

SOME FEATURES OF THE PHYSICAL OCEANOGRAPHY IN IRAQI MARINE WATERS

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Abstract

Iraqi marine water is the major (important) estuarine part at the north part of the Arabian Gulf. The harmonic constituents of tide M2, S2, K1, and O1 in Outer Bar station was found of order of 0.66, 0.18, 0.46 and 0.26 m. respectively. The type of tide is mixed, dominant semi-diurnal with range between 1 –3 m. The salinity values (4‰ – 39‰) are effected heavily by the rate of the Shatt Al-Arab discharge and the state of tide. Water temperature fluctuate during winter and summer, and it is reaching 12.5°C to 33.5°C respectively. Thermocline and halocline developed according to the season and state of tide. Different types of currents were effecting their water (tidal current, coriolis force, wind current, density current and Arabian Gulf current, Generally ,tidal current_ in the area are strong and reaching 0.8 -2 m/sec.

Introduction

The general description of the physical oceanography in an area is one of the major factors affecting navigation, fisheries, coastal environment, coastal configuration and marine construction.

No many investigations have been of the physical oceanography in the Iraqi territorial waters. Some aspects of the physical oceanography in the Iraqi marine waters has been reviewed by Mohamed *at el.* (1995), Al-Mahdi and Abdullah(1996), Abdullah *at el.* (1999), Hussain *at el.*(1999), Al-Mahdi (2001) and Abdullah (2002). Some of these studies are limited either specific area or duration. This paper will give general descriptions of some oceanographic conditions ,since the area represent the estuarine part of the Arabian Gulf ,which pertains to diurnal variations (13hr) during low and high discharges as well as through different tidal phases of neap and spring.

Description of the Study Area

The Iraqi marine water is the most northern-western part of the Arabian Gulf. This water body is consist of shatt AL-Arab Estuary (shallow, average depth of 5 meter at low water) and several open lagoons such as Khor Al-Kafka and Khor Al-Amaya (deep and narrow, average depth of 25 meter at low water) besides Khor Abdullah (Fig.1). Shatt Al-Arab River is the main source of the freshwater to the northern zone of the Arabian Gulf. Shatt Al-Arab River is formed from the three major rivers (Tigris, Eupharates and Karun), with total average outflow of 1200 m³/sec (AL-Mahdi &Salman, 1997).

The annual discharge of the Shatt Al-Arab River is varied seasonally in accordance with its tributaries contribution. In the Iraqi marine water, the temperature and salinity distribution is heavily dominated by the influx of the Shatt Al-Arab River.

The study area is characteristic with arid climate that have a small annual rainfall of order of 150(mm/year) and high rates evaporation (<2000 mm/year), most evaporation occurs in the winter season due mainly to the higher wind speeds (Reynolds, 1993).

The surface circulation in the Arabian Gulf seems to be counter clockwise, passing northwesterly along the Iranian coast and recession water southeasterly along the Arabian coast (Emery, 1956) Fig.2. The most famous, and notorious, weather phenomenon in the Arabian Gulf is a NW wind (locally name Shamal), which particularly strong in the early summer. This winds are below down the Gulf with estimate of as much as 100 km/hr (Williams, 1979). In the winter season the SE wind (known locally Koss) is dominate on the area It strong enough to stop commercial navigation.

Materials and Methods

Field measurements were made during the period Sep. 1993 to Aug.1994 on salinity, temperature, current and depths. These investigation were occupied most of the Iraqi marine water such as the head and the mouth of Shatt Al-Arab Estuary and inlet of Khor Abdullah. Three main stations were selected as shown in Figure 1. The first station is located in Fao port, the second in the Outer Bar area and the last station is situated in the inlet of Khor Abdullah.

These observations were made during 12 cruises of R.V. OLOUM. The foundation of the missing information in some stations were taken from previous studies.

Water samples were collected by using reversing water sampler Model 1506. Temperature water was measured by using reversing protected thermometers Model P 80-10. Salinity determinations were made by

conductivity measurements using an digital salinometer Model E-202.

