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A LIMNOLOGICAL STUDY ON LAKE NUBIA

(SUDAN)

M. EL Dardir

National Institute of Oceanography and Fisheries
Aswan, Egypt.

ABSTRACT

The aim of this work is to study the physico-chemical features and distribution of chemical constituents of Lake Nubia in land temperate region water depending on 45 analyses. The investigation revealed that, Lake Nubia is saturated by oxygen. The pH value in the lake water is higher in November than in August.

During Autumn the spatial variation of suspended matter and total dissolved salts in the lake water are mainly inconsistent in their distribution. In November, 1988 electrical conductivity (E.C) that was generally increases found to increase from south to north , is directly proportional to the amount of the total dissolved salts.

The northward increase of electrical conductivity in the water is due to the increase of Na^{+}, Ca^{++}, Mg^{++} *and* K^{+} *contents northwards.* Ca^{++}, Na^{+} *and* Mg^{++} *represent the most abundant cations.* K^{+} *is very low.* HCO_3^{-} *and sulfate are the predominant anions in the lake.*

INTRODUCTION

In the high Dam reservoir, the most sedimentation takes place at the area north of El Dawishat and south of Wadi Halfa in the lake Nubia within sudanese border. Sedimentation is stratified south the Second Cataract due to

he fluctuating semiriverine conditions and takes place ainly in the side area. Down the Second Cataract the process f sedimentation is more homogeneous and is concentrated to he old river channel (Entz, 1980).

Some studies have been carried out on the water of the lake Nubia (Entz and Latif, 1974; Sherif et al, 1978 and Elewa, 1980). Continuity of the studies on the characteristics of the lake is deemed necessary. The present study is undertaken to shed light on the limnological features of lake Nubia especially after the regression of the flood in the last years and the water of the Nile was strongly reduced.

MATERIALS AND METHODS

During August, 1985 when the level of the water was the minimum and November, 1988, after a pronounced flood water samples were collected from six sites at lake Nubia (Fig. 1) and for comparison, three representative sites of lake Nasser were sampled. Water samples were collected using Van Dorn bottle at 3 levels and were examined for temperature (^{o}C), dissolved oxygen (O_2). hydrogen ion concentration (pH), electrical conductivity (E.C.), suspended matter (S.M) and

