Bull. Nat. Inst Oceanogr. & Fish., ARE, 17 (1) 1991: 89 - 101.

EFFECT OF THE FLOOD WATER ON PHYSICO- CHEMICAL CHARACTERISTICS OF LAKE NUBIA.

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ABSTRACT

The inflow of turbid flood water, affects the physical and chemical conditions of Lake Nubia water. Thermal stratification and dissolved oxygen profiles along the Lake were destructed. Higher values of electrical conductivity, HCO^-, CO_3^{--} and SO_4^{--} measured during the flood period are due to the first washing of the dissolved salts through the Nile tributries. After sedimentation of the suspended particles, the sharp decrease in the concentrations of Ca^{++}, Mg^{++} and Na^+ is mostly due to the deposition through the electrical double layer on the surface of the fine suspended particles.

INTRODUCTION

The Aswan High Dam Reservoir is formed after the construction of Aswan High Dam in 1964 in upper Egypt. It extends over an area of 5,000 km^2 with the northern two third in Egypt (Lake Nasser, 300 km long) and the southern third in Sudan (Lake Nuia, 200 km long) and extends approximately within latitudes of 21° N in Sudan and 24° N in Egypt and longitudes of 30° E and 33° E respectively (Fig. 1).

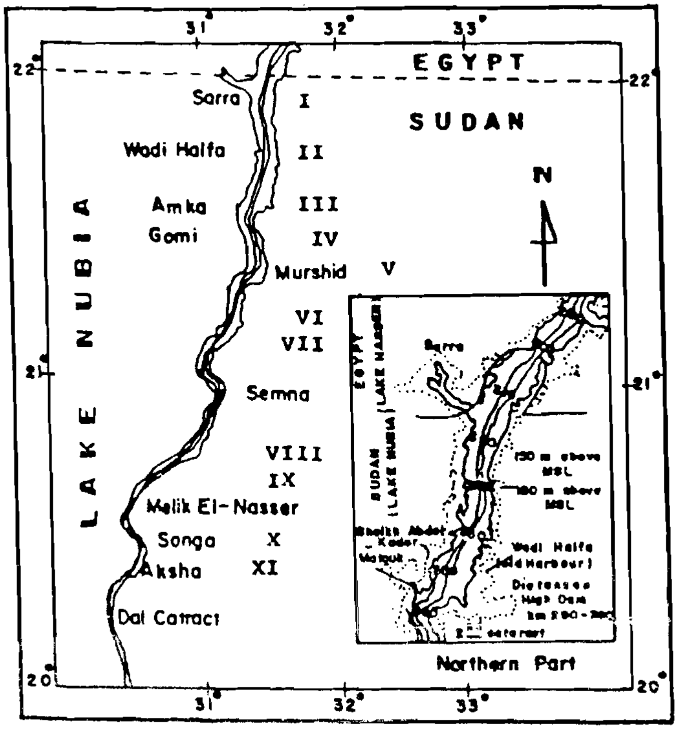
Some limnological studies were carried out on Lake Nasser (Entz, 1976; Elewa, 1980, 1985 & 1987). However, for Lake Nubia a few limnological studies in the early years of its formation took place (George, 1971; Abu-Gideiri and Ali, 1975; Ali, 1980 and Latif and Elewa, 1985). The aim of the present study is to investigate the effect of the flood water on some physical and chemical conditions of Lake Nubia.

MATERIAL AND METHODS

Three field trips were under taken in June, July and November, 1987 through the reservoir using a research boat. Eleven stations representing the different areas were sampled. Light penetration within the different water layers expressed in microeinsteins per square meter per second (µE / m^2/ Sec) was measured using a light-meter (Li - COR Sensors) Model LI - 185 A Quantum / Radiometer / Photometer.

