Acta Adriat. 21 (1): 105—117 (1980) YU ISSN: 0001-5113
AADRAY

TRANSPARENCY, CONDUCTIVITY, EVAPORATION AND THERMAL REGIME OF LAKE NASSER

PROZIRNOST, VODLJIVOST, ISPARAVANJE I TOPLINSKI REŽIM JEZERA NASSER

S. H. Sharaf El Din[1] and M. El Shahawy[2]

[1] *Oceanography Department, Faculty of Science, Alexandria University, Egypt*
[2] *Institute of Oceanography and Fisheries, Academy of Science and Technology, Egypt*

The physical limnological studies of Lake Nasser, such as temperature, conductivity, transparency, and water level fluctuations had been examined during the period 1970—1974.
From the temperature observations taken in the lake the thermal regime of Lake Nasser from one seanson to another was studied in details in the vertical and in the horizontal directions. The different approaches to estimate evaporation were applied to calculate the monthly figures of the evaporation losses from the lake.

INTRODUCTION

In 1964, the Aswan High Dam vas completed, and since that time all the Nile water discharge including the sediments impounded in the Lake Nasser reservoir behind the Dam, Fig. 1.

The importance of the Aswan High Dam reservoir, i. e. Lake Nasser, is that a minimum supply can be guaranteed all time by storing water in years with large inflows and using it later in years with small inflows.

Lake Nasser appears to be one of the basically most productive large bodies of water in Africa.

The present study describes some aspects of the physical limnological characteristics of Lake Nasser such as the conductivity, the transparency and the water level fluctuations during the five years (1970—1974).

From the temperature observations taken in the lake, the thermal regime of Lake Nasser from one season to another was studied in details in both vertical and horizontal directions. The different approaches to estimate evaporation were applied to calculate the monthly figures of the evaporation losses from Lake Nasser.

DATA AND METHODS USED

The data recorded in Lake Nasser are physical, limnological and meteorological data. The limnological data includes water temperature, turbidity and conductivity. The water temperature was measured from about sixteen stations at depths from 0 to 60 m below surface, at five meters intervals during each cruise, Fig. 1.

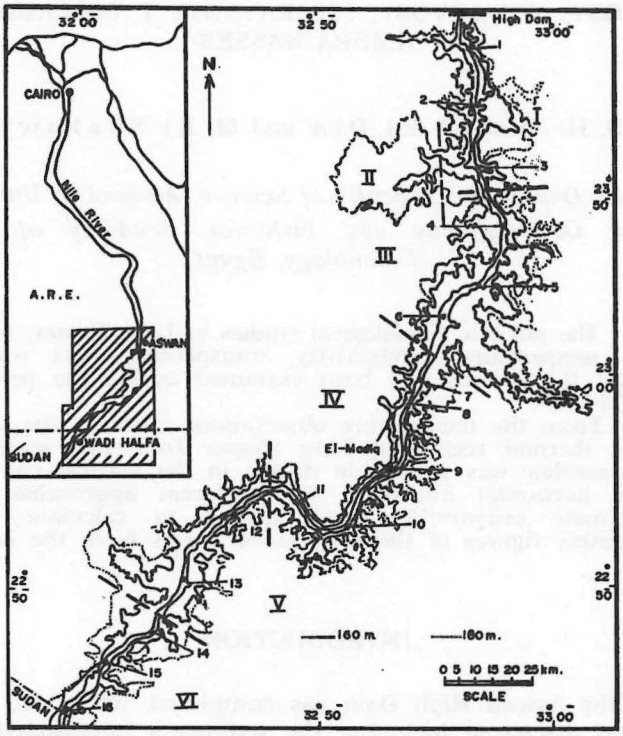

Fig. 1. Lake Nasser: sections and sampling stations

The water temperature was measured by the reversing thermometer, and by the hydrolab II A portable water quality analyser. The water samples were taken by Nansen bottle. The turbidity data were taken using Secchi disc while the conductivity was measured by the hydrolab II A (El-Shahawy 1975).

