chemical constituents of the bottom sediments of the High Dam Researvoir (Figs. 8-12) help greatly to understand the behaviour of the chemical elements under the known local physico-chemical conditions.

Al_2O_3 and Fe_2O_3 (Fig. 8) are mostly consistant in their distribution with each other in the sediments of the winter, autumn, and summer. In the spring their distribution patterns appear inconsistent. Their consistent distribution patterns can be explained since iron and aluminum are elements of hydrolysate due to their ionic potential (Mason, 1958) and can be separated simultaneously together in weakly alkaline medium. The occasional local deviation of their distribution is mostly due to the effect of the clay fraction amount.

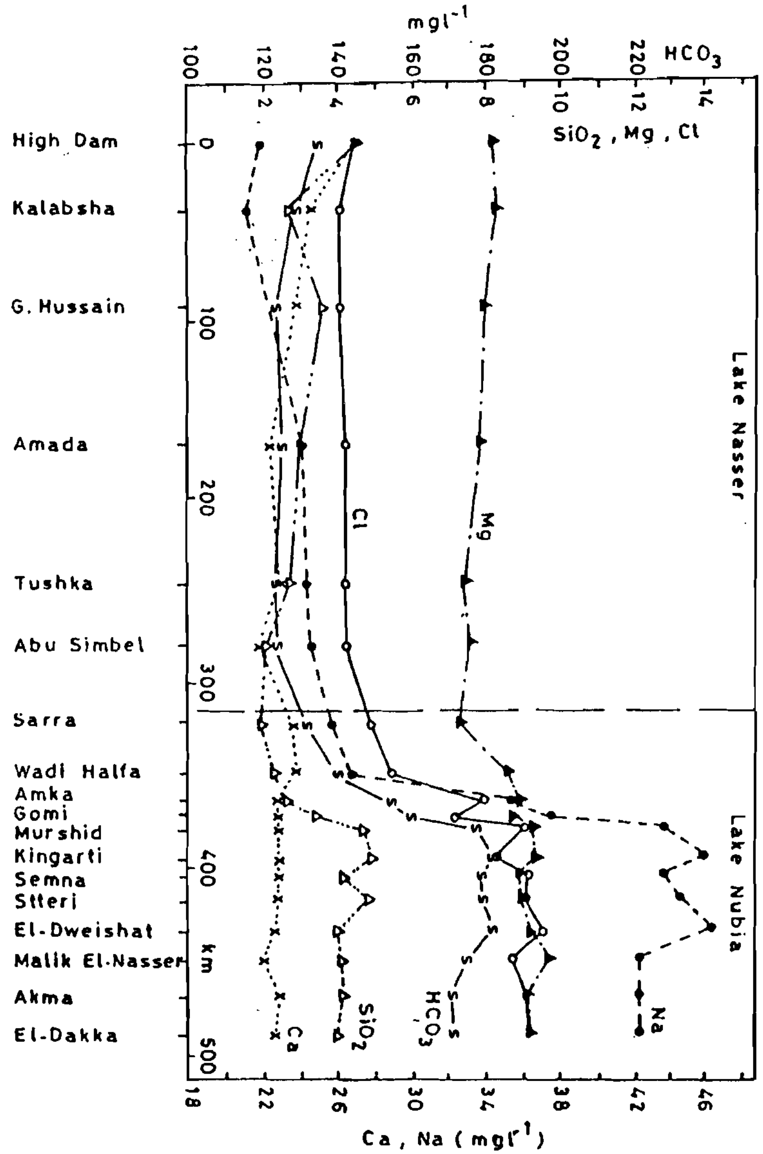

FIG. 7
Mean concentration of silicate, bicarbonate, chloride, calcium, High Dam Reservoir during June 1982.

