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Evaluation of Sediment Transport Along the Nile Delta Coast, Egypt

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ABSTRACT

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Surface synoptic charts of the Eastern Mediterranean Sea have been used for a decade (1980–1989) to obtain data of wind direction and speed. Wind waves are predicted along the Nile Delta coast at five locations (Abu Quir, Rashid, Burullus, Ras El Bar and Port Said). The coastal array system (CAS) wave data obtained in 1988 are used to carry out a comparison between predicted and observed values of wave parameters at Abu Quir and Ras El Bar.

It can be concluded that, the transport of sediment is eastward at Abu Quir, Burullus, Ras El Bar and Port Said. At Rashid the transport is mainly westward due to the effect of the NNE waves, while some reversal occurred. The transport is eastward when NNW and WNW waves dominate the area. The area between Abu Quir and Rashid and that between Ras El Bar and Port Said are characterized by accretion while those between Rashid and Burullus and between Burullus and Ras El Bar are characterized by erosion.

INTRODUCTION

Waves which are invariant with time and governed mainly by climate play a non negligible role in the manifestations created on the Nile Delta coast. To estimate the amount of sediment transport along the Nile Delta coast, it is important to have some wave data close to the shore area of the study. Limitations in the available instrumentations led to incomplete pattern of the wave field along the Nile Delta coast. For that, mathematical model can be used to estimate the wind field and then the wave field at the required areas using the synoptic weather charts of the eastern Mediterranean sea for a decade (1980–1989) with two charts daily. The study of wave growth in deep water is estimated. Inter-relationships between wave height, period, azimuth, water depth and orbital velocities lead to the calculation of the dissipation of waves in shallow water due to the effect of bottom friction. Whence, coastal currents, littoral drift transport and the volumetric transport are calculated.

The wave height, period and direction obtained from the mathematical model at the five locations (Figure 1) are compared with the actual field observations at Abu Quir and Ras El Bar. The correlation between predicted and observed wind wave parameters indicate some variabilities. HASSELMANN and COLLINS (1968) show that currents near bottom and also vertical current shear would have a strong influence on the wave generation and hence on the wave parameters and this will lead to the variability between observed and predicted wave parameters.

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WAVE CLIMATOLOGY

The methods used to calculate the wave roses at the different stations along the Nile Delta coast is clearly illustrated by MAHAR (1993). Seasonal wave roses for Abu Quir, Rashid, Burullus, Ras El Bar, and Port Said are given in Figure 2.

In winter season due to the rough weather the wave height of more than 2 m occur with 18.4%, 16.0%, 18.1%, 19.4% and 18.0% of the time at Abu Quir, Rashid, Burullus, Ras El Bar and Port Said, respectively. At Abu Quir and Port Said 70% and 75% of the time, the waves are from NW/NNW sector, while at Burullus and Ras El Bar 80% of the time the waves are from NNW/N sector. At Rashid, 55% and 33% of the waves are from NNW/N sector and NNE sector respectively. The mean wave periods are 4.8 s with a maximum of 9 s during that season.

In spring, the roughness of the weather decreases. The wave heights of more than 2 m occur with 6.1%, 11.0%, 10.8%, 11.9% and 6.1% of the time at Abu Quir, Rashid, Burullus, Ras El Bar and Port Said respectively. Wave angles are from the NW/NNW sector with 69% and 72% at Abu Quir and Port Said respectively, while at Burullus and Ras El Bar 81% and 94% of the waves are from NNW/N sector respectively. Finally, at Rashid 50.2% of the waves are from NNW sector and 38.7% are from NNE sector. The mean wave periods are 4.4 s with a maximum of 7.6 s during that season.

In summer, the wave height of more than 2 m occurs with 3.3%, 4.3%, 4.3%, 2.5% and 2.7% at Abu Quir, Rashid, Burullus, Ras El Bar and Port Said, respectively. Wave angles are 70% of the time from the NW/NNW sector at both Abu Quir and Port Said while they are 85% from NNW/N sector at Burullus and Ras El Bar and 68% from N/NNE sector at Rashid. The mean wave periods are 4.1 s with a maximum of 7.7 s during that season.