Fig. 1

Map of Lake Nubia (Sudan)
showing the sample locations



Photosynthetic rate at various depths was measured by the light / dark-bottle method followed by the winkler oxygen determination (Talling, 1965). Transparency was measured by the standard secchi disc. Other limnological measurments; temperature (°C), dissolved oxygen (mgl^{-1}), electrical conductivity (µmhos / cm.) and pH values were taken using Hydrolab surveyer model 6D water quality analyzer (Hydrolab, Austin, Texas).

For chemical analysis, water samples were collected from five depths using a Van Dorn sampler. Analytical procedures used for quantitive determination of the chemical parameters (total dissolved solids, carbonate, bicarbonate, chloride, sulphate, sodium, calcium, magnesium and nutrient salts) were based on methods described by Anon (1975). The analysis of the water samples was carried out in the field after collection.

RESULTS AND DISCUSSION

Light Penetration

Phytoplankton productivity in the aquatic environment is closely allied to the penetration of ambient surface radiation into the environment (Vollenweider, 1974). Thus, the attenuation of light in a column of water is determined by the interaction between three component factors; the extinction of light by water itself as well as by dissolved and supended materials (Hutchinson, 1957).

The schott coloured filters were used to divide the photosynthetically active region of the spectrum (400-700 nm) into bands of known midpoint and measured ambient light versus depth in different wavelength bands (Strickland 1958). Data obtained from Aswan High Dam Reservoir indicate that most penetrating component of light spectrum was in the yellow region during the earlier period of impoundment in 1971 and in the green region during 1979 (Fead, 1980). Several factors suggest that the most penetrating portion of the spectrum in Lake Nasser and Lake Nubia is normally in the yellow region, except when dense blooms of algae, high inorganic turbidity or a significant increase in transparency due to upwelling or low productivity in surface water occur. In Lake Nubia, high concentrations of non-living suspended matter were recorded (Entz, 1980), indicating that the shallower the light penetration, the more the spectra of ambient light is displaced to longer wave lengths. In Lake Nasser, it may be significant to note. that the penetration of yellow light was greater than green light followed by red and blue (Table 1). The turbid water coming from south to Lake Nubia during the flood season reduces the transparency to a minimum value. Meanwhile, this flood water brings a great of silt and clay (Table 2). The peak of suspended solids was recorded just in front of the flood period. After the sedimentation of these solid materials, the water column again becomes free from silt and clay resulting the increase of water transparency.

Primary Productivity

The results showed that maximum productivity was measured in July between 0.5 and 1.5 m in Lake Nasser and at 1.5 m in Lake Nubia (Table 3). In comparison to Lake Nasser, abundance of the suspended solid in Lake Nubia tends to restrict the penetration of light through different depths. On the other hand, the phytoplankton respiration rates are moderately high in Lakr Nasser than in Lake Nubia, due to the higher community in the first one. The highest rates occurred in the surface water when the gross productivity value was minimum. These results indicate that net productivity rate was lower at this depth and vice versa at 0.5 m depth.

Table 1.

Light intensity (UE / m^2 / Sec) in July 1987.

Depth (m.)	Lake Nasser					Lake Nubia				
	Without filter	RG_2	OG2+BG18	VG9	BG_{12}	Without filter	RG_2	OG2+BG18	VG9	BG_{12}
Surface	950	270	165	120	95	1000	250	180	150	90
0.5	700	190	100	100	55	400	110	95	60	20
1	500	130	90	75	30	100	40	35	22	2
1.5	400	85	75	60	18	20	17	20	10	0.65
2.0	300	60	65	55	11	12	9	10	6	
2.5	200	40	45	40	8	6.5	6	6	3.5	
3.0	150	25	40	30	4.5	4	4	4	2.1	
3.5	120	20	37	20	2	2.4	2.3	2	1.0	
4.0	90	15	20	15.5	1.5	1.4	1.0	1.4	0.6	
4.5	70	10	17	12	1.0	0.8	0.6	1.0	0.6	
5	60	8.5	14	11	0.7			0.5		
6	40	4	10	7						
7	25	2	5	4.8						
8	15	1	3.5	3.7						
9	12	0.7	3.3	2.7						
10	9		2.7	1.6						
11	7.5		2.0	1.5						
12	6.5		1.7	1.2						
13	6		1.2	0.8						
14	4.4		0.8							
15	2.7									
20	1.1									

RG_2 : Deep red filter (wave length 655 nm). VG : green filter (wave length 530 nm).
BG_{12}: blue filter (wave length 440 nm). OG2+BG18: Yellow filter (590 nm).

