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EVAPORATION OF COASTAL WATER IN THE NW RED SEA.

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ABSTRACT

Monthly evaporation, from the coastal water in front of Ghardaqa, was estimated. The area under study is the coastal zone including lagoons extending from Gimsha at north to Desha El-Daba at south (about 80 Km).

Results reveal that the northwestern coastal water of the Red Sea around Ghardaqa losts 128 cm annually (The extreme monthly values are 1.0 cm in March and April and 32.3 cm in September. This small annual value and the large annual amplitude represent the peculiar weather characteristics of the coastal area under study. The effect of such weather characteristics on the controlling meteorological parameters was discussed.

INTRODUCTION

Through evaporation, the Red Sea loses much more water than it gains due to its geographic position in an arid zone between two deserts. Evaporation is the controlling factor for water temperature and salinity and consequently density, circulation and steric sea level variation.

In the Red Sea, evaporation was firstly studied by Murray (1885) who estimated its annual value to be 450 cm. The results presented by Krummel (1911) revealed that the annual evaporation was 250 cm. Morcos (1970) mentioned that the measurement of Vercelli (1923-1924) of 350 cm could be reduced to 192.5 cm using Wust (1954) approximation which states that the the actual evaporation at the sea surface amounts to only 55% of the evaporation measured on board. Yegorov (1950), Neumann (1952) and Privett (1959), using the bulk formulae, have reported values of 230, 213 and 183 cm respectively. Morcos (1970) estimated the annual evaporation to be 205 cm.

Using the aerodynamic approach, Behairy et al. (1981a) have studied the monthly evaporation from the coastal water off Jeddah (21 30'N) where the annual value amounted to 205 cm with two monthly extremities of 11.5 cm in February and 22.8 cm in May. In another study, the annual value of evaporation in the central zone of Red Sea was estimated (Behairy et al., 1981b) to be 144 cm with a minimum (9.6 cm) in September and a maximum (17.5 cm) in November. When Meshal et al. (1981) have compared the results of the two studies just mentioned, they came to the conclusion that the product of multiplying the vapour pressure deficit by the friction velocity was the major factor controlling evaporation while the other parameters of the aerodynamic fromula applied were in significantly effective.

The present study is an attempt to compute the monthly evaporation from the coastal area extending from Gimsha (north of Hurgada) to Desha El-Deba (south of Hurgada), (fig.1). Observations were made on board the R/B GOHR, during the period November 1987 October 1988. This work was funded by Ministry of Reconstruction and New Communities (The study of the Red Sea Coastal Lagoons). Field observations were measured using standard instruments for the determination of humidity, atmospheric pressure and air temperature. The instruments were placed inside a special shelter at a height of about 2.0 m above sea surface. Wind speed was measured using standard wind anemometer at the same level.

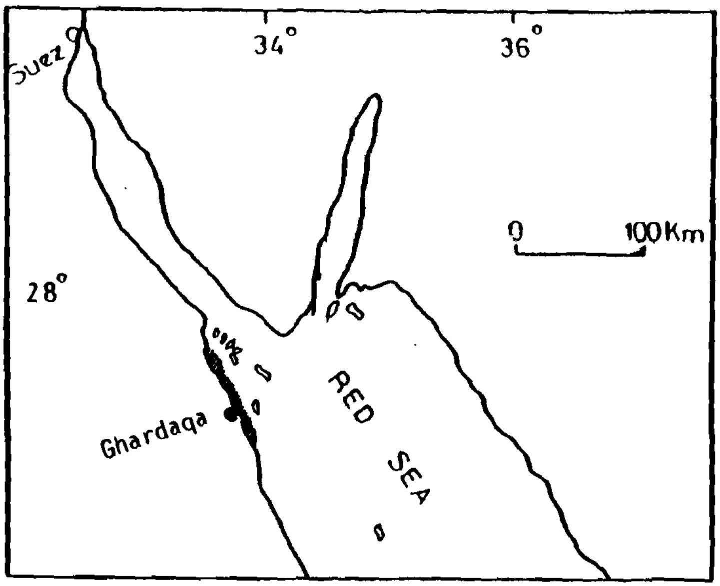

Fig. 1. ▨ Area under study.

FORMULATION

Several evaporation equations based on the aerodynamic method were developed by Sverdrup (1937), Miller (1937), Norris (1948) and Sutton (1949). In the present work, the aerodynamic method is applied in order to compare the evaporation results for the western coast with those calculated by Behairy et al.(1981 a,b) for the eastern coast and central part of the Red Sea in front of Jeddah Saudia Arabia.

