

ON THE ESTIMATION OF EVAPORATION FROM LAKE NASSER

By

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Summary

The evaporation rate from lake Nasser has been estimated for the different months of the year. The study was based on Penman's work which implies the knowledge of the available meteorological data.

The expected amount of water to be lost by evaporation would come to 200 mm per month corresponding to 10.6×10^9 m³ per annum.

1 — Introduction

Lake Nasser which will be formed in front of Aswan High Dam will be one of the biggest artificial lakes of the world (area about 4000 km.²). Its northern extremity starts 8 km. south of Aswan and extends 500 km. southward. Its average width is 8 km. and its depth is about 50 m. Its capacity will reach 136×10^9 m³ of flood water that used to be lost in the Mediterranean.

This huge water reservoir extending up to contour 182 m. will offer, besides the generation of electric power (10 milliard kilowatt hour/annum), an increment of one million feddans of

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cultivated land and the changement of the basin system of irrigation in Upper Egypt to the canal system. Moreover, it will guarantee the irrigation needs of all cultivated land even in years of low water floods. It will offer basin lands along its boundaries to be cultivated and increase the potentialities for fish breeding.

The extended water surface of the lake, subject to the severe solar radiation and other climatic factors will, evidently, lead to enormous losses of water to the atmosphere. The knowledge of the rate of evaporation from the lake is, naturally, of value to scientists and engineers interested in water economy. It is the purpose of this paper to evaluate the expected losses due to evaporation for the different months of the year.

2 — Theory

The evaporation from a lake or a reservoir could be obtained by a purely observational technique, i.e., measuring the water level, precipitation, inflow and outflow of water. On the other hand, to estimate the expected rate of evaporation from meteorological data, two quite distinct methods could be adopted :

1 — The diffusion method, which depends on the mechanism of removal of vapour by diffusion.

2 — The energy balance method, which depends on the determination of the amount of energy used to change water to the vapour phase.

Different workers have treated the two methods and gave various formulae to evaluate the rate of evaporation : Brunt (1939), Sutton (1950), Priestley (1949) and Pasquill (1943, 1949). Either method could be applied when the surface temperature is known.

Penman (1948, 1950), has approached the problem combining the two classical conceptions to eliminate the unknown surface temperature and gave the following formula :

$$E_0 = (\Delta H + 0.27 E_s) / (\Delta + 0.27) \text{ mm/day}$$

where :

- Δ = the slope of vapour pressure curve for water at mean air temperature T_a (mm mercury/ $^{\circ}$ F)
- H = $R_A (1-r) (0.18+0.55 n/N) - \sigma T_a^4 (0.56-0.92 \sqrt{e_d}) (0.10+0.90 n/N)$. 0.27 is the constant for the standard hygrometer equation mm/ $^{\circ}$ F.
- E_a = $0.35 (e_s - e_d) (1+u_2 \times 10^{-2})$ mm/day.
- R_A = theoretical calculable amount of radiation that could reach the earth in the absence of an atmosphere in evaporation units, ($59 \text{ cal/cm}^2 = 1 \text{ mm}$ evaporation).
- r = reflection coefficient, to be taken as 0.05 in case of open water surface.
- n/N = actual possible hours of sunshine. In the first term in H it is a factor limiting incoming short wave radiation; in the second it is a transform of a cloudiness factor limiting outward long wave radiation.
- σT_a^4 = theoretical black body radiation at mean air temperature T_a K (in evaporation units).
- e_d = saturated vapour pressure at dewpoint (mm Hg).
- e_s = saturated vapour pressure at mean air temperature.
- $e_d - e_s$ = mean saturation deficit.
- u_2 = average wind speed in miles/day at two m. above the ground.

3 — Available Meteorological Data

To apply the above relation, it is required to know the meteorological data at the different localities where the lake will be formed. The available data in the Climatological Normals for Egypt and the Sudan (1938 & 1950) are only those for Aswan ($24^{\circ}2'N$, $32^{\circ}53'E$, h. = 111 m.) and Wadi Halfa, ($21^{\circ}55'N$, $31^{\circ}19'E$, h. = 135 m.). Table 1 summarizes the monthly mean values for these two Stations; (number of years of observations are 45 and 34 for Aswan and Wadi Halfa, respectively). It could be noticed from Table 1 that their weather conditions are almost similar. The air temperature and the humidity are slightly lower

Table I
Monthly means of different meteorological factors at Aswan and Wadi Halfa