Table 3.

Transparency (cm), total suspended and dissolved solids (mg l^{-1}), electrical conductivity (umhos), dissolved oxygen (mg l^{-1}) and pH values in Lake Nubia during 1987.

Site No.	Km/High Dam	Depth (m)	Secchi (cm)	Suspended Solids		Total dissolved		Electrical Conductance			O_2		PH	
			June	July	November	July	Nov.	June	Jule	Nov.	June	Nov.	June	Nov.
I	310	50	100	121	43	175	152	236	267	154	5.16	9.68	7.87	7.8
II	360	25	100	147	74	198	153	249	265	158	7	10	8.79	7.85
III	365	18	90	3106	249	197	152	259	268	139	7	10.2	8.42	7.65
IV	372	12	50	2614	238	177	154	281	245	125	6.64	8.4	7.84	7.9
V	375	11	40	2824	247	186	152	271	240	131	6.48	10.0	7.76	7.7
VI	396	5	40	2898	252	191	156	273	306	131	7.2	9.68	7.94	7.74
VII	400	12	40	3463	258	168	186	256	283	128	7.68	9.1	8.28	7.65
VIII	430	6	30	3716	270	215	153	259	246	146	7.8	8.28	8.17	7.75
IX	440	6	30	3785	287	166	154	256	256	131	7.68	7.88	7.76	7.65
X	450	10	30	3470	250	177	155	258	242	138	8.32	8.12	7.71	7.85
XI	480	5	30	5443	276	188	162	260	272	124	7.53	7.44	8.62	7.77

Table 2.

Productivity (gm C /m^2 / day) of Aswan High Dam Reservoir in July 1987 (incubation period 10 Am - 2 PM).

Depth (m.)	Gross Primary Production.		Net Production		Respiration rate	
	L.Nasser.	L.Nubia	L.Nasser.	L.Nubia	L.Nasser.	L.Nubia
Surface	3.7	5.48	3.27	3.73	2.18	1.44
0.5	6.53	3.98	5.81	2.07	0.44	1.49
1.5	6.97	8.96	5.46	7.72	1.27	1.04
3.0	5.0	1.74	3.27	0.99	1.45	0.62
Average	5.55	5.04	4.45	3.628	1.34	1.15

Electrical conductivity

The flood water affects considerably the changes in the electrical conductivity in the areas. As presented in Table 3, the values of electrical conductivity were maximum during the flood period, (306, umhos in July). This may be due to the wash out of cations and anions to reach maximum average of 306 umhos in July. However, after the flood period (in November) the cations and anios were sedimented throughout the chemical adsorption on suspended matter to the bottom resulting in reduction of the electrical conductivity values. Talling and Rzoska (1967) found that variations in conductivity was highest during the phase of low water levels, preceding the flood. However, variation in the concentrations of HCO_3^- + CO_3^{2--} (alkalinity in meg/l) is closely correlated with that of conductivity, as would be expected from the predominance of these anions. Again there is a positive correlation between the electrical conductivity and total dissolved solids. The relationship between these two parameters before and after was as follows:

$$Y = 130.47 + 0.2043 x \text{ in July}$$

$$Y = 204.3414 - 0.3449 x \text{ in November}$$

The correlation coefficient (r) between the electrical conductivity (Y) and total dissolved solids (x) was 0.7193 and 0.7978 calculated in July and November, respectively.