The meteorological data which include wind speed and direction, atmospheric pressure, relative humidity and air temperature were taken from three sources:

1. Aswan airport meteorological station situated at 5 km to the south west of Lake Nasser.

2. Meteorological station of Lake Nasser Development Center, at Abu Simbel, 275 km from Aswan.

3. Direct measurements of climatological conditions over the lake during each cruise.

All the data taken from the lake were carried out by the Research Vessel Bolti.

FLUCTUATIONS OF LAKE LEVEL

Vater level in Lake Nasser is varied according to the value of stored water. This amount, in turn depends upon the amount of incoming vaters (inflow) as well as the amount of water that passes through the H. D. for purposes of irrigation, electric power, etc, (oufflow). Also it depends on the water lost from the lake by evaporation.

The storage was increasingly from year to year during the filling stage of the lake and consequently the water level was increasing as shown in Fig. 2.

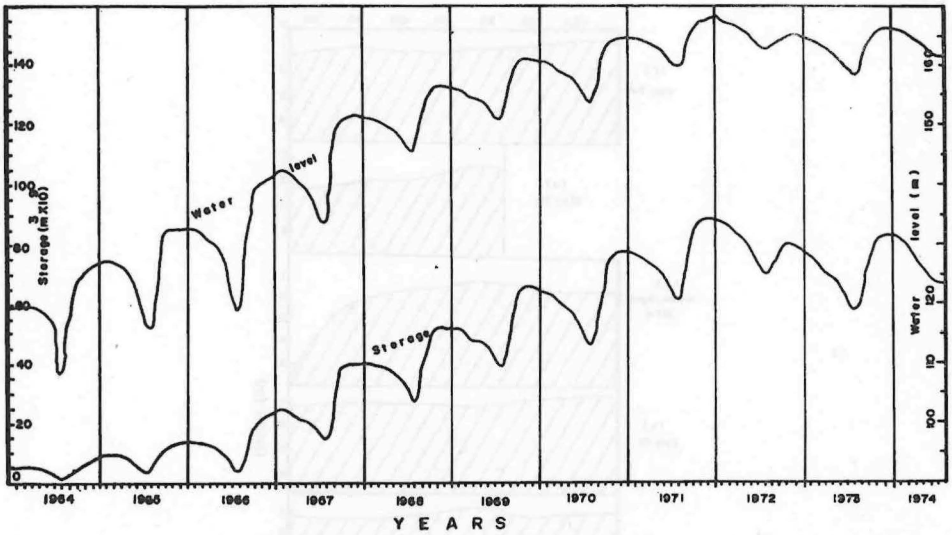

Fig. 2. Water level in m and storage in $m^3 \times 10^9$ in Lake Nasser during the period 1964—1974

The seasonal fluctuation in water level of lake can be classified to:

a) Low water period from April to August, with a marked minimum in July where at that time of the year the discharge of fresh water coming from the Ethiopia does not start to flow through the lake. Also the decrease in the water level in the lake during the period June-July is mainly due to the high evaporation over the lake as the air temperature reaches its maximum during that period.

b) Higher water levels from August until the end of the year is due to the arrival af the inflowing waters of the flood season. The rate of increase of the water level from year to year depends upon the amount of flood water reach year, and of the outflow through the H. D., as well as from the water lost by evaporation and seepage.

TRANSPARENCY

In Lake Nasser, the turbidity of the water is mainly caused by:

1- the dense phytoplankton development (diatoms and blue green algae).

2- the suspended silt and clay of the flood water.

In general, stations with highest transparency were these far from rivers or other sources of sediments. So, the transparency was usually high in the northern part of the lake near the High Dam, and decrease towards the south. From the observations of the Secchi disc taken in Lake Nasser, it is clear that the transparency varies from one season to another. Fig. 3A, 3B, 3C, show the variation of transparency along Lake Nasser during the different trips.