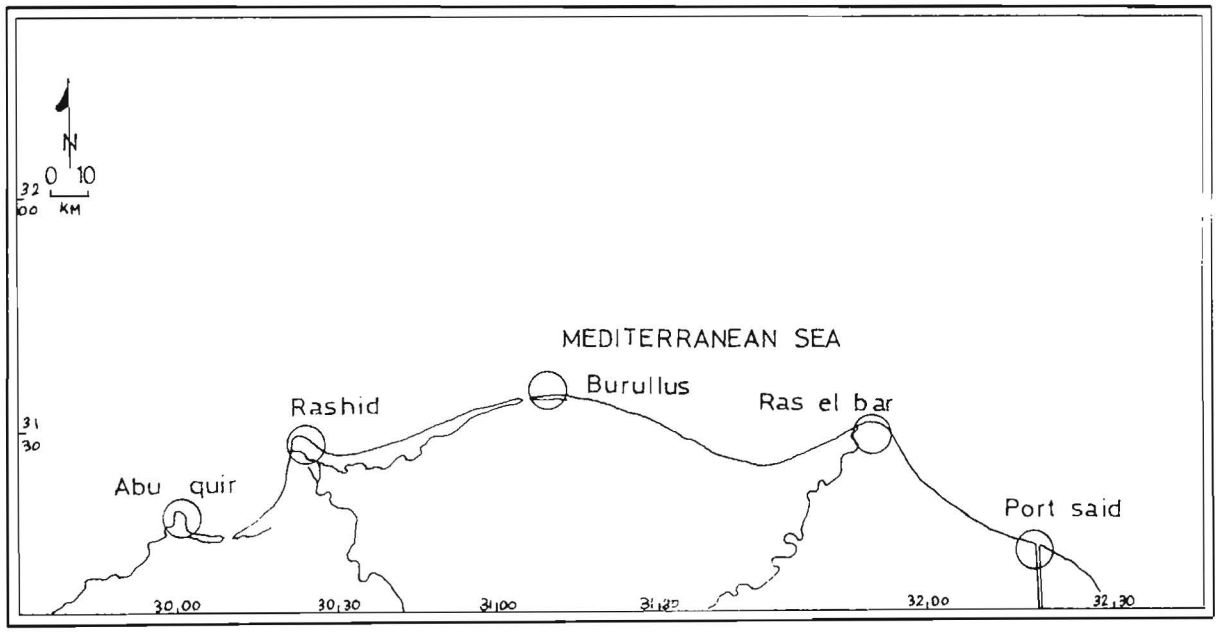

Figure 1. Chart showing the five locations at which wave parameters were predicted.