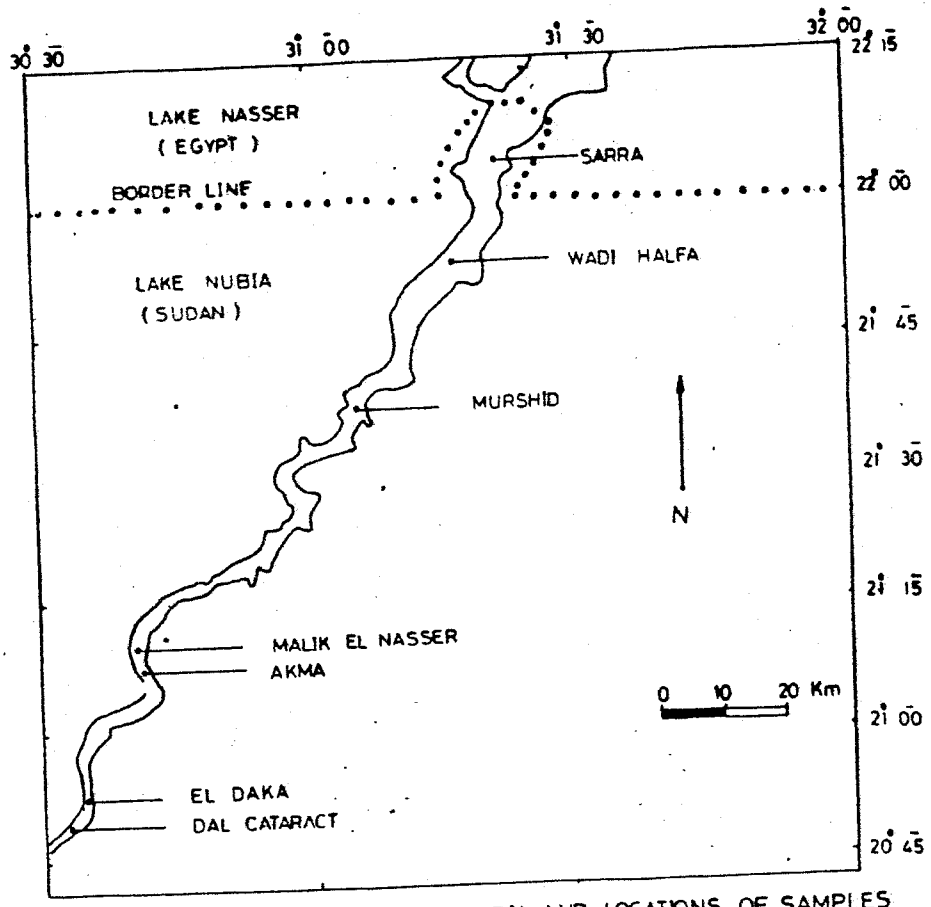

Fig. 1 KEY MAP SHOWING LAKE NUBIA AND LOCATIONS OF SAMPLES

Table (1): Temperature (°C) dissolved oxygen (mg/l), pH, electrical conductivity (μ mhos), total dissolved salts (mg/l) and suspended matter (mg/l) of lake Nubia water during August, 1985 and November, 1988.

Location	Km/H.D	depth	August, 1985						November, 1988					
			°C	O_2	pH	E.C	T.D.S	S.M	°C	O_2	pH	E.C	T.D.S	S.M
El Daka	481	Surface	30.0	5.92	8.00	276.0	200	6340.0	21.0	8.87	8.40	186	133.0	267.8
El Daka	481	Middle	28.5	5.94	8.10	272.0	215	6330.0	21.3	8.85	8.42	185	132.0	282.0
El Daka	481	Bottom	30.5	5.90	8.00	269.5	215	6325.0	21.5	8.85	8.44	183	131	301.0
Akma	466	S	30.5	7.51	7.90	275.0	162	4835.0	21.7	8.70	8.47	181	130	248.4
Akma	466	M	29.5	7.54	8.00	275.0	163	4830.0	21.5	8.50	8.50	185	134	284.8
Akma	466	B	28.5	7.49	7.97	268.1	170	4829.0	21.5	8.50	8.50	185	134	279.8
Malik El Nasser	448	S	29.0	6.10	7.99	250.0	170	3560.0	20.5	8.[illegible]	8.54	[illegible]80	130	231.0
Malik El Nasser	448	M	29.0	5.90	7.91	240.0	180	3555.0	20.7	8.57	8.57	180	131	266.8
Malik El Nasser	448	B	27.5	5.88	7.80	239.0	181	3550.0	21.0	8.57	8.57	181	131	242.6
Murshid	378	S	29.5	4.3	7.85	246.0	182	2877.5	20.5	8.45	8.45	186	135	249.4
Murshid	378	M	29.0	4.4	7.80	238.5	185	2878.0	20.5	8.45	8.45	187	135	233.0
Murshid	378	B	28.5	3.45	7.69	236.5	191	2878.8	21.0	8.48	8.48	187	135	244.2
Wadi Halfa	347	S	28.5	5.40	7.78	276.5	195	128.0	20.0	8.56	8.56	200	144.5	45.5
Wadi Halfa	347	M	27.8	5.00	7.77	260.0	196	128.0	20.7	8.52	8.52	203	147.0	75.6
Wadi Halfa	347	B	26.8	5.1	7.67	259.0	189	129.2	21.0	8.51	8.51	205	148.0	82.6
Sarra	323	S	28.5	6.50	7.90	270.0	169	129.0	22.5	8.53	8.53	202	145	37.0
Sarra	323	M	28.0	4.40	7.88	270.0	185	129.0	21.7	8.52	8.52	205	146	34.8
Sarra	323	B	26.3	4.10	7.80	261.0	172	132.0	21.7	8.51	8.51	210	153	38.8

El Dardir et al., (1986) reported that, in water of lake Nasser a remarked increase of Na^{+} ions occurs from south to north, i.e., it migrates with the water current as one of the light elements.

