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SURFACE HEAT BUDGET OF LAKE QARUN, EGYPT

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ABSTRACT

In the present time, there is an increasing awareness of the significant relationship between climate, continental waters (seas, lakes and rivers) and environment. The effects of climate, which regularly affect Lake Qarun, are till now not understood.

Climate change and the lake's level rise cause an accumulation0of additionql problems to Lake Qarun. On the other handl changes in climate affect the water chemistry ind biological ecosystem and(the reverse is also true. The knowledge of the lake is basel on(observation of the dimensions and characteristic of the lake water. The primary purpose of this work is to determine the surface heat balance in Lake Qarun.

Lake Qarun is one of the most important lakes in Egypt. The lake located between latitudes 29° 24' and 29° 33'N, and longitudes 30° 25' and 30° 50' E.

The total annual rate of absorbed solar radiation is 122.365 kcal/cm², heat loss due to evaporation is 101.332 kcal/cm², and heat exchange by conduction is heat gain of 1.776 kcal/cm². The annual surface heat budget is a positive value of 22.809 kcal/cm². The heat gain of the lake might be, compensated by heat loss through the conduction with the lake's body, by conduction heat to the landmasses surrounded the lake, through the water seepage to or from the lake. On the other hand, the inter-annual variation in the amount of solar radiation reaching the Lake surface, might be the reason of such positive surface heat balance.

INTRODUCTION

Fayoum is a natural depression covering 12000 km². The depression (50m below mean sea level) is one of the old oases. It lies in the western of Egypt, about 100 km, to the southwest of Cairo City (Mehrniger ***et al***, 1979).

The present depression was formed, probably by wind erosion in the area of West River Nile, at least 1.8 million year ago. It was in the form of a huge lake. The Lake was used as a natural reservoir for the Nile water during the flood season. In the drought season, the lake was used to supply northern part of the country with required water (Soliman, 1989).

Fayoum depression (fig. 1) is separated from the Nile valley by a narrow strip of calcareous plateau, which is broken only in the East-South-East side as a narrow natural cut. In the present time, the cultivated land of Fayoum Governorate receives its water supply indirectly from the River Nile. Bahr Youssef is considered the only source of water to Fayoum Governorate (Bishai & Kirollus, 1980).

The agricultural drainage water is passed intro two basins: old reservoir (Lake Qarun) and man-made lakes (Wadi El- Rayan lakes); fig. 1.

LAKE QARUN

Lake Qarun is one of the most important lakes in Egypt. It is an inland closed basin, located in the deepest part of Fayoum depression. The lake located between latitudes 29° 24′ and 29° 25′ and 30° 50′ E. It is bordered from its northern side by the desert and by cultivated land from its south and southeastern side (Meshal, 1977 and Sabae, 1993).

Lake (Birket) Qarun represents the remnant of ancient pre-historic fresh Water Lake Moeries. Its area was about fourteen times, while its volume was about thousand times the present (Ball, 1939).

Lake Qarun is a closed basin with no apparent natural outlet. It receives the agricultural drainage water through some drains. Most of the drainage water reaches the lake by two greatest drains: El-Batts drain (at its northeastern corner) and El-Wadi drain (near the mid pont of the southern shore).