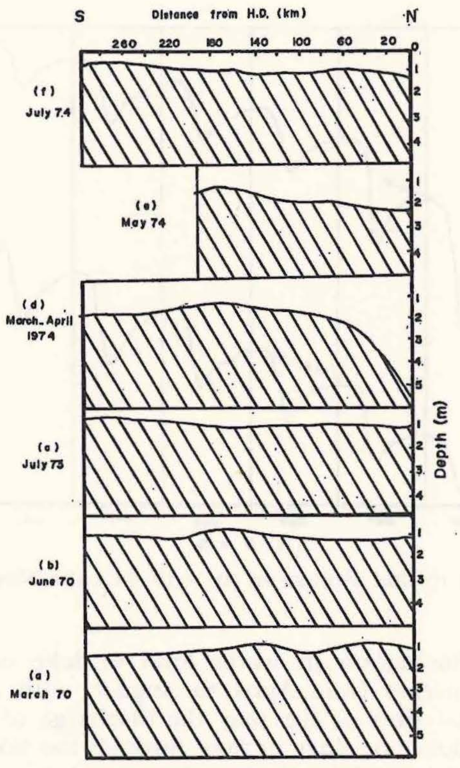

Fig. 3A. Depth of visibility during the period March — July

During the winter season (February), the transparency is high compared with the other seasons. This can be contributed to the fact that there is no flood in that season and also the phytoplankton bloom was not created at that time of the year.

During the flood season (August-November) the Secchi disc observations gave a higher values near the High Dam and low ones south of the lake. This contributes to the fact that after 1968, no turbid water coming with the flood passed through the H. D. Besides, the suspended particles coming with the flood water have been sedimented along the lake on its way before reaching the H. D. At the Khors, the transparency of light was found to be lower than that at the open lake infront of the Khor.

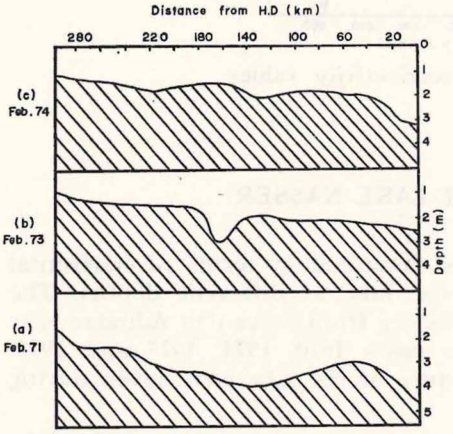

Fig. 3B. Depth of visibility in Lake Nasser during Winter

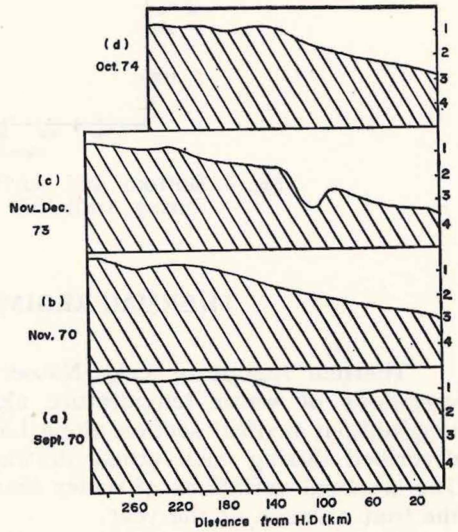

Fig. 3C. Depth of visibility during the period Sept.—Dec.

CONDUCTIVITY

Variations in the conductivity of Lake Nasser follow the movement of the water masses of the flood water. The highest conductivity can be found just in front of the flood water (280—350 m mhos) and the howest value at the end of the flood water as it is intruding the lake (160—200 m mhos).

In winter the variation in conductivity along the lake varies from 245 m mhos at H. D. to about 223 at Adindan (296 km from H. D.). In Summer (in particular during July), the conductivity is higher than that recorded during February.

In Lake Nasser, the conductivity increase with depth as variation in specific conductance are caused by variations in the concentrations of various conductivity ions. Figure 4, shows the variation of conductivity at the surface and at the bottom along the lake during the cruise of April 1974.