Magnesium is the third most abundant cation in Lake Nubia as an inland water of temperate region. Mg^{++} Concentration vaires from 5.20 mg/1 at El Daka to 7.5 mg/1 at Akma, in November, 1988 as compared with its range from 8.60 mg/1 at W. Halfa to 11.70 mg/1 at Murshid during August, 1985 (Table 3). Consequently, calcium surpasses magnesium in Lake Nubia like other fresh waters because there is abundant calcium over magnesium in sedimentary rocks (Cole, 1979).

K^{+} concentration is very low in the studied samples. Potassium value varies between 1.29 mg/1 in teh bottom water at Sarra and 6.60 mg/1 in the same water layer at Wadi Halfa during August, 1985. It ranges between 2.54 of Malik El Nasser site and 6.90 mg/1 at Wadi Halfa in NOvember (Table 3). This most probably due to its tendency of bieng adsorbed by the caly mineral in the bottom sediments of the lake.

In the studied water samples Co_3^{--} is not detected in the

most samples (Table 3) with the exception of the surface water during August, 1985. This is attributed to the increased temperature in that water layer.

As shown in table 3, lake Nubia is rich in dissolved HCO_3^-. The maximum value of HCO_3^- recorded is 146.5 mg/l during August, 1985 while the minimum amount observed is 110 mg/l during November, 1988. Generally, the average distribution curves (Fig.7) show that HCO_3^- in lake Nubia is more enriched in August, 1985 than in November, 1988 except at Wadi Halfa.

Chlorides vary during August, 1985 from 5.40 to 8.80 mg/l at Sarra and Malik El Nasser respectively. In November, 1988 chlorides fluctuate from 2.35 mg/l at Sarra to 3.55 mg/l at Murshid (Table 3). This, indicates that the main source of chlorides is the Nile flood.

SO_4^{--} content varies between 15.90 mg/l in August, 1985 at El Daka and 6.50 mg/l in November, 1988 at Malik El Nasser (Table 3). Lake Nubia is very rich in concentration of SO_4^{--} as compared with lake volta (0.5 mg/l) [Entz, 1974] .

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Table (3): Major cations and anions (mg/l) of lake Nubia water during August, 1985 and November, 1988.