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II	360	25	100	147	74	198	153	249	265	158	7	10	8.79	7.85
III	365	18	90	3106	249	197	152	259	268	139	7	10.2	8.42	7.65
IV	372	12	50	2614	238	177	154	281	245	125	6.64	8.4	7.84	7.9
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Temperature

The average air temperature over the Lake varied in the range of 14.3 to 33.3°C (maximum range was from 28 to 45 °C). The maximum water temperature (31°C) was measured in the surface water at Amka in July. The temperature difference between the surface and the bottom was maximum at Sarra (6°C). At the same time, the thermal stratification was destructed by going southward under the effect of flood water. Moreover, the average temperature varied between 23.8 and 29.8°C.

Oxygen

Vertical variation of dissolved oxygen was generally limited in the southern area of Lake Nubia in June when the difference between the surface and the bottom water at Sarra site was 3.0 mgl^{-1}, compared with 1.8 and 1.0 mgl^{-1} at Wadi Halfa and Kignarti sites, respectively.

In the surface water, the oxygen content varied between 6.6 and 8.4 mgl^{-1}, measured at Sarra and Melik El Nasser, respectively. In the bottom water, the range was 3.6 and 8.0 mgl^{-1} at these two sites, respectively (Table 4).

The average values of oxygen content in Lake Nubia showed higher values after the flood period in November (7.4 - 10.2 mgl^{-1}) compared with those (5.2 - 8.3 mgl^{-1}) in June before the flood. The appearence of a low oxygen value in June is mainly due to the decomposition of detrital plankton and organic matter, whereby oxygen becomes consumed and carbon dioxide is produced (Brewer et al., 1977. and Golterman, 1975). The rise of water temperature and the increase of the total dissolved salts (Table 3) in this month probably diminished the solubility of oxygen in Lake waters (El-Wakeel and Wahby 1970).

pH

The pH values of the Lake water lies in the alkaline side. Higher pH values were recorded during June (range of 7.71 to 8.79). In November, there is no compa'able changes in pH between different sites of the Lake with values varying between 7.65 and 7.9 (Table 4). Generally, lower values of pH were found only in silt-laden water probably corresponding to increased concentration of CO_2 resulting from organic matter decomposition.

Sodium

Sodium distribution in the Lake water in July and November showed irregular variations at different areas. Generally, the values fluctuated from 6.0 to 24.7 and from 7.3 to 18.5 mgl^{-1} in July and November, respectively (Table 5).

Table 4.

Average concentration of carbonate, bicarbonate, sulphate, chloride, sodium, calcium and magnesium (mg l^{-1}) in Lake Nubia during 1987.

Site	June		July		Nov.		June	Jule	Nov.	June	Nov.	July	Nov.	June	Jule	Nov.	June	Jule	Nov.
No.	HCO_3	CO_3	HCO_3	CO_3	HCO_3	CO_3	SO_4			Cl^-		Na^+		Ca^{++}			Mg^{++}		
I	101.2	3.6	129.9	1.8	141.5	0	9	17.9	14.7	7.6	5.86	16.2	15.6	20.4	25	27.3	6.8	8.9	9.2
II	107.2	3.2	117,7	1.8	131.8	0	8.7	12.4	14.2	7.8	4.61	9.2	11.6	19.6	25.3	27.6	7.2	11.3	8.9
III	104	12.4	156.8	1.8	129.3	0	9.8	11	16.5	7.8	5.83	12.5	16	19.5	28.5	25.4	7.6	14.2	8.2
IV	114.4	1.6	152.5	1.8	124.4	0	11.9	11.2	13.5	7.8	5.68	24.7	14.9	18.7	20.3	23.1	6.8	12	8.4
V	114.4	1.6	145.8	1.8	118.3	0	11.4	13.1	13.8	7.8	4.08	16.6	12.9	17.9	25.7	24.1	6.6	9.7	7.0
VI	116.4	0	120.2	1.8	103.4	0	12.7	12.2	18.2	7.88	5.32	6	12.1	17.3	25.7	22.1	7.4	13.4	7.0
VII	114.8	0.8	140.3	1.8	117.1	0	10.5	10.6	17.3	8.98	5.5	7.9	18.5	17.9	36.3	23.7	7	12.3	5.6
VIII	113.6	0.8	147	1.8	124.4	0	14.6	15.9	8.8	8.7	5.85	10	10.2	17.9	36.2	23.7	7	9.5	9.7
IX	109.6	4.4	123	1.8	115.9	0	12.6	16.7	9.1	8.7	5.85	11.3	7.3	17.4	28.2	22.8	7.4	7.6	9.5
X	110.	4.0	129.9	1.8	128.1	0	12	18.8	13.4	8.7	4.97	7.5	18	17.4	39.1	23.7	7.4	12.6	6.2
XI	108	6.0	141.9	2.1	114.7	0	12.5	17.4	9.3	9.9	5.32	2.8	12.5	17.4	35.3	22.5	7.2	13.4	6.4

