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EVAPORATION FROM WADI EL-RAYAN LAKES, EGYPT

By

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ABSTRACT

Evaporation plays a very important role in any ecosystem. The rate of evaporation is a major factor controlling the heat, water and salt budgets of Wadi El-Rayan Lakes. Before the installation of the Automatic Weather Station, there was no database about the climate prevailing over Wadi El-Rayan depression.

Wadi El-Rayan is a great depression located in Fayoum Governorate. It was connected with agricultural drainage water system of Fayoum depression to get a secondary reservoir of drainage water that exceed the capacity of Lake Qarun. Wadi El-Rayan depression consists of two man-made Lakes. It occupies the area between Latitudes 29^0 *05'&* 29^0 *18' N and Longitudes* 30^0 *21' &* 30^0 *32' E.*

The air is warmer than the surface water during four months (May & July-September), while it is cooler in the rest months of the year. The difference (Ta-Tw) is a maximum positive value (1.28 ^0C*) in September, while the maximum negative value (-4.59* ^0C*) is in February. Air pressure over the Lakes is relatively high. It changes between 1011.8 mb in July and 1022 mb in December. The wind speed increases from 2.11 m/s in December to 5.4 m/s in June. The relative humidity changes between 36.82% in June and 57.66% in November.*

Monthly evaporation from Wadi El-Rayn Lakes was calculated by the Bulk-aerodynamic method. The minimum monthly value of evaporation (3.18cm) is observed in December, while the maximum one (25.67 cm) is found in August. The annual rate of evaporation from the Lakes is in the order of 170.7 cm. This result is considered the first attempt to determine the rate of evaporation from Wadi El-Rayan Lakes.

INTRODUCTION

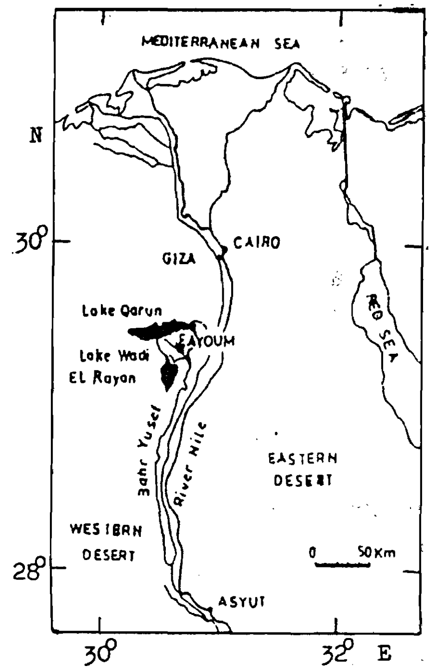
Fayoum (one of the old Oases) is a natural depression covering 12000 km^2. It lies in the western desert of Egypt, about 100 km, to the southwest of Cairo City. The depression was in the form of a huge fresh water lake (Lake Moeries).

Before the construction of the High Dam at Aswan, Lake Qarun was the only reservoir for agricultural drainage water of Fayoum depression. Controlling the River Nile, which is considerably the only source of water to the depression, leads to increase the agricultural land. The drainage water consequently increased and became a dangerous problem. Wadi El-Rayan Project has been conducted to solve this problem.

Wadi El-Rayan Lakes

Wadi El-Rayan depression consists of two Man-Made Lakes. They occupy the area between Latitudes 29° 05' and 29° 18' N and Longitudes 30° 21' and 30° 32' E. The two Lakes are bordered by the desert in all directions with only source of El-Wadi Drain of agricultural drainage water.

Fox (1951), who stated that "As Egypt is the gift of the Nile, Wadi El-Rayan is the gift of the Western desert" expressed the importance of Wadi El-Rayan depression. Wadi El-Rayan is a great depression (703 km^2 in area) located in Fayoum Governorate. The project was started in 1968 and has been operating since 1973. Wadi El-Rayan is connected with the agricultural drainage water system of Fayoum depression to get a secondary reservoir of drainage water that exceed the capacity of Lake Qarun (Fig. 1).



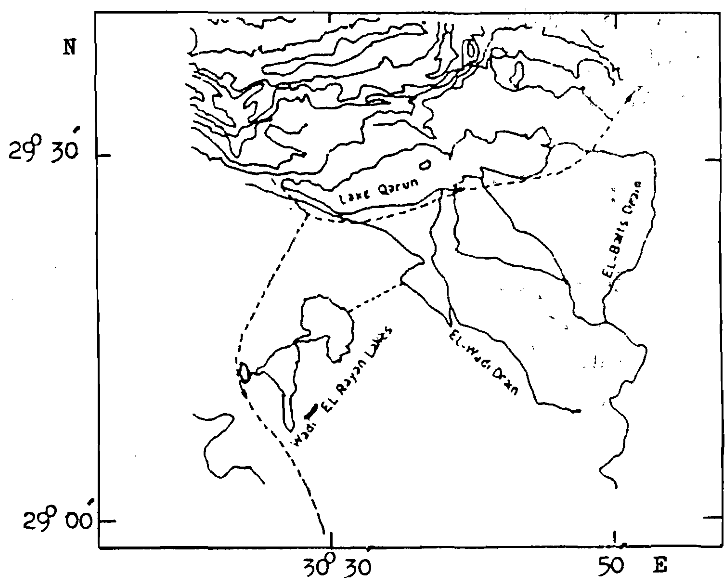


Fig. (1): EGYPT and Fayoum depression maps.