Sverdrup (1937) considered the sea surface as to be invariably rough and characterized by a constant roughness independent of wind speed. He assumed that a laminar layer exists between the surface and the turbulent layer. Sverdrup's (1937) equation can be written as:

$$E=0.623\,\rho D(e_0 - e_z)\,U_*/P(D/K\,\mathrm{Ln}\,(z + z_0)/(d+z_0) + dU_*)$$

where:

E : the rate of evaporation cm/s,

ρ : the density of air = 1.2 x 10 gm/cm,

D : the diffusion coefficient of water vapour = 0.35 cm/s;

K : the dimensionless Von Karman's constant =0.4,

Z_0 : the roughness length = 0.6 cm,

d : the thickness of the laminar layer = 30 V/U_* cm,

V : the kinematic viscosity of the air = (0.5) cm/s,and

U_*: the friction velocity, cm/s where,

$$U_* = K\,U_z/\,\mathrm{Ln}\,(z + z_0)/z_0)$$

U_* : the wind speed at hight z above the sea surface, cm/s,

e_z : the vapour pressure (mb) at height z,and

e_0 : the saturated vapour pressure (mb) at sea surface temperature,and

P : the atmospheric pressure in mb,

DISCUSSION

Monthly mean values of sea surface temperature, air temperature, wind speed, vapour pressure, vapour pressure deficit and atmospheric pressure in the period November 1987 - October 1988 are illustrated in figure (2).

The air temperature reached its minimum value (19.6° C) in January 1988 increasing gradually to reach its maximum value (34.0° C) in June 1988. After June, the air temperature decreases slightly to the end of August and then decreases rapidly to reach its minimum value in the following winter. The annual amplitude was 14.4 C.

The monthly water temperature has the same trend as for the air temperature with some variations in magnitude. The maximum surface water temperature was observed in August 1988 (27.5° C). The annual magnitude was only 8.8° C. This value is slightly lower than that of the eastern Red Sea coast (9.0° C, Behairy et al. 1981b), but higher than that of the same latitude outside the Red Sea (6.9° C, Morcos, 1970).

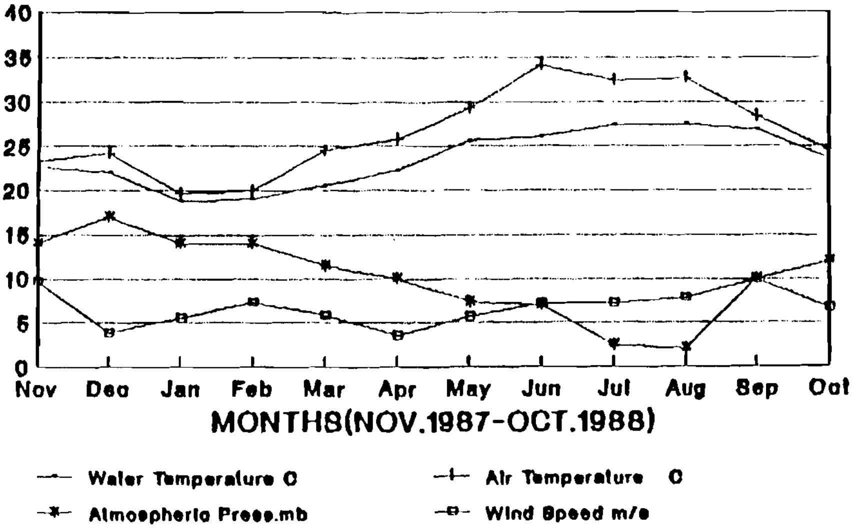

Fig. 2.

Mean monthely temperature (c), atmospheric pressure (-1000) and wind speed (m/s).

The mean monthly vapour pressure varies between its extreme values 11.3 and 24.2 mb in January and August 1988, respectively. The annual amplitude was 12.9 mb, which is lower than that along the eastern coast of the Red Sea (15.0 mb, Behairy et al., 1981b).

In the aerodynamic equation the vapour pressure deficit (e_o - e_Z) is the main factor beside winds. The parameter was irregular depending upon the origin of the air mass (from the sea or land) and the time of stay over the area. Its value changed from 0.4 mb in March 1988 to 8.0 mb in September 1988.

The high annual amplitude of the previous parameters is mainly due to the contenintal influence on the coastal shallow areas.

The mean monthly wind speed was, to some extent, irregular. There was a general high wind speed of more than 4.0 m/s especially in September when the maximum wind speed reaches 9.9 m/s. The lowest value was observed in April and December 1988 (3.5 and 3.9 m/s, respectively).