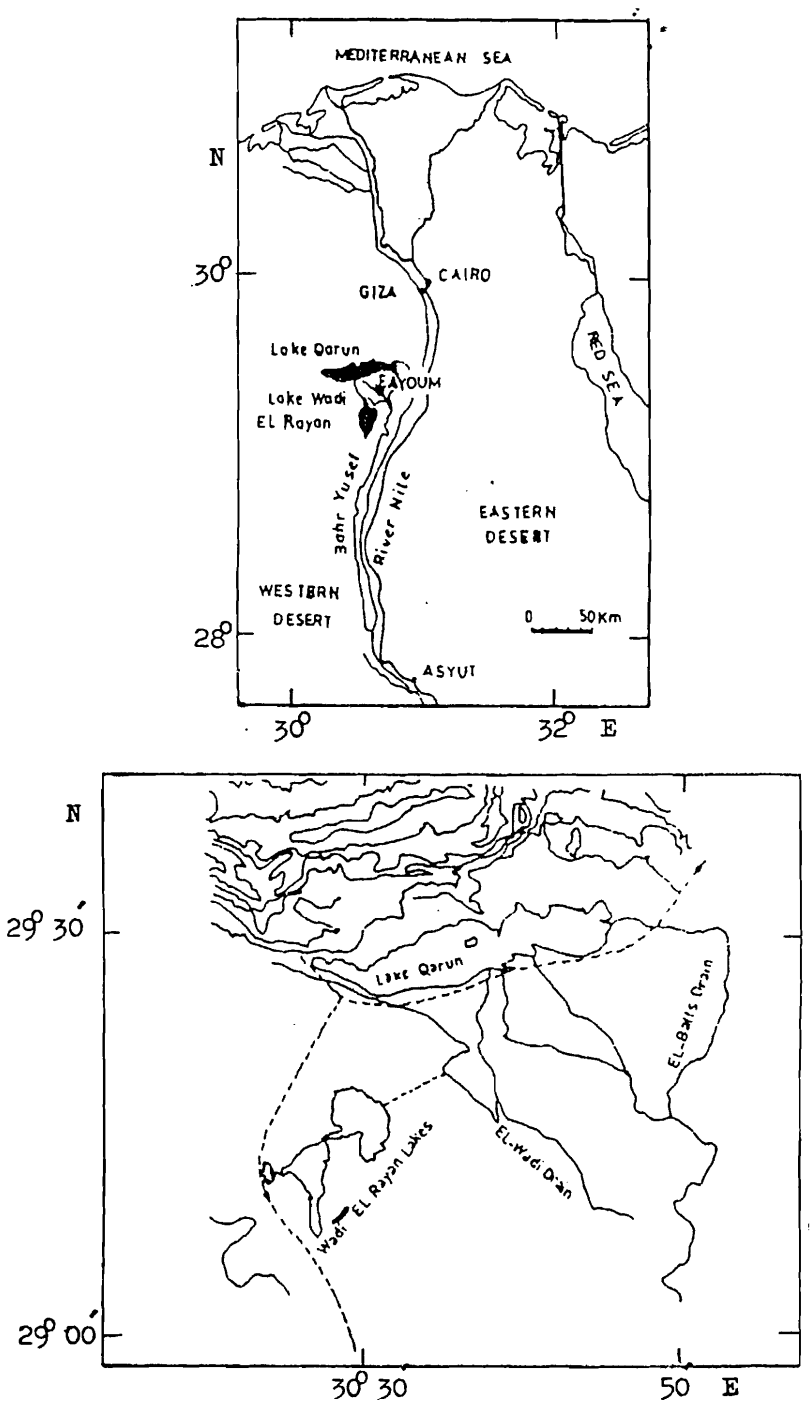

Fig. (1): EGYPT and Fayoum depression maps.

Lake Qarun is an inland, closed basin. It has irregular shape of about 40 km length and about 6 km mean width. The average area is about 6 km mean width. The average area is about 240 km^2, with one km^3 in volume. The lake is shallow, with mean depth is 9m to the northwest of Al-Qarn island, which is a sandy island located in the middle of the lake. Nearly most of the lake's area has a depth ranging from 2 to 5m, while a portion of the area has depth ranging between 5 and 8 m. The water level of the lake fluctuates between 43 and 45m below MSL (Abd Ellah 1999).

The only source of heat to the earth is the sun. Solar radiation mainly is absorbed on the earth's surface (land and water). From the surface the heat propagate vertically (up and down) and horizontally (in all directions). The variability in solar energy absorption in space and time is the reason of all physical activities in atmosphere and in Oceans including seas and lakes.

Studying the Meteorological conditions over a specific area enables the understanding relationships between different phenomenon. One of the best ways to understand the state of any water body is to study the heat. This paper discusses different factors affecting the surface heat budget of Lake Qarun during 1996 calendar year.