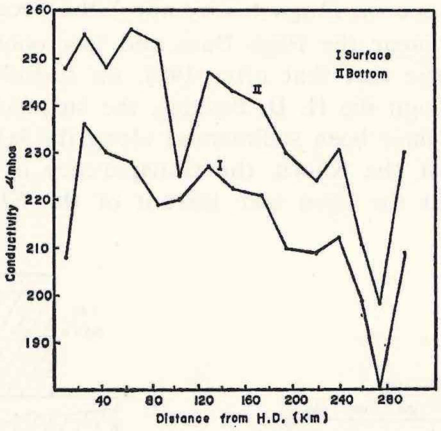

Fig. 4. Bottom and surface conductivity values during April 1974

THERMAL REGIME OF LAKE NASSER

Thermal regime of Lake Nasser was described in terms of horizontal variations of water temperature along the lak\ at different depths. The longitudinal vertical section along Lake Nasser from Aswan to Adindan was described during eacn cruise during the years 1970, 1971, 1973 and 1974. The seasonal variations of water temperature of the lake were given during the four seanson of the year.

In winter (February-March), the surface water temperature of the lake varied from minimum value of 16.5°C to a maximum of 22.9°C. The air temperature flucutated widely during that season with a minimum value oh 14.8°C and maximum one of 27°C.

The range of water temperature variation at 10 m and 50 m (bottom) was small in comparison with that recorded at the surface, Fig. 5.

During the spring (April-June), the surface water temperature of the lake started to raise up. It varied from a minimum value of 19.0°C to a maximum one of 28.7°C. The range of variation of air temperature along the lake was from 22.8°C to 37°C. Generally lake water temperature at the different layers increased from North to South, Fig. 6.

In summer season (July) the surface water temperature reached high values as the air temperature raised to its maximum value during June.

During that season the surface water temperature along the lake varied from 26.5°C to 29.5°C, while air temperature from 29.3°C to 34.5°C. The range of water temperature variation at the subsurface layers, along the lake was small and is shown in Fig. 7.

In Autumn (September-November), the air and surface water temperatures started to drop down at the end of the season. The air temperature changed from 20°C to 37°C during that season. The variation of water temperature at surface did not change much from that at the bottom giving

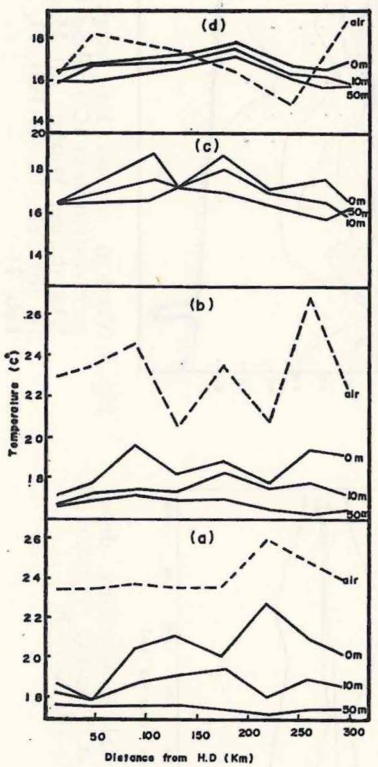

Fig. 5. Horizontal temperature distribution (C°) in Winter: (a) March 70, (b) Feb. 71, (c) Feb. 73, (d) Feb. 74