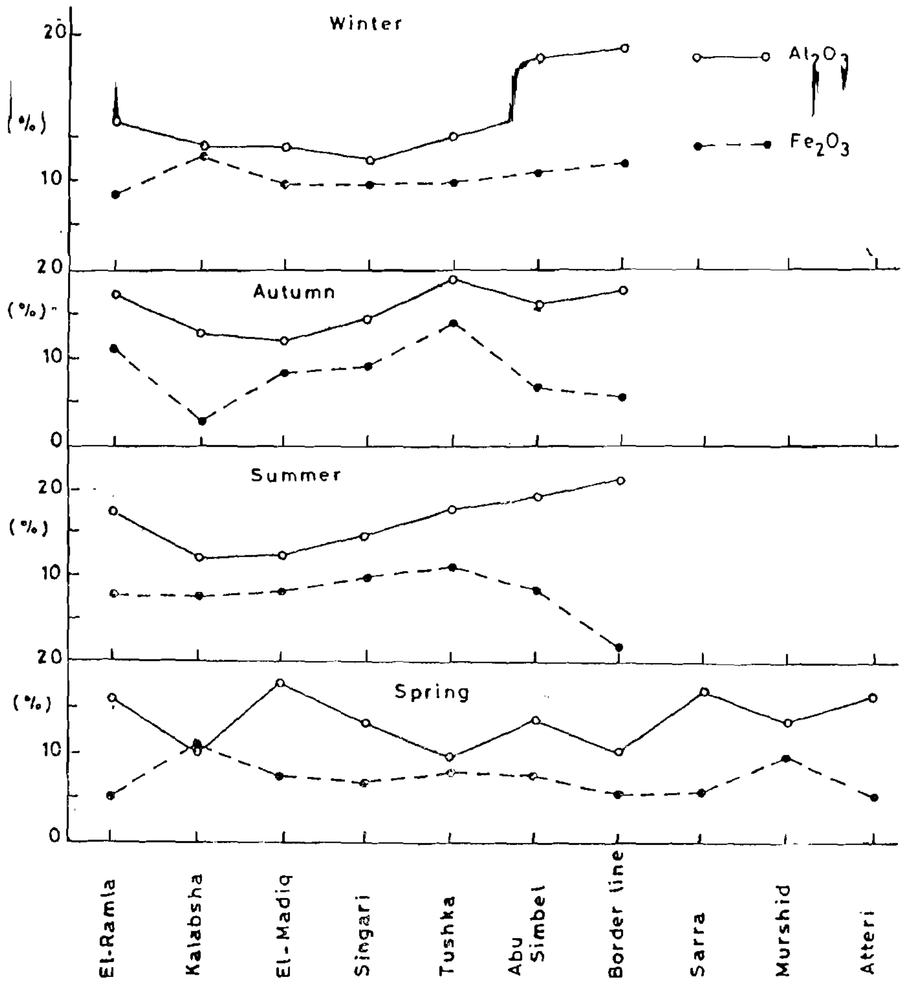

FIG. 8

Average distribution of Al_2O_3 and Fe_2O_3 of the bottom sediments of Lake Nasser during different seasons of 1982-1983.

Lime and magnesia distribution curves (Fig. 9) are almost consistent throughout but show a slight inverse relationship in the sediments representing the four seasons. $CaCO_3$ value is extremely high in the sediments of Singari relative to the other profiles. This is mostly due to the biologic activity.

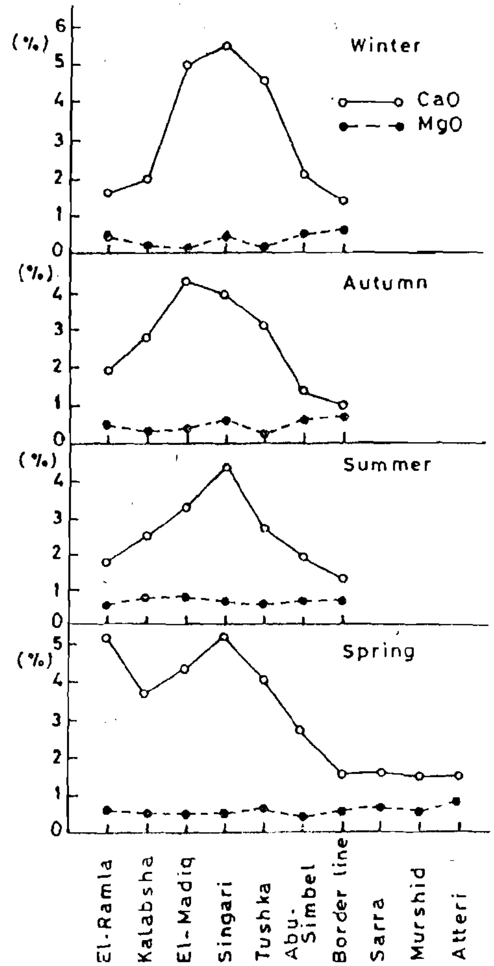

FIG. 9
Average distribution of CaO and MgO of the bottom sediments of Lake Nasser in the different seasons.