Location	Deph	August, 1985								November, 1988							
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	Co_3^{--}	HCo_3^{-}	So_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	Co_3^{--}	HCo_3^{-}	So_4^{--}
El Daka	Surface	21.50	11.40	16.90	5.00	7.30	4.0	144.50	15.90	21.50	5.20	11.70	4.27	2.70	--	112.20	9.90
El Daka	Middle	21.60	11.60	17.30	5.70	7.70	-	144.50	15.40	21.30	5.40	10.50	5.10	2.70	-	110.00	10.50
El Daka	Bottom	22.30	11.50	17.10	5.60	7.50	-	147.50	15.20	21.60	6.00	9.70	3.56	2.60	-	110.00	10.60
Akma	S	21.70	10.50	16.10	2.00	7.20	4.0	137.50	12.50	20.70	7.50	10.12	4.67	3.50	-	116.70	9.70
Akma	M	21.70	10.70	16.50	2.00	7.70	-	140.10	13.00	20.95	7.30	11.00	5.30	3.20	-	114.30	10.10
Akma	B	22.30	10.60	16.50	2.00	7.00	-	140.40	12.60	21.30	6.40	11.60	4.20	3.20	-	115.50	10.50
Malik El Nasser	S	21.00	9.30	16.70	5.10	8.30	4.5	129.00	14.30	21.70	5.53	9.20	4.50	3.17	-	111.70	6.50
Malik El Nasser	M	21.20	8.90	17.30	5.30	8.80	-	131.30	14.70	21.50	5.80	10.20	3.10	3.30	-	110.50	8.90
Malik El Nasser	B	21.70	8.80	17.60	5.20	8.40	-	132.10	14.50	21.0	5.85	10.10	2.54	3.40	-	110.00	9.20
Murshid	S	20.40	11.4	19.50	2.00	8.00	5.5	145.00	14.40	19.20	6.30	12.00	6.25	3.55	-	114.00	10.10
Murshid	M	20.60	11.7	19.00	2.00	8.30	-	146.50	14.00	19.25	7.40	10.14	4.60	3.30	-	112.50	9.70
Murshid	B	20.50	11.4	19.40	2.40	8.20	-	146.50	13.60	20.00	7.00	10.10	4.30	3.20	-	111.70	9.90
Wadi Halfa	S	21.30	8.60	15.40	6.40	6.50	5.0	120.00	12.80	22.30	6.60	12.50	4.40	3.60	-	119.50	12.00
Wadi Halfa	M	22.60	8.70	15.50	6.50	6.70	-	120.00	12.40	22.60	5.80	14.50	3.50	2.70	-	123.00	11.50
Wadi Halfa	B	23.10	9.40	15.90	6.60	6.60	-	119.10	12.60	22.60	5.85	12.20	6.90	2.70	-	120.00	11.00
Sarra	S	23.60	9.40	13.10	2.00	6.10	6.0	129.10	14.10	23.90	6.50	9.30	4.00	2.41	-	114.20	14.17
Sarra	M	24.30	9.55	12.09	1.93	5.90	-	129.90	14.00	23.60	6.51	11.20	6.10	2.70	-	122.00	13.90
Sarra	B	23.80	9.55	12.00	1.92	5.4	-	131.10	13.60	23.50	6.70	11.75	7.40	2.35	-	122.50	14.00

content of HCo_3^- from a site to another, however, it generally decreases nothward. Mg^{++} almost shows consistent distribution with HCo_3^-.

During November, 1988 So_4^{--} and HCo_3^- are of least concentration at Malik El Nasser and increases northward and southward (Fig.7). Na^+, Mg^{++}, Cl^-, HCo_3^- and So_4^{--} are almost consistent in their distributions along the lake from the south northward.

Ca^{++} in Fig.(7) represent the most abundant cation and is relatively of higher value in August than in NOvember (Fig.7). The concentration of Ca^{++} ranges during November, 1988 from 19.20 mg/l at Murshid to 23.9 mg/l at Sarra and during August, 1985 from 20.4 mg/l at MUrshid to 34.30 mg/l at Sarra (Table 3).

Soduim is the second most abundant metal in alke Nubia. In the analysed samples, Na^+ concentration ranges from 9.20 mg/l at M. El Nasser to 14.50 mg/l at W. Halfa in November, while it ranges from 12 mg/l at Sarra to 19.50 mg/l at Murshid during August (Table 3). From Fig. 7 it is clear that, Na^+ concentration gets higher in the northern parts than in the sourthern parts during November, 1988.

deep lakes are mostly characterised by deoxygenated lower water layer in certain periods of the year. The pH values are relatively high in the surface water of lake Nasser, indicating that pH value in this layer is caused mainly by the activities of photosynthesis. In southernmost part of lake Nubia at El Daka, T.D.S is high at different depths as compared with lake Nasser. This phenomenon could be explained by the fact that the most sources of T.D.S. is mostly flood water.