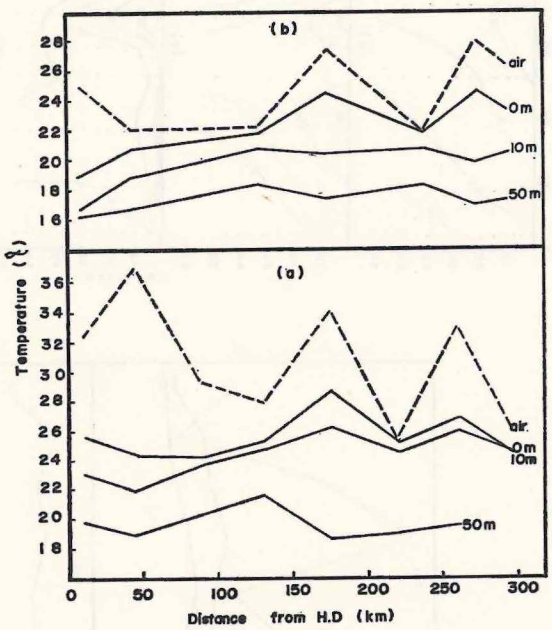

Fig. 6. Horizontal temperature distribution in Spring: (a) June 70, (b) March-April 74

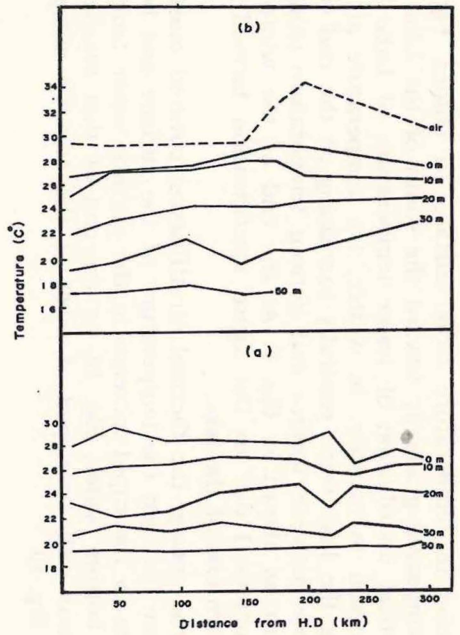

Fig. 7. Horizontal temperature distribution (C°) in Summer: (a) July 71, (b) July 74

slight variation in temperature from surface to botom, Fig. 8. The fall overturn disappeared gradually toward the south of the lake.

The vertical distribution of water temperature of Lake Nasser varies from one season to another. In winter, the temperature at the different depths along the lake were generally increasing at the end of the season. The difference between surface and bottom temperature along the lake is not consistent as shown in Fig. 9. At the end of the winter season this difference increased due to the dense stratification formed in particular at the southern end of the lake.

During the spring, the thermal stratification covered most of the lake. The difference between the temperature of the surface and bottom waters increased due to the rapid increase in the surface water temperature than that of the bottom water, Fig. 10. At the end of that season the thermocline layer was well developed at most of the stations along lake in the upper 30 m, Fig. 10.

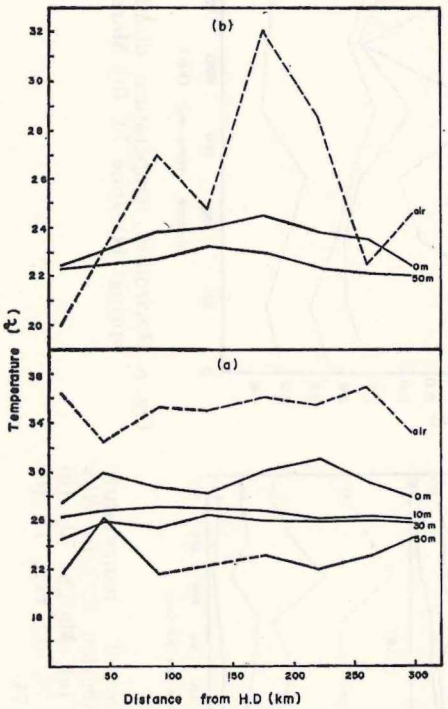

Fig. 8. Horizontal temperature distribution (C°) during Autumn: (a) Sept. 70, (b) Nov. 70