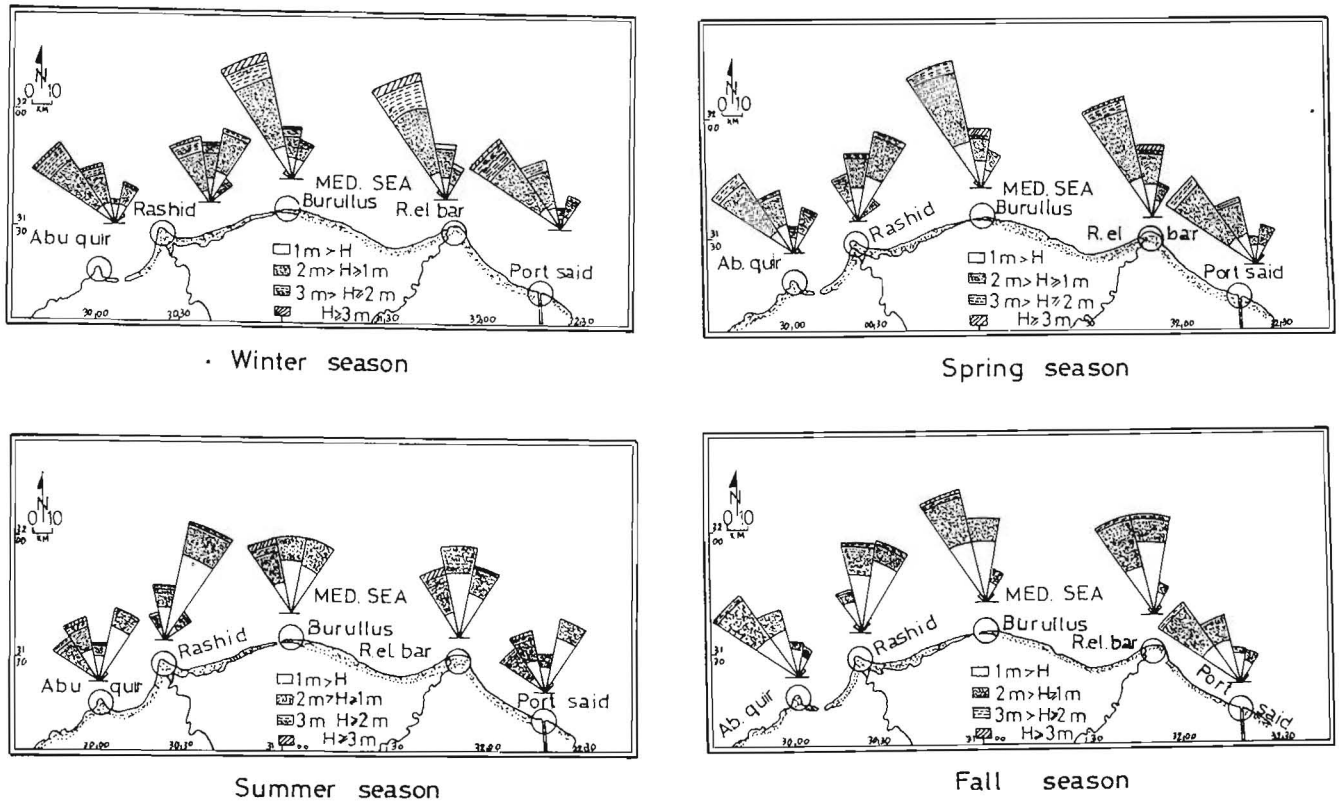

Figure 2. Wave roses obtained along the coast of the Nile Delta during the four seasons (MAHAR, 1993).

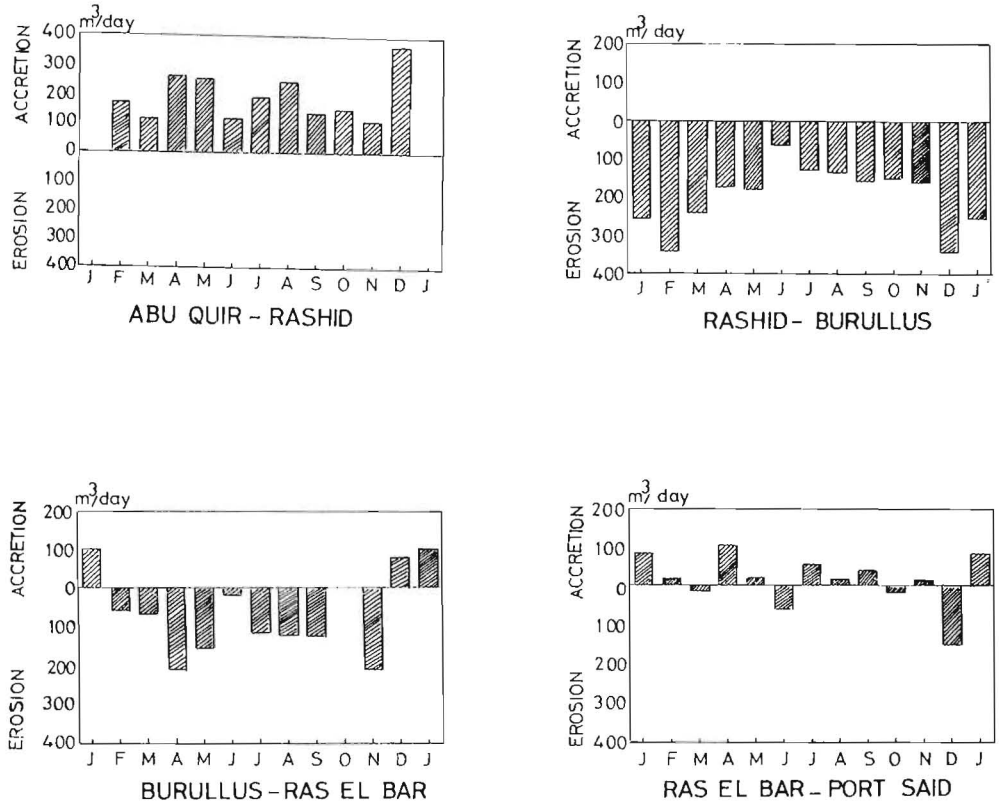

Figure 3. Monthly mean budget of sediments for the coastal sections along the Nile Delta coast (MAHAR, 1993).

In autumn 8.0%, 4.2%, 6.2%, 6.8% and 7.5% of the wave heights are more than 2 m at Abu Quir, Rashid, Burullus, Ras El Bar and Port Said, respectively. 50% of the waves are from NW/NNW sector and 47% from N/NNE sector at Abu Quir and Port Said, 88% from NNW/NNE sector at Rashid, while at Burullus and Ras El Bar, 99% of the waves are from NNW/NNE sector. The mean wave periods are 4.6 s with a maximum of 9.3 s.