Chemical constituents:

Figure 5, shows silight stratification of water due to distribution of chemical components. The surface water at the sites south of Malik El Nasser during August 1985, when low flood prevailed contain lower Ca^{++}, Na^{+} and K^{+} than the middle and bottom water. So_4^{--} and HCo_3^{-} anions at the localities north of Murshid behave similary and vise verca for the sourthern sites. The middle water contains the highest Cl^{-} values . During November, 1988 after a medium flood, the surface water show less stratification relative to August, 1985 since there is variation in the vertical distribution of the elements from a site to another (Fig.6). During August, 1985 although there is variation in the

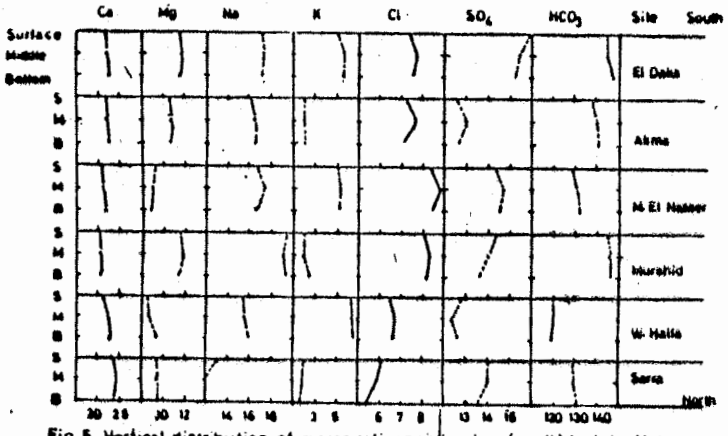

Fig 5 Vertical distribution of major cations and anions (mg/l) in lake Nubia water during August 1985.

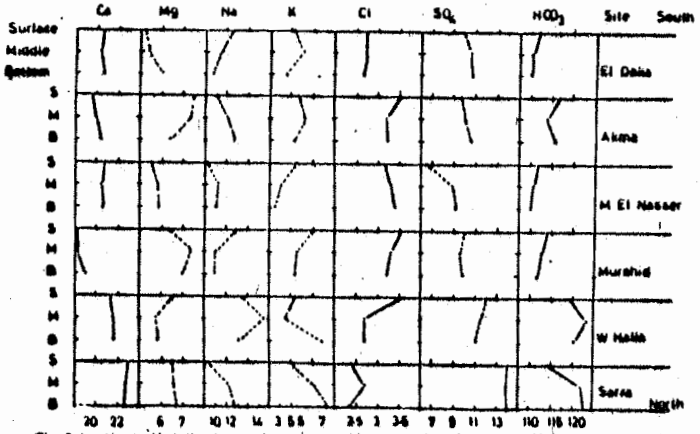

Fig.6 Vertical distribution of major cations and anions (mg/l) in lake Nubia water during November 1988.

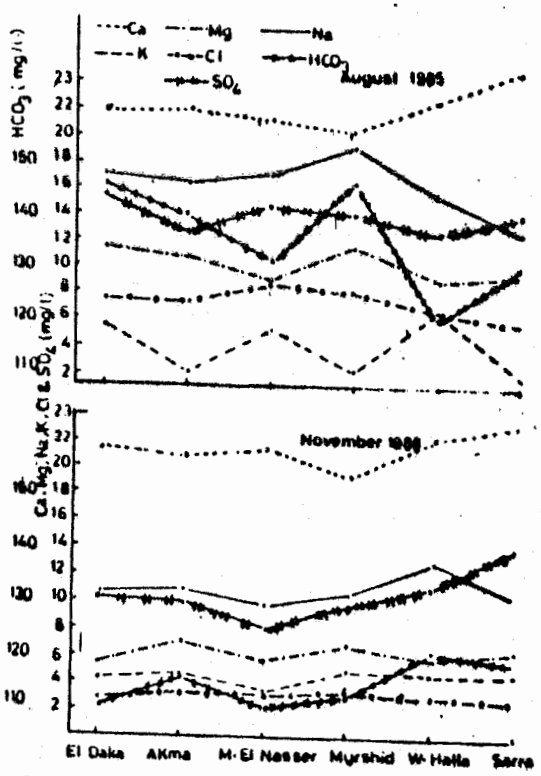

Fig. 7 Average distribution of major cations and anions along lake Nubia water during August 1985 and November 1988.