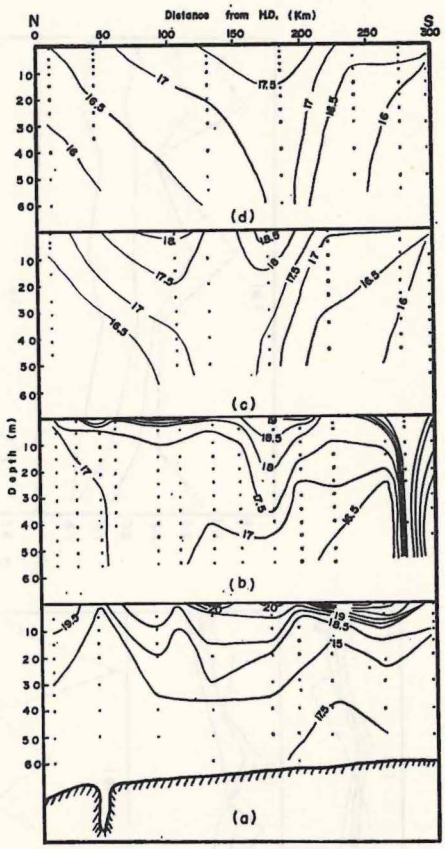

Fig. 9. Vertical section for temperature distribution (C°) along the lake during Winter: (a) March 70, (b) Feb. 71, (c) Feb. 73, (d) Feb. 74

In summer, lake Nasser can be divided thermally into three layers, the epiliminion, the thermocline, and the hypolimnion layer.

The thickness of the epilimnion layer varied from one station to another. At some stations it was 5 m thick or less, while at the others it was 10 meters, Fig. 11. In the thermocline layer, the temperature gradient varied from a maximum value of 0.37°C/m to a minimum value of 0.25°C/m. Below a depth of 30 m at most of the stations along the lake, thermal stratification was less dense, Fig. 11.

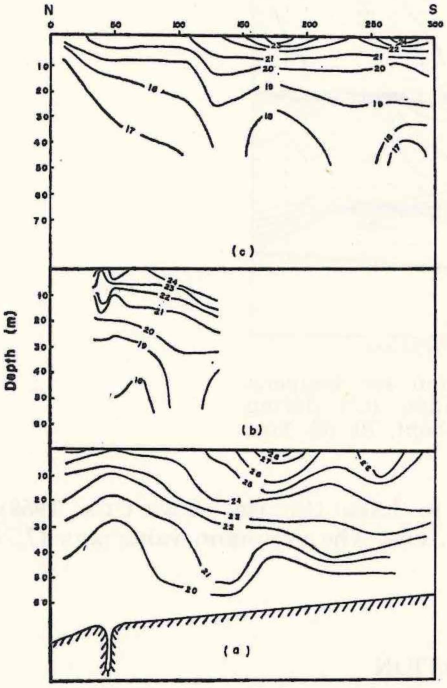

Fig. 10. Vertical section for temperature distribution (C°) along the lake during Spring: (a) June 70, (b) May 73, (c), March-April 74

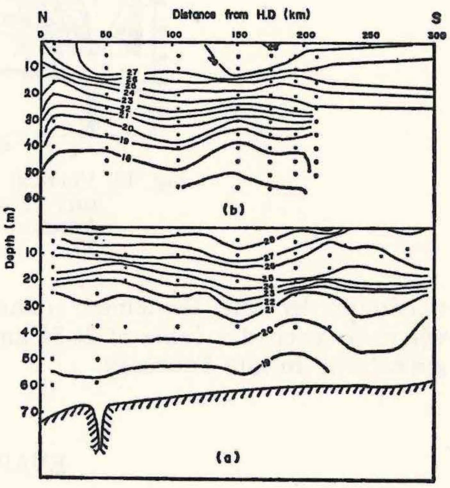

Fig. 11. Vertical section for temperature distribution (C°) along the lake during Summer: (a) July 71, (b) July 74

During the Autumn season, in September, the air temperature starts to go down in comparison with the summer months, Consequently this will affect on the thermal stratification of the lake. In the upper five meters the thermal stratification was more dens in the southern part than that in the northern section of the lake, Fig. 12. This was due to the fact that the dense stratification in the southern part of the lake was mainly attributed to the warmer inflowing water of the flood coming from the highlands of Ethiopia. From the vertical distribution of temperature along the lake, it is clear that the stratification in the upper 30 meter moved down towards the bottom layers, Fig. 12. During November, the air temperature continued to drop down and the wind strengthened up making the whole column of water in the lake nearly homogeneous, producing the autumn overturn conditions.