After the filling of the small basin adjacent to the depression and the formation of the first Lake, water is flowing through a series of tunnels and open canals of about 5 km long to reach the great depression of Wadi El-Rayan forming the Second largest Lake.

Morphometry and bathemetry of Wadi El-Rayan Lakes

The first Lake covers an area of about 47.59 km^2 at 9 m below MSL, with maximum depth of more than 25 m in the central part. At this level, the first Lake discharges its water into the second Lake through the connected channel. The second Lake has an area of about 51.81 km^2 at 34 m below MSL. Its maximum depth is about 28 m in its central and northern parts.

Getting information about the Meteorological Conditions over a specific area enables one to understand the relationships between different status when they are considered as the major categories affecting the ecosystem of any basin.

Evaporation from Wadi El-Rayan Lakes is an essential factor for the estimation of heat, water and salt budget of Wadi El-Rayan Lakes. This paper discusses the rate of evaporation and the meteorological conditions controlling the evaporation from Wadi El-Rayan Lakes in 1996 calendar year.

DATA AND METHODOLOGY

Sverdrup (1937) developed several evaporation equations based on the aerodynamic method, Millar (1937), Norris (1948) and Sutton (1949). When Sverdrup (1937) and Sutton (1949) equations were applied to a small lake, they gave satisfactory results (Marciano and Harbeck, 1954)

In the present study, Sverdrup's equation developed by Meshal and Morcos (1984), is used to determine the rate of evaporation from Wadi El-Rayan Lakes. The equation applied is:

$$E = \frac{0.229U^* (e_o - e_z)}{P \ln (1000.6/ (\delta+0.6)) + 1.6\, U^*\delta} \times 10^{-3} N$$

where

E : the rate of evaporation, cm/month,

U*: the friction velocity, cm/s,

e_o : the saturated vapor pressure, mb,

e_z : the vapor pressure of air at high z, mb,

P : the atmospheric pressure, mb,

δ : The diffusion coefficient of water vapor, cm^2/s,

N : the number of seconds in the concerned month.

The Automatic Weather Station model 555, Hander was installed to reco[r]d and storage the hourly prevailing meteorological parameters over Wadi [El] Rayan depression. It is located at the northern part of the second Lake (29° 36" N, 30° 25' 48" E). The recording parameters are: air and surface wat[er] temperature, wind condition (speed, gust and direction), air pressure and relati[ve] humidity.

DISCUSSION AND CONCLUSIONS

Air and surface water temperature

As air masses move from one place to another, their temperature a[nd] moisture content are modified to some extent. The lowest values of a[ir] temperature are in winter (February; 12.21 °C), while the highest values ar[e] summer (August; 28.39 °C). The higher air temperature, in summer months, tha[n] the rest of the year is related to the highest net radiation in summer compari[ng] with other seasons.

The surface water temperature is low (16.55 °C) in January, while it is hi[gh] (28.14 °C) in August.

The air is warmer than the surface water during four months (May, Ju[ne], August and September), while it is cooler during the rest of the year (Fig. The temperature difference (Ta-Tw) is of great importance to the calculation