The inverse behaviour of Al_2O_3, CaO and MgO (Figs. 8 and 9) indicates independence of each of CaO and MgO from aluminium silicates such as plagioclase and chlorites respectively. Their inversed relationships favor as well that the increase of CaO and MgO is at the expense of aluminium bearing minerals mainly silicates. This enhances the presence of CaO and MgO as carbonates.

Na_2O and K_2O variation curves (Fig. 10) show mostly consistent relationship and almost inverse mutual relation. This relation indicates their occurrence as feldspars.

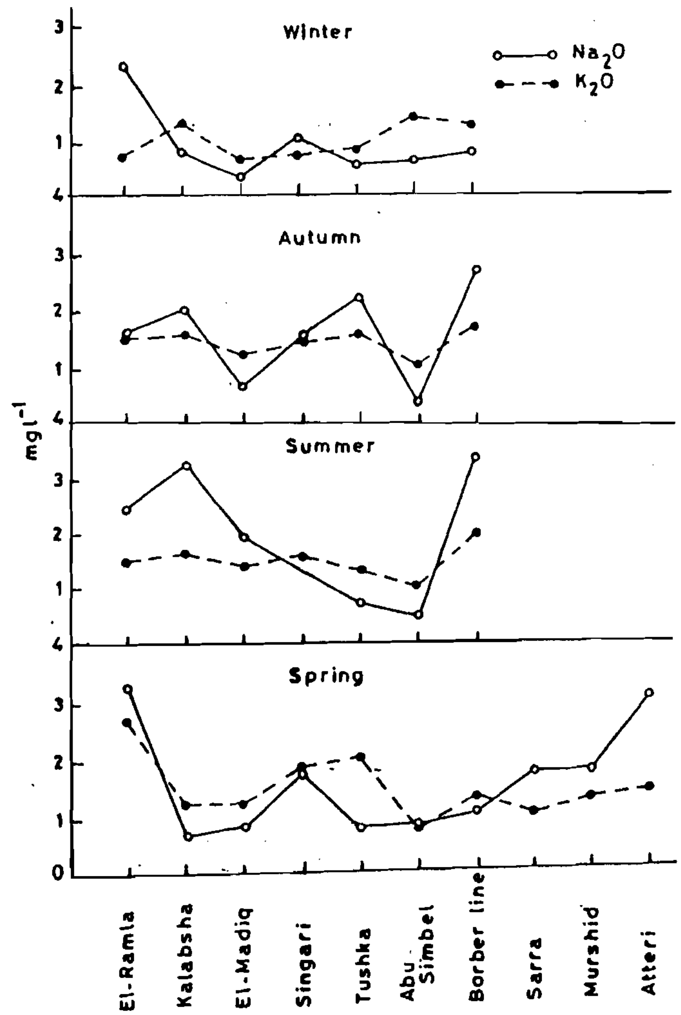

FIG. 10
Average distribution of Na_2O and K_2O in bottom sediments of Lake Nasser in the different seasons.

Copper and zinc distribution curves of the sediments collected during 3 seasons are highly consistent with each other (Fig. 11). Those of iron and manganese of the autumn and the spring sediments are almost consistent with each other, while the summer sediment curves show inversed pattern (Fig. 12). The strongly related distribution of Cu, Zn and Mn favors their adsorption into the colloidal manganese compounds.