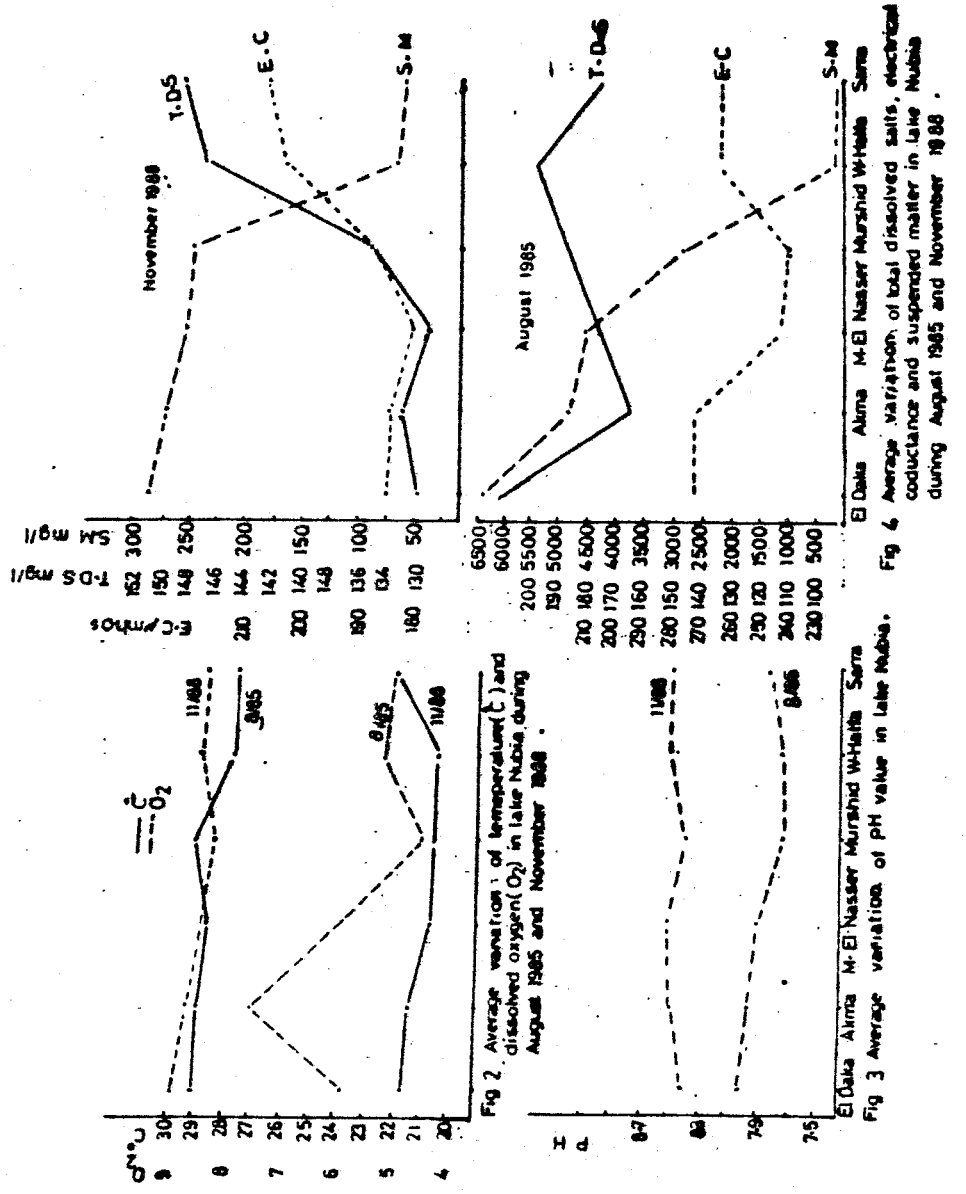

Fig 4 Average variation of total dissolved salts, electrical coductance and suspended matter in lake Nubia during August 1985 and November 1988 .