The surface heat budget is the major category of the net heat budget. It is the total amount of heat gain or loss through the lake surface.

DATA AND METHODS OF CALCULATION

Meteorological conditions:

The meteorological conditions were recorded by automatic weather station (2700-model AANDRAA instrument). It records and storage the data every hour for Lake Qarun (29° 27′ 13″ N, 30° 42′ 12″ E). The recording parameters are Air and surface water temperature, wind condition (speed, Gust and direction), Air pressure, Net radiation, Relative humidity and Rainfall.

Radiation balance (Q_r):

The radiation balance equation for a unit area of the water surface in a unit interval of time (Jerodoc & Malevck, 1973):

$$Q_r = Q_o (1\text{-}C) F_n - E^*$$

Where

Q_o : the amount of heat penetrating to the water surface,

C : the Albedo of the water surface,

F_n : a factor depends on the cloudiness cover,

E^* : the reflected solar radiation for surface as a long wavelength radiation.

Heat loss due to evaporation (Q_e):

The estimation of heat loss by evaporation was made using the following equation:

$$Q_e = -LE$$

Where

L: the latent heat of evaporation.

Heat exchange due to conduction (Q_c):

The heat exchange due to conduction through the water surface between water and atmosphere (Jerodoc & Malevck 1973)

$$Q_c = A\ U\ (T_a - T_w)$$

Where

A: the sensible heat exchange coefficient,

U: the wind speed at m/s,

T_w : the water temperature in °C

T_a : Air temperature in °C

Surface heat budget:

The surface of lake Qarun gains heat due to absorbed solar radiation (Q_r), loss heat through the evaporation process (Q_e) and gains or loss heat due to conduction between the air and surface water (Q_c). The surface heat budget of the lake (Q_s) can be represent by an equation in the form:

$$Q_s = Q_r + Q_e + Q_c$$

DISSCUSSION AND CONCLUSIONS

Radiation balance (Q_r):

More than 99% of the energy that involved in weather phenomena comes directly from the Sun. Sun's energy travels through space at the speed of light in the form of electromagnetic radiation as photons or Quanta.

The amount of heat actually received at a given point on the earth's surface depends on: the angle of the rays; the length of exposure Latitude and season of the year and the extend of cloud covers. Altitude also can be considered.

The short wave radiation that reaches the earth's surface comes directly from the Sun and partly from the Sky as refracted or scattered radiation.

When lake's surface emits long-wave heat radiation, small part of this radiation is reflected. The amount of reflected heat varies from one place to another, depending on the nature and smoothness of the lake's surface i.e.Albedo.

When sunlight (radiation) strikes water body, it is gradually absorbed through a surface thin layer. The absorbed solar radiation depends on the amount of energy incident, the reflection from the lake's surface and the absorption of heat along the water column. The amount of dissolved and suspended (transparency) matters in water also affect.

The monthly rate of the absorbed solar radiation

During winter the absorbed solar radiation is lowest in comparing with that for other seasons (fig.2). The minimum rate of radiation balance (3.243 kcal/cm^2) is in December, while the maximum one (15.509 kcal/cm^2) is in July. The annual rate of absorbed solar radiation is 122.365 kcal/cm^2 (fig.2).

HEAT LOSS DUE TO EVAPORATION (Q_e):

Most heat exchange parameters are involved in the evaporation. Because the latent heat of evaporation is supplied from the upper most layer of the water, it results in cooling of that layer and consequently the water body beneath.