From the temperature observations taken during the different seasons along the lake, the heat content was calculated. The total heat content was

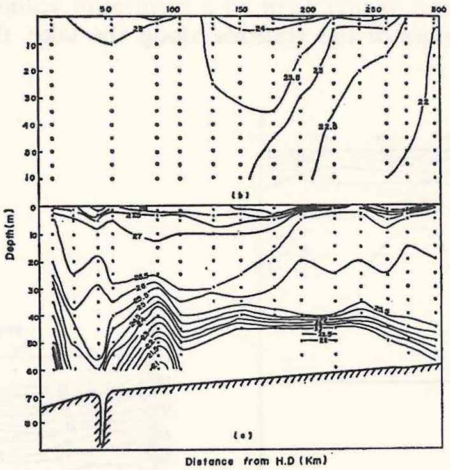

Fig. 12. Vertical section for temperature distribution (C°) during Autumn: (a) Sept. 70, (6) Nov. 70

maximum by late September (similar to Lake Ontario, S w e e r s 1969), where it reached a value of 26.54 gm cal./cm^3. The minimum value was 17.71 gm.cal/cm^3 in late February.

EVAPORATION

. Several methods were applied for determining the evaporation in Lake Nasser. In this study evaporation from Lake Nasser is estimated by the mass transfer method (S v e r d r u p, 1937 equation and P e n m a n, 1962 equation). There were no facilities for applying the energy budget method.

The values of evaporatoin can be taken as that obtained by Sverdrup equation (S v e r d r u p, 1937) using $Z_o = 0.6$ (Table 1). The evaporation from lake Nasser has the maximum value of 40.95 cm (13.7 mm/day), in September and has its minimum value during Jannuary 16.21 cm (5.2 mm/day). The average annual evaporation is about 359 cm. Comparing these results with the ones obtained by O m a r and E l - B a k r y (1970) using indirect measurements for Lake Nasser and applying three other different approaches it is clear that our results give higher values during the autumm and winter season (Table 2). This is probably right as the parameters used in the modified method of Penman represent to a certain extent the gical conditions over the lake. Table 3 give the evaporation in mm/day using Sverdrup 37 equation and Penman modified equation.

Table 1. Monthly values of evaporation from Lake Nasser estimated using Sverdrup's equation

Month	Evaporation in cm, z = 1400 cm	
	$Z_o = 0.6$ cm	$Z_o = 0.014$ cm
November 70	26.69	16.82
December	24.13	15.13
January 71	16.21	10.20
February	19.32	12.11
March	28.28	17.75
April	33.08	20.76
May	29.43	18.64
June	29.38	18.60
July	39.85	25.10
August	38.11	4.15
September	40.95	25.67
October	33.80	21.32
Total	359.2	226.2
Annual mean in mm/day	9.8 mm/day	6.2 mm/day

Table 2. Monthly values of estimated evaporation from Lake Nasser by different approaches in mm/day

Month	Dalton*	Combination*	Pan*	Sverdrup
January	4.7	3.6	4.0	5.2
February	5.0	5.3	5.5	6.9
March	6.5	7.8	7.5	8.7
April	7.8	10.3	9.8	11.0
May	9.4	10.8	10.2	9.0
June	11.2	12.9	11.3	9.8
July	10.3	11.5	10.9	11.7
August	10.6	11.2	10.9	12.3
September	9.8	10.2	9.7	13.7
October	8.6	7.8	7.5	10.9
November	7.0	5.4	6.4	11.0
December	5.6	3.3	4.3	9.5
Average annual mm/day	8.0	8.3	8.1	9.8

* Omar and El-Bakry 1970.