		A S W A N						W A D I H A L F A						
Air		Temp.	R. Hum.	W. vel.	V. pr.	n/N	Rad.	Evap.						
Month	°C	%	km/h.	mb.	g. cal/cm ²	mm/day	(Piche)							
								Temp.	R. Hum.	W. vel.	V. pr.	Evap.		
								°C	%	km/h.	mb.	mm/day	(Piche)	
Jan.	15.0	45	6.3	7.7	85	22.0	7.3	14.5	47	5.5	7.6	8.8		
Feb.	17.2	40	8.3	7.6	88	25.1	8.8	16.0	37	5.5	6.3	10.9		
Mar.	21.3	32	9.6	8.5	89	28.6	12.6	26.5	29	6.0	6.4	15.4		
Apr.	26.2	27	10.0	10.0	89	30.9	16.2	28.7	23	6.0	6.9	18.1		
May	30.5	27	11.8	13.5	90	31.8	18.0	29.6	21	5.0	8.4	19.4		
June	32.9	25	9.3	14.3	97	32.1	20.6	31.5	20	5.5	8.9	21.5		
July	33.2	26	7.4	15.2	97	31.8	18.6	31.6	23	5.0	10.1	19.4		
Aug.	33.0	29	8.5	15.0	96	30.9	18.6	31.2	27	5.0	12.0	17.5		
Sep.	30.9	33	7.6	14.0	97	28.9	17.7	29.4	30	8.0	11.6	18.2		
Oct.	28.3	35	8.1	13.1	95	25.8	14.9	26.8	33	6.0	11.1	15.9		
Nov.	22.6	40	5.6	12.2	89	22.5	10.7	21.4	41	4.5	9.9	11.7		
Dec.	17.4	45	7.4	8.7	88	20.9	7.2	16.0	48	4.5	8.5	8.6		
Mean	25.8	34	8.1	11.6	92	27.6	14.2	24.5	32	5.5	9.0	15.4		

Table 2
Details of Calculation of the Evaporation E_0

Month	Δ mm Hg/ $^{\circ}$ F	R_A mm ev./day	$e_a - e_d$ mm Hg	e_d mm Hg	σT_a^4 mm/day	E_0 mm/day	E_0 mm/month
Jan.	.46	11.2	6.6	6.3	13.8	4.2	130.2
Feb.	.51	12.8	8.9	5.7	14.2	5.4	115.2
Mar.	.60	14.5	12.7	6.2	15.1	6.6	204.6
Apr.	.86	15.7	18.2	7.0	16.1	8.1	243.0
May	1.05	16.2	22.7	9.2	17.0	9.0	279.0
June	1.22	16.3	27.1	10.1	17.6	10.3	309.0
July	1.18	16.2	27.0	11.0	17.4	9.6	297.6
Aug.	1.20	15.8	26.7	10.8	17.6	9.2	285.2
Sep.	1.07	14.7	22.8	10.2	17.1	8.4	252.0
Oct.	.93	13.2	18.7	9.6	16.6	7.1	220.1
Nov.	.65	11.5	12.4	7.9	15.5	5.2	156.0
Dec.	.49	10.7	8.0	6.7	14.2	4.2	130.2
Mean	.88	14.0	16.1	8.3	16.0	6.3	221.5

annual evaporation
= 2658 mm.

for Wadi Halfa than for Aswan, while the evaporation as measured by Piche evaporimeter is slightly higher. This could be attributed to the relatively high intensity of solar radiation at wadi Halfa which is situated 250 km. towards the south.

4 — Calculation of the Evaporation Rate from Lake Nasser

As the meteorological data for Aswan may give a fair representative of the weather conditions over the whole area of the lake, it has been found convenient, for simplicity, to make use of it only in calculating the evaporation rate from the lake. The details of calculation are given in Table 2.

It could be concluded from this table that the mean annual evaporation is about 220 mm per month. It has a lower value in the winter months (average 140 mm per month from Jan. to Feb.) and increases gradually till it reaches its maximum value in summer (average 300 mm/month in June and July).

5 — Discussion

Taking into consideration the amount of solar energy incident on the lake and the influence of the weather conditions, it could be seen that the results obtained and presented in Table 2 are quite reasonable. The mean daily value of 6.3 mm is of the same order of magnitude for large extended areas of water under comparable conditions. Comparing these results with the corresponding values obtained by Piche evaporimeter, it is found that the latter are nearly double (or even more in winter months) than the calculated values. This could be attributed mainly to the smaller area of the evaporating surface of Piche evaporimeter and the greater effect of the long wave radiation from the air and the earth. Piche's data are therefore unreliable for use in water economy studies of the Nile.

Integrating the amount of water evaporated from the whole surface of the lake, it could be seen that it rises to 10.6×10^9 m³ per annum, which corresponds to about 8% of the full capacity of the lake.

Would the evaporation from the lake be stopped, this amount of water is sufficient to irrigate about 1,000,000 feddans. The question now arises, is it possible to control this evaporation? In fact, recent studies on evaporation control has shown the practical utility and success of monolayers of cetyl, stearyl and a number of alkoxy ethanols in reducing evaporation; Trapeznikov (1963), Mihara (1963) and Ganapathy (1963). Three different methods for the control of evaporation could be used either individually or jointly. The first is a solution of the chemical in a solvent like petroleum ether, the second a water emulsion and in the third blown particles of the chemical are let to settle on water surface.

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