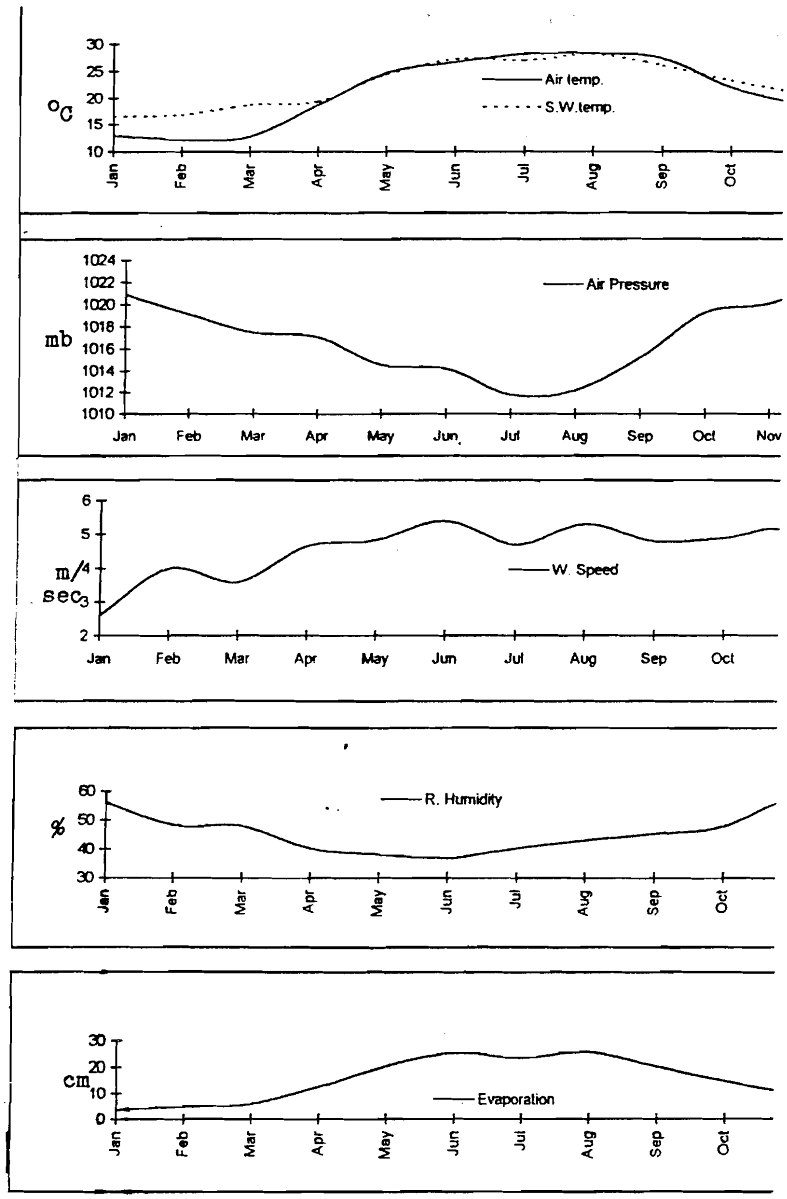


Fig. (2): Hydrometeorlogical conditions of Wadi El-Rayan Lakes.

of evaporation, because the exchange of heat and vapor between the atmosphere and the lake depends greatly upon (Ta-Tw) value. The difference (Ta-Tw) is a maximum positive value (1.28 °C) in September, while the maximum negative value (-4.59 °C) is in February.

Air pressure

The air pressure is a good indicator of the Weather State. It becomes stormy when air pressure falls and improves when air pressure rises. In fact the main factor controlling the air masses movement is the pressure difference.

The minimum air pressure (1011.8 mb) is in July, while the maximum one (1022.2 mb) is in December (Fig. 2). Air pressure over Wadi El-Rayan Lakes is high, when air temperature is low and vises versa. The decrease in air temperature leads to an increase in the air density and consequently an increase in air pressure.

Wind speed

The wind conditions are of great variability from one hour to anther. The wind has a great influence on the water movement and circulation in the Lake.

The wind speed is high in summer and autumn, while it is low in winter and spring (Fig., 2). The minimum wind speed (2.11 m/s) is in December, while the maximum value (5.4 m/s) is in June.

In spite of the higher mean monthly scalar wind speed in the warm period of the year, the wind Gust has the reverse characteristics but the winter storms are limited in period.

Relative humidity

The lowest relative humidity is recorded in June (36.82%), while the highest relative humidity value is encountered in November (57.66%, Fig. 2). Relative humidity of Wadi El-Rayan Lakes is directly proportional to air pressure, while it decreases with increasing wind speed.

Relative humidity increases in two phases; firstly, the air is cooled, which reduces its capacity to hold water vapor, secondly, more water vapor is added to the air. The more common way for air to approach saturation is by cooling.

Relative humidity is perhaps the most familiar way of describing the amount of water vapor in the air.

RATE OF EVAPORATION

The lowest evaporation occurs in winter season. The minimum value is 3.18 cm in December, while the highest evaporation is taking place in summer. The maximum one is 25.67 cm in August (Fig. 2). A layer of thickness 170.7 cm is being evaporated annually (1996 calendar year).

Table 1 shows the annual rate of evaporation at different places in the surrounding areas. The lowest rate of evaporation (128.0 cm) was calculated at the North West of the Red Sea, while the highest evaporation (256.7 cm) was estimated at Lake Nasser. These results may be, due to the wet wind prevailing over the North West of the Red Sea in comparing with very dry wind prevailing on arid zone and higher air temperature at Lake Nasser.

Table (1): Annual evaporation rate (cm/year) at different zones areas

Zone	**cm**	
-Lake Nasser, Egypt	256.7	El- Bakry (1993)
-Coastal zone of the Red Sea	205.0	Meshal *et al* 1983)
-Lake Burullus, Egypt	200.0	Maiyza 1989)
-Lake Qarun, Egypt	174.17	Abd Ellah 1999)
-Mediterranean Sea	154.0	Bethoux & Gentili (1994)
-Central zone of the Red Sea	144.0	Behairy *et al* 1981)
-Northwest Red Sea	128.0	Maiyza 1988)

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