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Water Exchange of Sharm Obhur, Jeddah, Red Sea

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Abstract. The exchange of water between coastal inlets and the inner continental shelf is mainly due to astronomical, meteorological and thermohaline forces. The relative importance of these factors depends on local tides and characteristic wind speeds. Sharm Obhur is a shallow and narrow coastal inlet about 10 km long. The maximum depth at the entrance is about 35 m. It has marinas, hotels, and other tourist attractions along its periphery. The study of water exchange is of significant importance because of sewage coming from the hotels and marinas. Temperature and salinity vertical distribution showed that during winter at most of the stations the water column is well mixed and stratified during summer season. The study shows that the flushing time of Sharm Obhur is about 12 days. This time scale should be taken into account for any future constructions in Sharm Obhur to ensure the water quality.

Introduction

The exchange of water between coastal bays/lagoons and the inner continental shelf occurs in response to a variety of forces. The tides are of primary influence along most coastlines, providing a periodic exchange, which is both dependable and predictable (Smith, 1977 and meshal *et al*., 1983). In addition to the tides, meteorological forces, especially wind stress plays a variable but sometimes dominant role in some areas depending on local tides and characteristic wind speeds (Brooks 1978; Fischer *et al*., 1979; Ahmad and Sultan, 1992 and Sultan and Ahmad, 1990). The main objective is to study the physical oceanography prosperities (temperature, salinity and density) of Sharm Obhur.

Study Area

It is planned to study the exchange of water of Sharm Obhur. It is about 35 km to the North of Jeddah and is approximately 10 km long 500 m wide (Fig. 1). The maximum depth at the entrance is 35m (Behairy *et al.*, 1983). The area has considerable recreational importance as can be judged from the large number of visitors/tourist (several thousand) who may be present on any single day. For the exchange of water, currents over a tidal cycle will be monitored at the inlet to the Sharm.

Eight hydrographic stations along the axis of Sharm Obhur are occupied for the measurement of Temperature and Salinity in addition to a station at the inlet of Sharm Obhur. These stations are occupied twice in winter and summer seasons.

Materials and Methods

The field work trips started on February 2nd 2008, where hydrographic stations were chosen (Fig. 1). Eight hydrographic stations were chosen along the main axis of Sharm Obhur. The measurements were recorded on February 23rd 2008 to represent winter season and on July 20th representing summer season. Station 1 which is located at the entrance of Sharm Obhur and stations 8 is at the end of the Sharm. The depth varies at each station, where it becomes shallower at the end of the Sharm. One current meter (OSK-CM2) and one CTD (Valeport) were used.

Results

In this part the field results obtained during the project are presented. These results contain measurements of sea water temperature, salinity and current meter data. Also computed density (shown as σ_t) is presented. Flushing time calculation is shown and discussed.

Water Temperature

Figure 2 shows the vertical distribution of temperature with depth during winter season. Water temperature varies between 26°C and 28ºC. During summer season the vertical distribution of the temperature in the eight hydrographic stations along Sharm Obhur are shown in Fig. 3. The surface temperature of these stations varies between 30°C and 31ºC.