The prevailing wind directions during the months of the investigated period were NNE and NNW. The easterly components of the wind were developed in late winter and early spring (NE, N & ESE). It is noteworthly to mention that, along the coasts of the Red Sea the variations in wind characteristics are more complicated than those over the open sea. The prevailing wind, due to its direction and the geographic nature of the Red Sea, varies according to the wind coming from land (hot dry air) or from sea (wet air) which accelerate or impede evaporation from the coastal water.

The mean monthly atmospheric pressure was high (1017mb) in early winter (December 1987) and decreased gradually to reach its minimum value (1003 mb) in summer (August 1988).

Figure (3) shows the estimated monthly evaporation from the coastal area in front of Hurgada. The higher evaporation occurs in summer and reaches its maximum value in September (32.4 cm) decreasing gradually to reach its minimum value in March and April (1.0 cm). This small value of monthly evaporation, in late winter and early spring, was associated with very low wind speed (< 4 m/s) blowing from the sea (wet air mass). The maximum value of evaporation in September is associated with maximum mean wind speed (9.9 m/s) from the NNE direction (from the Eastern Desert of Egypt).

Behairy et al. (1981a) estimated the annual evaporation for the central part of the Red Sea to be 144 cm. This value is slightly higher than that of the present study. The difference is 16 cm. Also, Behairy et al. (1981b) estimation for evaporation was 205 cm annually which is appreciably higher than the present results. This obvious difference may be due to the following two reasons: i) The difference in latitude between Jeddah (21° 30' N) and Ghardaqa (27° 20' N) and ii) The prevailing wind off Jeddah is mainly from north (from the desert). This dry hot air mass accelerates the rate of evaporation.

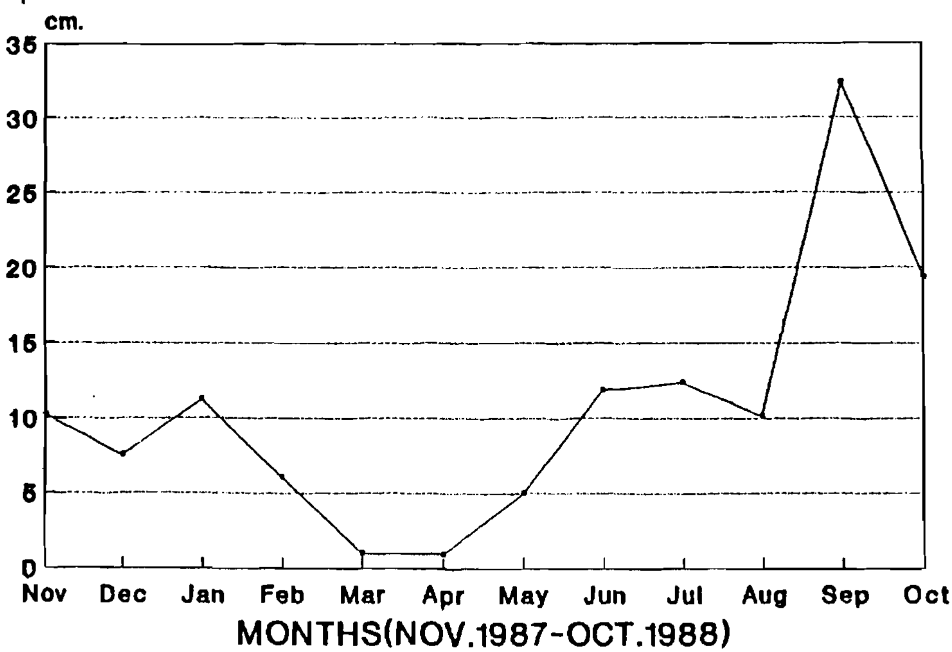

Fig. 3
Monthly evaporation (cm) in the NW Red Sea.

CONCLUSION

Monthly evaporation from the coastal water extending from Gimsha (60 km north of Ghardaqa) to Desha El-Daba (20 km south of Ghardaqa) was computed using the aerodynamic method. The month to month variations for the meteorological parameters including the sea surface temeprature were discussed. The effect of the wind speed and direction on the evaporation were discussed and concluded to be the main factor. The monthly evaporation ranged between 1.0 cm in March and April to 32.3 cm in September. The annual amount of evaporation from the coastal area in front of Ghardaqa is estimated to be 128 cm which represents peculiar weather characteristics. This needs surface synoptic observations of the marine-meteorological elements from coastal and open sea waters.

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