Fig 2 Average variation of temperature(t°) and dissolved oxygen(O_2) in lake Nubia during August 1985 and November 1988 .

Fig 3 Average variation of pH value in lake Nubia.

suspended material, this relation shows remarkably irregular variation from one site to another (Fig.4).

During August, 1985 electrical conductivity (E.C) does not show particular trend due to effect of flood while during November, 1988 E.C mostly increases from south to north, that directly proportional to the amount of T.D.S. the decrease of the E.C. in November is attributed to low content of Na^{+}, Ca^{++} and Mg^{++} in the sourthern than the northern part of the lake (Fig. 4).

Most of the salts entering the lake are carried by the flood water. The amount of total dissolved salts ranges between 162 and 215 mg/1 and between 130 and 153 mg/1 in the lake water during August and November respectively (Table 1).

From table 2 lakes Nubia and Nasser have certain similarities but also other interesting differences are present. In lake Nubia no hypolimnion exists and the total water mass is well mixed. Within lake Nasser (Elewa et al., 1984) a hypolimnion is present (non oxygenated layer) where oxygen is absent in the bottom waer layer, since that is refered to that it is more deeper. Thresh et al.,(1944), Aleem and Samman (1969) and Nessiem (1972) reported that the

average distribution of the pH vcalues. In lake Nubia water, the mean pH values are high as compared with the mean values of alke volta (Eutz, 1974). Worsley (1929) stated that the increase of salt content in water may cuase decrease in its pH value. The total dissolved salts (T.D.S) in lake Nubia water are higher in Agust than in November, 1988 and the pH value varies between 7.67 and 8.10 mg/l during Agust between 8.40 and 8.57 mg/l during November (Table 1). This supports the findings of Worsley (1929).

The bulk of the suspended material carried by the Nile flood is deposite around the second Cataract near Wadi Halfa. Mechanicsl analysis for selected suspended particles showes that most of the grains are of the silt in size. Furthermore, The amount of the suspended matter decreases from the south to the north parallel with variation in speed of current. In August,1985 the average value of the suspended material ranges between 128.4 and 6331.8 mg/l as compared with the lowest values in November, 1988 (60.8 and 283.70 mg/l) (Table 1) when most of the suspended matters have been deposited.

During November, 1988 the suspended matter and T.D.S. in the water of the lake behave reversably in their distribution (Fig. 4). During August, 1985 and before deposition of the

Table (2): Some physical and chemical parameters [temperature (°C), dissolved oxygen (O_2), pH, electrical conducatance (E.C.) and total dissolved salts (T.D.S)] for lake Nubia water as compared to lake Nasser water (August, 1985).

Lake	South ↔ North						
	Nubia				Nasser		
Km/H.D / Site / Depth	481 El Daka	448 Malik El Nasser	323 Sarra	280 Abu Simbel	170 Wadl El Arab	7 High Dam	Parameter
Surface	30.0	29.0	28.5	27.2	29.3	27.5	°C
Middle	28.5	29	28	26.1	24.2	24.8	
Bottom	28.5	28.5	26.3	22	23	23.5	
S	5.95	6.10	6.50	6.0	8.0	8.2	O_2 (mg/l)
M	5.94	5.90	4.40	3.4	2.6	1.6	
B	5.90	5.88	4.10	-	-	-	
S	7.50	7.99	7.90	8.30	8.70	8.77	pH
M	8.10	7.91	7.88	8.10	7.85	8.56	
B	8.0	7.80	7.80	7.75	7.80	8.50	
S	275.0	250.0	270.0	283.0	288.0	233.0	E.C. (μ mhos)
M	272.0	240.0	270.0	283.5	305.5	237.0	
B	269.5	239.0	261.0	312.0	307.5	240	
S	200.0	170.0	169.0	161.7	177.0	175.0	T.D.S (mg/l)
M	215.0	180.0	185.0	159.0	183.0	173.0	
B	215.0	181.0	172.0	153.5	192.0	120.0	