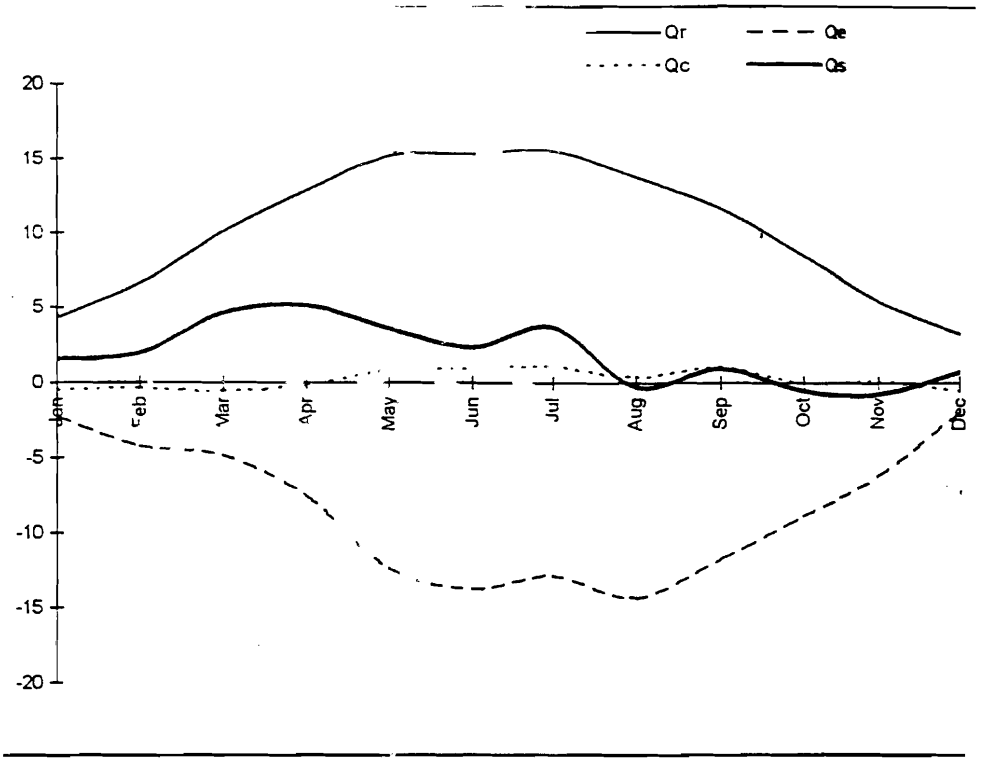

Fig. (2): Surface heat budget of Lake Qarun

The heat loss due to evaporation depends not only on latent heat, but also on temperature, vapor pressure and wind promotes.

The monthly rate of heat loss due to evaporation:

The rate of heat loss due to evaporation of Lake Qarun is shown (fig.2). The minimum rate of heat loss due to evaporation (1.940 kcal/cm^2) is registered in December while the maximum value (14.377 kcal/cm^2) is observed in August. The total annual rate of heat loss due to evaporation is 101.332 kcal/cm^2.

HEAT EXCHANGE DUE TO CONDUCTION (Q_c):

The heat is to be conducted from the lake to the air, when the lake surface is slightly warmer than the overlying air and therefore loses heat by conduction. When the overlying air is warmer the reverse is true.

The monthly rate of heat gain or loss due to conduction

The monthly rate of heat exchange due to conduction is positive value (heat gain) higher than 0.5 kcal/cm^2, in four months (May-July and September), with maximum one (1.084 kcal/cm^2) is in July. The heat exchange due to conduction between air and surface water of the lake is negative value (heat loss), higher than 0.5 kcal/cm^2, in three months (January, March and December), with maximum one (0.614 kcal/cm^2) is in March (fig.2). The total annual heat due to conduction is heat gain (positive value) of 1.776 kcal/cm^2, which represents the lowest contribution of that factor to the surface heat budget.

SURFACE HEAT BUDGET

The rate of surface heat budget is positive value (gain heat), higher than 1.0 kcal/cm^2 during seven months (January-July), with maximum one (5.119 kcal/cm^2) in April. During the rest months of the year, it varies between loss and gain heat in order of absolute magnitude of about ± 1.0 kcal/cm^2. The annual surface heat budget is positive value in order of 22.809 kcal/cm^2 (fig.2).

The heat gain of the lake, might be, compensated by heat loss through the conduction with the Lake's body, by conducting heat to the landmasses surrounded the lake, through the water seepage to/from the lake. On the other hand, the annual variation in the amount of solar radiation reaching the Lakes surface, might be the reason of such positive surface heat balance in 1996 calendar year.

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