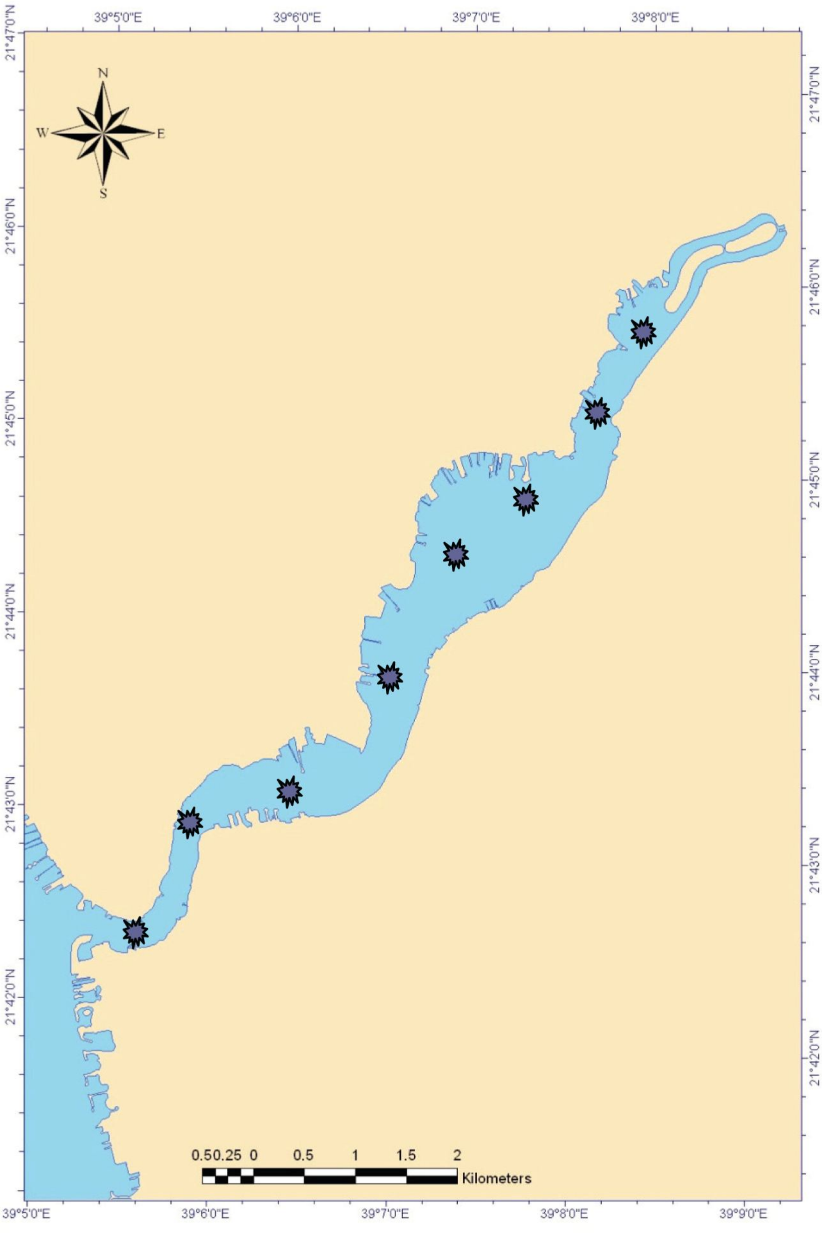

Fig. 1. Chosen hydrographic stations at the study area ( ).

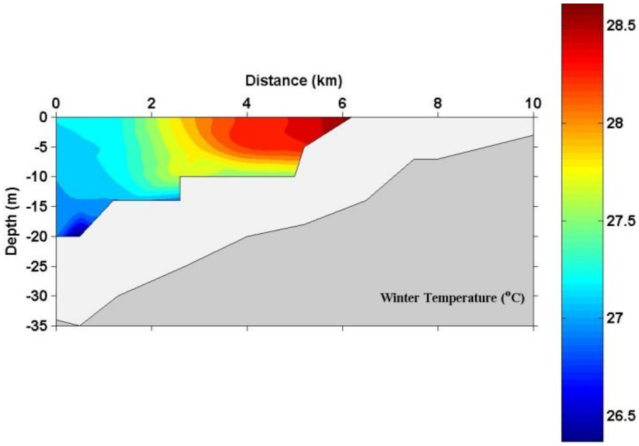

Fig. 2. Winter temperature distribution.

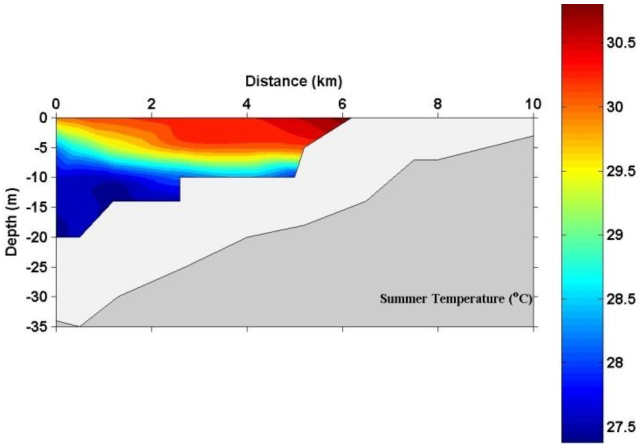

Fig. 3. Summer temperature distribution.

Water Salinity

Figure 4 shows the vertical distribution of salinity with depth during winter season. Water temperature varies between 40.5 and 42.3%. During summer season the vertical distribution of the salinity is shown in Fig. 5. The surface salinity of these stations varies between 39 and 39.7%.