total dissolved salts (T.D.S). They were chemcially analysed for cations (Ca^{++}, Mg^{++}, Na^{+} & K^{+}) and anions (Co_3^{--}, HCo_3^{-}, Cl^{-} & So_4^{--}) according to procedures described by the American Puplic Health Association APHA (1980). The temperature, O_2, pH value, E.C. as well as Co_3^{--} and HCo_3^{-} determination during sampling on the boat. The chemical analysis as well as T.D.S and S.M. determination were undertaken in the laboratories of lake Nasser Research Station and Aswan Regional Planning by the author. Mechanical analysis for the suspended particles was undertaken by the author using Folk's method (1974).

RESULTS AND DISCUSSIONS

Physico-chemical characteristics:

Lake Nubia lies within the district of continental arid climate. The water of the lake is affected by this climatic conditions and the River Nile flood. Temperature represents the most effective parameter which influences all physical and chemical processes in aquatic environments. The water temerature in lake Nubia dereases with depth. It ranges from 26.3 to 30.5 ^{o}C and from 20 to 22.5 ^{o}C during August [1985] and November [1988] respectively (Table 1). Generally the water temperature decreases from south to north during

August, 1985 but fluctuated during November, 1988 (Fig., 2). From the present study lake Nubia soes not exhibit thermal stratification like lake Nasser (Elewa et al., 1984).

Golterman (1975) pointed out that when the physical stratification is well established, chemical changes in the hypolimnion (non-oxygented layer) follow, whereby oxygen becomes consumed. Consequently dissolved oxygen in water environment is one of the most important parameters in controlling the oxidation reduction conditions. However Figure 2 shows the average concentration of dissolved oxygen in Lake Nubia. It varies in August from 4.10 mg/1 at Sarra to 7.54 mg/1 at Akma as compared with its range from 8.45 mg/1 at Murshid to 8.87 mg/1 at ElDaka during November , 1988 (Table 1). The rise of water temperature diminishes. The rise of water temperature diminishes the solubility of oxygen in lake water (Ruttner, 1957).

The pH values are always on the alkaline side and in several analysed surface water are more alkaline than the deep water (Table 1). This could be explained by the activities of phytoplankton (El Wakeel and Wahby, 1970) besides the higher temperature of the surface water than the middle and bottom water (Masson, 1966). Figure ,3 shows the

CONCLUSIONS

Physical and chemical studies made on water of lake Nubia do not indicate oxygen and thermal stratification. The pH value of the water is high in November, 1988 than in August, 1985. During Autumn the suspended matter and total dissolved salts in the lake are mainly inconsistent in their distribution. Electrical conductivity is found to be directly proportional to the amount of total dissolved salts. The increase of electrical conductance northward is due to increase of Na^{+}, Ca^{++}, Mg^{++} and K^{+} concentration.

Ca^{++}, Na^{+} and Mg^{++} represent the most abundant cations. K^{+} is very low due to its tendency to be adsorbed on the surface of the clay minerals particles. HCo_3^{-} and So_4^{--} are the most abundant anions in the lake.

Lake Nubia and Nasser have certain similarities but also other interesting differences are present. In lake Nubia no hypolimnion (non-oxygenated layer) exist and the total water mass is well mixed. Within lake Nasser a hypolimnion is present where oxygen is absent in the bottom water and this is attributed to its relatively great depth.

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