Table 5.

Average concentration of phosphate, nitrate and silicate ($mg\ l^{-1}$) in Lake Nubia during 1987.

Sites	PO_4			NO_3	SiO_2		
	June	Jule	Nov.	June	June	Jule	Nov.
I	0.01	0.9	0.15	0.18	6.2	2.6	6.3
II	0.01	0.04	0.1	0.14	6.16	6.8	6.9
III	0.01	0.1	0.16	0.17	6.3	8.5	9.5
IV	0.01	0.2	0.32	0.23	7.84	8.3	5.3
V	0.02	0.07	0.4	0.18	8.16	8.0	8.5
VI	0.01	0.08	0.37	0.17	8.2	10.5	6.3
VII	0.01	0.1	0.26	0.09	8.66	8.0	4.0
VIII	0.01	0.2	0.4	0.14	8.6	11.5	5.8
IX	0.01	0.16	0.4	0.15	8.48	13.5	8.9
X	0.01	0.14	0.36	0.07	8.64	6.3	11.2
XI	0.0	0.2	0.4	0.13	8.64	13.5	10.8

Calcium

The data of calcium showed a pronounced variations along the different areas, especially in July (flood period). Before the flood period in June, variations in calcium content was limited between stations V and XI (range of 17.3 to 17.9 mgl^{-1}) as compared with the values from 18.7 to 20.4 mgl^{-1} in the northern area. in July, there was a wide difference between the minimum (20.3 $mg\ l^{-1}$) and the maximum value (39.1 $mg\ l^{-1}$). After the flood period and precipitation of suspended solids, the calcium content decreased to reach the range of 22.1 - 27.6 $mg\ l^{-1}$. Generally, the higher calcium content in July may be to redissolution of organisms and suspended solids containing calcium in the presence of dissolved CO_2. On the other hand, the lower values in July may be due attributed to its consumption by phytoplankton and fishes, its adsorption on magnesium hydroxide or suspended solids and its precipitation to the bottom sediments.

Magnesium

Distribution of Mg in the Lake water showed the same trend of Ca variations (Table 5). Thus the higher values were measured in July (range 7.6 to 14.2 $mg\ l^{-1}$) in comparison with the minimum values observed in June (ranging from 6.6 to 7.6 $mg\ l^{-1}$). In November, the magnesium range was 5.6 to 9.7 $mg\ l^{-1}$. The relative increase in the Mg content in July may be ascribed to redissolution of organisms containing Mg, redissolution of $MgCO_3$ by the CO_2 or due to the high temperature resulting to the increase in the rate of evaporation of water which led to increase of the Mg content. The decrease in the Mg content in November may be a result of the dilution by the flood water.

Chloride

The chloride distribution in Lake Nubia showed higher values in June (range 7.6 - 9.9 mg l^{-1}), as compared with those (4.1 - 5.8 mg l^{-1}) in November. Variation of chlorosity in Lake Nubia is related mainly to evaporation as well as dilution by the flood water as reflected on the values reported in November.