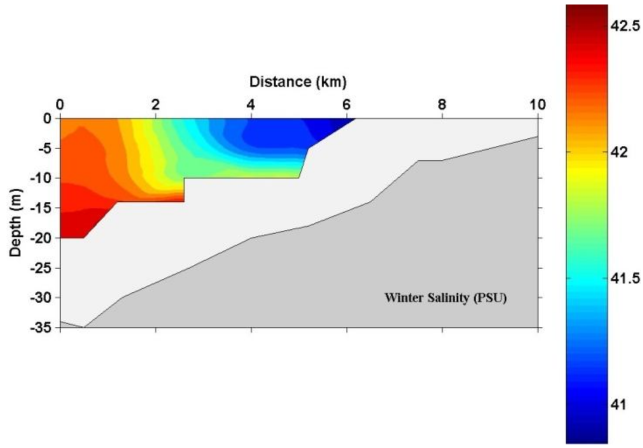

Fig. 4. Winter salinity distribution.

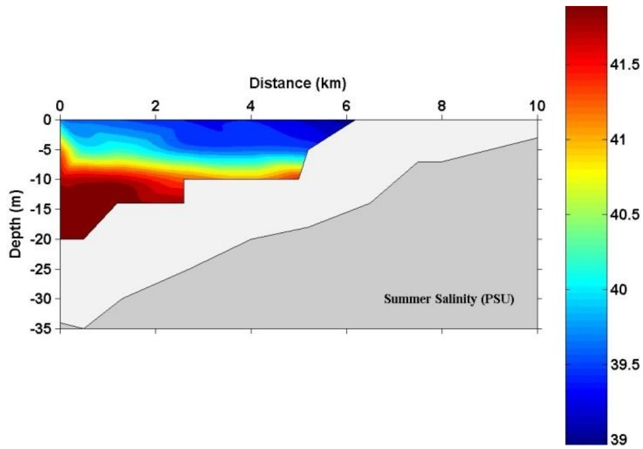

Fig. 5. Summer salinity distribution.

Water Density

Figure 6 shows the vertical distribution of density (shown as σ_t) with depth during winter season. During winter season σ_t varies between 26.6 and 28.5. During summer season the vertical distribution of the density are shown in Fig. 7. The surface density is (shown as σ_t) of these station varies between 24.5 and 25.25.

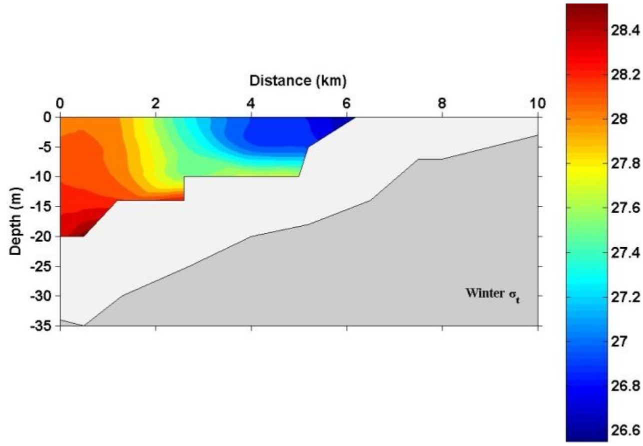

Fig. 6. Winter density distribution.

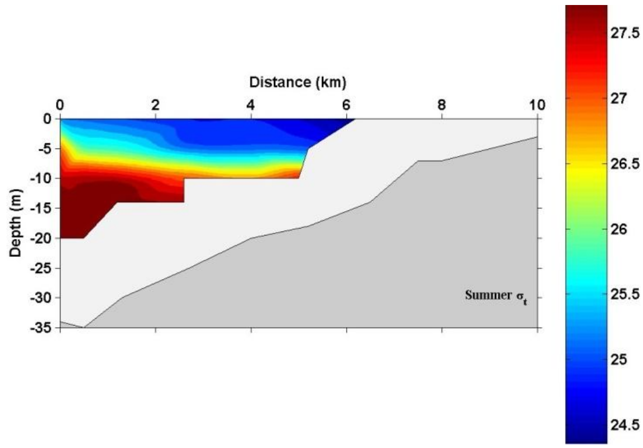

Fig. 7. Summer density distribution.

Flushing Time

Measurements of the current speed and direction at the entrance of Sharm Obhur for one complete tidal cycle were taken at July 8th 2008. These data were used to calculate the flushing time of Sharm Obhur. Flushing time is calculated to investigate the renewal of Sharm Obhur water. The rate at which the Sharm Obhur exchanges with the open sea depends greatly on the geometry, depth, and circulation near the entrance.