The CAS (Coastal Array System) wave data of 1988 are used to compare between the predicted and actual values of wave parameters at Abu Quir and Ras El Bar. The comparison is carried out using the hourly values, so that there is no time lag between the compared pairs of data. Regression analysis show that the correlation coefficients are 0.887, −0.774, 0.914 and 0.919 for wave heights at Abu Quir during winter, spring, summer and fall season respectively. For wave period, the values are 0.973, 0.702, 0.934, and 0.939 respectively. Finally, they are −0.936, 0.964, −0.919 and 0.933 respectively for wave direction. Also at Ras El Bar, the correlation coefficients due to the regression analysis are −0.894, 0.972, −0.982, and 0.755 for wave height during winter, spring, summer, and fall seasons respectively. For wave period the values are 0.908, 0.922, −0.886 and 0.942; while for the wave directions they are 0.980, 0.938, 0.981 and 0.913 respectively for the same seasons.

The variability of the wave's directions during winter are due to the effect of the cyclonic storms which travel from west to east in the Mediterranean Sea (INMAN *et al.*, 1975). The migratory cyclones are channeled over the Mediterranean due to the eastward extention of the Azores high across North Africa and the westward extention of the Siberian high. During spring, as the Siberian high is displaced by the Asian thermal depression over the Eastern Mediterranean, the cyclonic activity is weaken and the severity of sea decreases. In summer, the Azores high and the Asian low were completely dominating the climate and reach maximum intensity causing the frequency of severe seas to be at its minimum for the year. During autumn, the Asian low and the Azores high diminish in intensity as the Siberian high becomes prominent so that a low pressure trough with associated migratory cyclones is created in the Eastern Mediterranean and this causes abrupt increase in the severity of the sea.

LONGSHORE SEDIMENT TRANSPORT

The volumetric transport (Q_s) is given by KOMAR (1983) by

$$Q_s = (Ecn)_b \, v/Um$$

where, E is the wave energy, c is the phase velocity, n is ratio between group and phase velocity, v is the littoral current and Um is the maximum bottom horizontal orbital velocity of the waves evaluated at the breaker zone.

The budget of each coastal section between two sequential points is taken as the difference between the input—output

at the two bordering locations. The positive and negative budget of each section is a sign that indicates the variation of the shoreline.

Due to the effect of the prevailing WNW and NNW waves at Abu Quir, NNW waves at Burullus, NNW and N waves at Ras El Bar and WNW and NNW waves at Port Said the transport is found to be eastward. At Rashid the transport is mainly westward due to the effect of the predominant NNE waves.

Figure 3 shows the monthly budget of the transported sediments for the coastal sections along the Nile Delta coast. The method of estimating the sediment transport budget for each of the four sections is clearly indicated by MAHAR (1993). The coastal section (Abu Quir—Rashid) is under the effect of accretion all over the year with a maximum rate of 369 m^3d^{-1} during December, while the coastal section (Rashid—Burullus) is under the effect of erosion all over the year with a maximum rate of 342.3 m^3d^{-1} during December also. The coastal section (Burullus—Ras El Bar) is under the effect of accretion with a maximum of 108.7 m^3d^{-1} during April and under the effect of erosion during March, June, October and December with a maximum rate of 153.7 m^3d^{-1} during December. The coastal section (Ras El Bar—Port Said) is under the effect of erosion with a maximum rate of 213.4 m^3d^{-1} during November except for the months January, October and December which are under the effect of accretion.

It has been found that, the area between Abu Quir and Rashid and that between Ras El Bar and Port Said are characterized by accretion; while the area between Rashid and Burullus and that between Burullus and Ras El Bar are characterized by erosion.

CONCLUSION

During the winter season: 81.6%, 84.0%, 81.9%, 80.6% and 82.0% of the waves had heights less than 2 m at Abu Quir, Rashid, Burullus, Ras El Bar and Port Said, respectively. The roughness of sea surface decreases to its minimum during summer so that 96.7, 95.7, 95.7, 97.5 and 97.3 percent of the waves had heights less than 2 m.

The transport is found to be eastward due to the effect of WNW and NNW waves at Abu Quir, NNW waves at Burullus, NNW and N waves at Ras El Bar and WNW and NNW at Port Said while at Rashid the transport is westward due to the effect of NNE waves. A good correlation has been obtained between the observed wave data of the CAS system from Coastal Research Institute in Alexandria at Abu Quir and Ras El Bar, and that calculated by MAHAR (1993) applying mathematical model to synoptic charts.

The budget of the transported sediments along the Nile Delta coast show that, the area between Abu Quir and Rashid and that between Ras El Bar and Port Said are characterized by accretion while those between Rashid and Burullus and between Burullus and Ras El Bar are characterized by erosion.

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