Sulphate

In June the maximum concentration of sulpate was 14.6 mg l^{-1}. At Atteri the values decreased progressively to reach 9.0 mg l^{-1} in the northern area at Sarra (Table 4). The major factors causing regional changes in sulphate content may be the degree of sulfur reduction as well as the thermal stagnation in the subsurface water where anoxic situation prevailed above the bottom sediment especially in the northern areas of the Lake. Planktonic organisms may also influence the sulfate concentration in the Lake, due to the mineralization of organic cellular sulfur content (Hutchinson 1957). In July the average value of sulphate varied between 10.6 and 18.8 mg l^{-1} at Semna and Melik El Nasser sites, respectively.

Carbonate and Bicarbonate

In June (before the incoming of flood), carbonate was recorded in the surface water at Amka with the maximum average value of 12.4 mg l^{-1}. In the middle area of the Lake, the water column was devoid from carbonate beneath the surface. In the southern area, there was a minor variation with depth. The average concentration of carbonate ranged from 0.0 to 12.4, and from 1.8 to 2.1 in June and July, respectively. No carbonate content was measured in November (Table 4). This may be attributed to precipitation with the suspended silts to the bottom.

The free CO_2 was only measured in the middle area of the Lake in June. The maximum recorded value was 1.76 mg l^{-1}.

As shown in Table 4, bicarbonate content gave higher values in July in accordance with the electrical conductance (Table 3), as compared with the minimum values in June.

Phosphorus

The reactive phosphorus content of Lake Nubia was minimum in June (0.000 - 0.018 mg l^{-1}), compared with that (0.04 - 0.2 mg l^{-1}) measured in July. Generally, the minimum values were obtained in the north while meximum concentrations were observed in the south (Table 5). In November, the phosphorus concentration was higher in comparison with the preceding periods, ranging between 0.1 and 0.4 mg l^{-1} (Table 5). The relative decrease in phosphorus concentration or its complete depletion, especially in the surface waters in June coincided with the corresponding decrease in the amounts of allochthonous and autochthonous supply of phosphate (Saad, 1973) and to the increase in its consumption by algae, bacteria or other plants, precipitation with Ca, Fe and Al as well as its adsorption on hydrous iron or aluminium oxides, silt and clay particles suspended in the water column during flood should also be considered.

As most localities, PO_4 increased in the deep water layer. This was in accordance with the low amounts of dissolved oxygen obtained. On the other hand, dissolved oxygen plays an important role in controlling the rate of phosphate release from the sediment to the uper water layers. When the sediment-water interface becomes anoxic, phosphate passes rapidly into the upper layer.

Nitrite and Nitrate

Compared with nitrate, the nitrite content was depleted in the different areas of the Lake. The absolute values of nitrate (Table 5) ranged between 0.07 and 0.23 mg l^{-1} measured at Melik El-Nasser and Gomi sites, respectively.

Complete depletion of nitrite may be due to its oxidation into nitrate or as a result of its denitrification to ammonia, as well as its uptake by phytoplankton (Golterman, 1975).

Reactive Silicon

The minimum reactive silicon content was measured in June in the northern area of the Lake compared to higher values recorded in the south (Table 5). This condition is mainly due to the uptake of silicate by phytoplankton in the north and the increase in the south in the riverine area rich in suspended matter. Fluctuation of silicate in the Lake water may be due to the biological effect and / or by upwelling of deep water of high silicate and from relict enriched flood water. It seems probable that silicate content is influenced mainly by physical and chemical condition of the Lake water rather than by diatoms consumption (Aleem and Samaan, 1969).

On conclusion, an important gain from the construction of Aswan High Dam is the productive lake fishery. An artificially dammed lake is always more biologically productive than the original river, provided that the nutrients that accumulate in it are adequately circulated. The annual flood-water provides nutrients in solution, but the abundant sediments that fall to the bottom decompose and yield much soluble nutrient materials. These are circulated into the surface euphotic zone by the currents generated by the inflowing river, and by the seasonal alternate stratification and overturn of the deeper water. Consequently the productivity of the Lake has progressively increased since its inception (Beadle 1974).

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