Table 3. Evaporation in mm/day using Sverdrup 1937 equation and Penman modified equation

Month	Using Sverdrup 37 equation $Z_o = 0.6$ $Z = 1400$	Using Penman modified equation (1963)
February	6.9	7.0
March	8.7	9.1
May	8.0	9.4
July	11.7	12.8
November	11.0	8.9
December	9.5	9.5

REFERENCES

El-Shahawy, M. 1975. Studies on the physical properties of lake Nasser, M. Sc. thesis, Faculty of Science, Cairo University. Egypt, 128 p.

Omar, M. H., & M. M. El Bakry, 1970. Estimation of evaporation from lake Nasser. Meteorological Research Bulletin Vol. 11, No. 1, Cairo, March 1970.

Penman, H. L., 1963. Vegetation and hydrology. Tech. Com. No. 53, Common Wealth Bureau of Solis, Harpenden, pp. 124.

Sverdrup, H. U., 1937. On the evaporation from the Oceans. Journal of Marine Research, Vol. 1, No. 1, pp. 3—14.

Sweers, 1969. Structure, Dynamics and chemistry of lake Ontario. Manuscript report series. Department of Energy, Mines and Resources, Ottawa, Canada, 227 p.

Receired: 24. X. 1978.

PROZIRNOST, VODLJIVOST, ISPARAVANJE I TOPLINSKI REŽIM JEZERA NASSER

S. H. Sharaf El Din[1] and M. El Shahawy[2]

[1] *Oceanography Department, Faculty of Science, Alexandria University, Egypt*
[2] *Institute of Oceanography and Fisheries, Academy of Science and Technology, Egypt*

KRATAK SADRŽAJ

Razina vode u jezeru Nasser se mijenja u odnosu na količinu akumulirane vode, koja opet ovisi o veličini dotoka i izlaza vode, kao i o evaporaciji i gubicima kroz tlo. Niža razina se pojavljuje od aprila do augusta, a viša razina od augusta do kraja godine.

Prozirnost vode u jezeru Nasser je uglavnom uzrokovan gustoćom razvoja fitoplanktona te suspendiranom ilovačom i glinom poplavne vode. Za vrijeme sezone poplava (august-novembar) opažanja prozirnosti pomoću Secchi ploče daju visoke vrijednosti u blizini Velike brane, a niske vrijednosti južno od jezera. Uzrok takove raspodjele može biti u činjenici da poslije 1968. zamućena poplavna voda praktično ne prelazi preko brane.

Promjene konduktiviteta u jezeru Nasser slijede do neke mjere gibanje poplavne vode. Najviši konduktivitet je izmjeren upravo ispred poplavne vode, a najniži na zadnjem kraju pojavljivanja te vode. Konduktivitet u jezeru raste s dubinom ovisno o koncentraciji raznih jona.

Termalni režim u jezeru je opisan pomoću horizontalnih promjena temperature na različitim dubinama, a u vezi s promjenama temperature zraka. Longitudinalni vertikalni profil uzduž jezera od Aswana do Adindana je opisan za krstarenja tokom 1970, 1971, 1973. i 1974. godine.

Iz temperaturnih podataka u različitim sezonama računat je sadržaj topline. Maksimum se pojavljuje krajem septembra (slično kao u jezeru Ontario, Sweers 1969) kada dostigne vrijednost od 26.54 g cal/cm^3. Minimum je nađen krajem februara s vrijednosti od 17.71 g cal/cm^3. Evaporacija u jezeru je računata uz pomoć više metoda. Najbolje vrijednosti daje metoda Sverdrupa prema jednadžbi iz 1937. uz $Z_o = 0.6$ cm. Maksimalna evaporacija se javlja u septembru (40.95 cm) a minimalna u januaru (16.2 cm). Srednja godišnja evaporacija iznosi oko 359 cm. Vrijednosti evaporacije dobivene iz proračuna budžeta vode u jezeru se ne slažu s ovdje iznesenima.