Flushing Time	=	Lagoon volume / Flow rate
Entrance width	=	80 m
Average depth at the entrance	=	20 m
Vertical area	=	1.6×10^3 m^2
Water volume entering Sharm Obhur	=	50×10^6 m^3
Average velocity at the entrance	=	4.9×10^{-2} $m.s^{-1}$

Applying equation (1) to calculate the flushing time for Sharm Obhur gave about 12 days renewal of the water of Sharm Obhur.

Discussion

Shallow water is especially responsive to heating and cooling processes. Even over diurnal time scales, warming and cooling is distinct. Wind effects cause intense vertical mixing and significant wave action and these mixing processes can extend to the bottom. Tidal forcing is continuous in a periodic sense, but tidal motions arise from exchanges with adjacent continental shelf waters, and inlet jetting can result in rapid dispersion and attenuation of the tidal current. Thus, passes may have a significant constricting effect. Wind forcing can be both local and non-local (by changing sea level outside passes), but it is intermittent in time, and variable in speed and direction. Thus, near passes, tidal currents are often dominant. The circulation of a coastal lagoon is highly variable in both space and time.

Sharm Obhur is located in the central region of the Red Sea. The tides in the Indian Ocean do not enter the Red Sea directly. Therefore, there is no progressive wave which moves through Bab Al-Mandab and raises and lowers the water level within the Red Sea. Instead there is local oscillatory tide of small amplitude and semi-diurnal period which results in high water at the other end. The time difference between successive high waters or low waters at any location is approximately 12 h and 25 min. The Range of the tide is greatest at the two ends averaging about 0.6 m near the Gulf of Suez and about 0.9 m in the south. There is a difference in the range during spring and neap times.

Associated with the changes in the tidal level is the horizontal movement of water, called the tidal streams. In general the tidal streams in the open Red Sea are very less but in shallow areas the tidal currents may be very strong. These may be of tidal origin but the topographic influences and the effect of local or diurnal wind variation are the major factors influencing them. Accordingly, the currents speed at the entrance and inside Sharm Obhur are mainly due to tidal effects with less wind effect.

The vertical distribution of the water temperature and salinity show that, during the winter season the water column is almost mixed near the entrance. On the other hand, during the summer season the vertical stratification is clear in the vertical distributions. Also the measurements showed that during winter and summer seasons there is a decrease in the temperature and increase in the salinity with depth at the stations located near to the end of Sharm Obhur. This is due to the shallow water column where the surface water is affected by the surface heat input.

The flushing time calculation is depending on the tidal forces. The calculation showed that the flushing time is about 12 days, which is reasonably good for the Sharm water to be renewed taking into account the huge activities in the area.

During high tide, a layer of relatively cold and low salinity water from the Red Sea enters Sharm Obhur during most of the year. During low tide the higher temperature and higher salinity water from Sharm Obhur flows into the Red Sea. Temperature variations in the area are controlled by meteorological conditions.

The productivity results from the interplay of oceans and continents. A large number of species establish themselves permanently in Sharm Obhur; others colonize them temporarily for the purpose of reproduction. Therefore, oceanic inputs play an important part in the processes of fertilization of the lagoon.

In the arid zone lagoons, the marine environment is under stress due to high temperature and salinity but the calculated flushing time for Sharm Obhur may not cause intolerable stress to its ecology.

Conclusion

A fairly good hydrographic data were collected. Trips were taken place during winter and summer seasons. The current measurements were taken at the entrance of Sharm Obhur covering one complete semi-diurnal tidal cycle (13 h). Flushing time calculation showed the renewal time scale for Sharm Obhur water is reasonable to keep the rich marine ecosystem in the area. Accordingly, any dredging or damping (man-made) in the area will change the natural environmental balance. In other word, the marine environment will be damaged.

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التبادل المائي بشرم أبحر، جدة، البحر الأحمر

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المستخلص. إن التبادل المائي بين أي شرم ورصيف قاري داخلي بواسطة قوة المد والجزر وقوة إجهاد الرياح وقوة انحدار الضغط والأهمية النسبية لكل من هذه القوى يختلف باختلاف المكان والزمان، يقع شرم أبحر شمال مدينة جدة بطول ١٠ كم مُقام عليه العديد من المشاريع السياحية، مثل الفنادق والمنتجعات السياحية، ويقدر عدد المرتادين بضعة آلاف في اليوم الواحد، ومن هنا تكمن أهمية هذه الدراسة لمعرفة زمن تجدد المياه. وقد بينت هذه الدراسة أن شرم أبحر يحتاج إلى ١٢ يوم لكي تتجدد مياهه بشكل كامل، وهذه المدة الزمنية لابد أن تؤخذ بعين الاعتبار عند عمل الإنشاءات الجديدة بشرم أبحر.