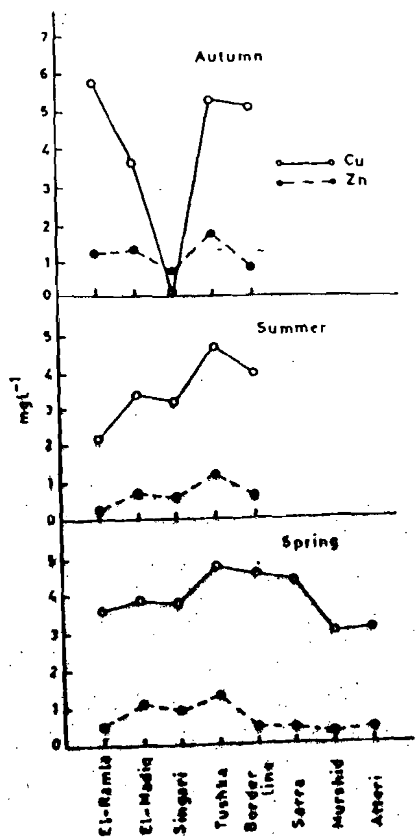

FIG. 11
Average distribution of available Cu and Zn in bottom sediments of Lake Nasser during different seasons of 1982.

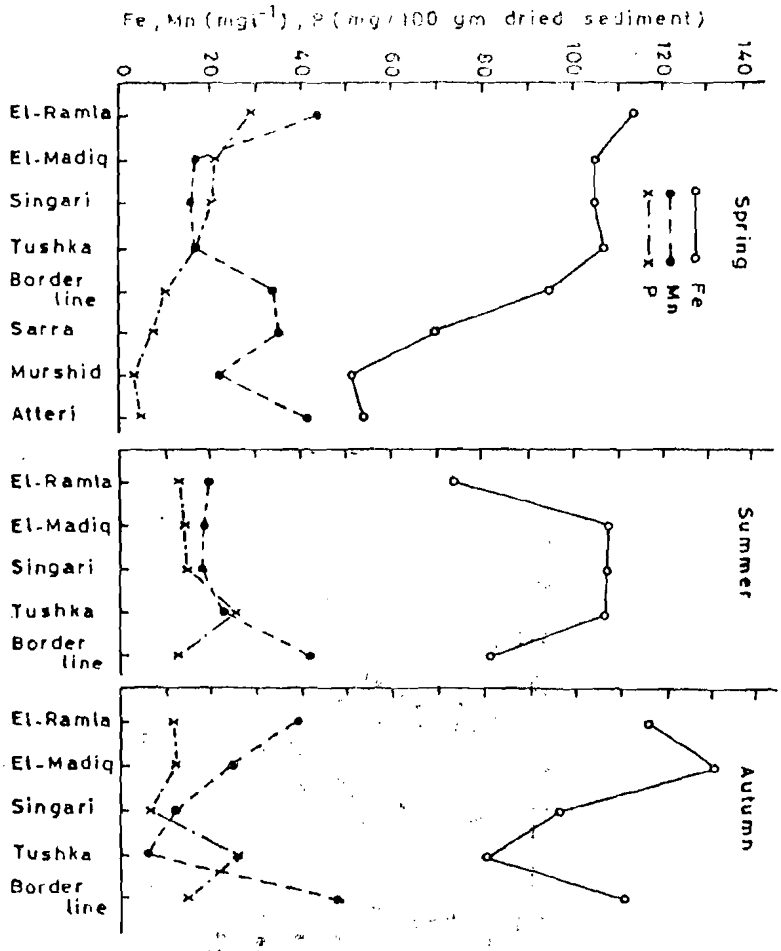

FIG. 12
Average distribution of available Fe, Mn and P in the bottom sediments of Lake Nasser during different seasons of 1982-1983.

CONCLUSIONS

1- The water of the Reservoir can be subdivided into two media:

a- Oxidized (the oxygenated layer) alkaline.
b- Reduced with free H_2S, slightly alkaline (the non-oxygenated layer).

2- Temperature, oxidizable organic matter and free oxygen play the important role to form the two media.

3- Deposition of the carbonates is related partly, to the alkaline medium, however, the carbonate secreting or encrusting organisms play the chief role at some parts of the Reservoir.

4- Al_2O_3 and Fe_2O_3 are deposited simultaneously as hydrolysates, however, the distribution of Na_2O and K_2O favored the presence of sodic and potash feldspars.

5- Iron, manganese and heavy metals were deposited in the form of colloidel sulphides in the reduced, slightly alkaline medium.

6- Copper and zinc were deposited adsorbed onto the colloidal manganese.

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