Measurements of current velocity and direction were made by using current meter Model CM-2.

Exception water temperatures, all the measurements were done with intervals 2-meter in deep water and 0.5 meter in shallow depths. Depths survey were made by using an Echo Sounder Model OSK 3336.

These observations were made during low and high discharges and for different tidal phases (neap and spring). The average depth salinity $\langle s \rangle$ and velocity $\langle u \rangle$ over the tidal cycle were determined by theirs weight along the depth.

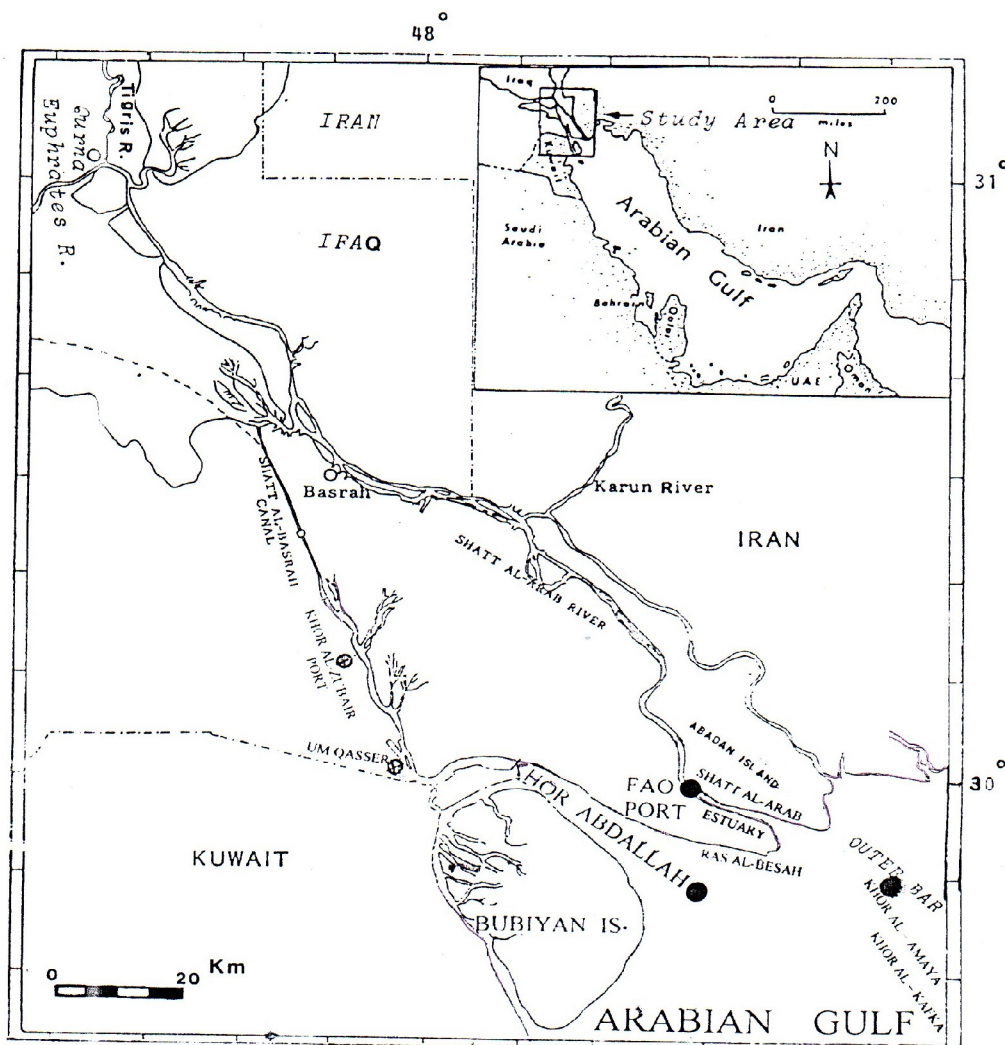


Fig.1. Location map of the study area .

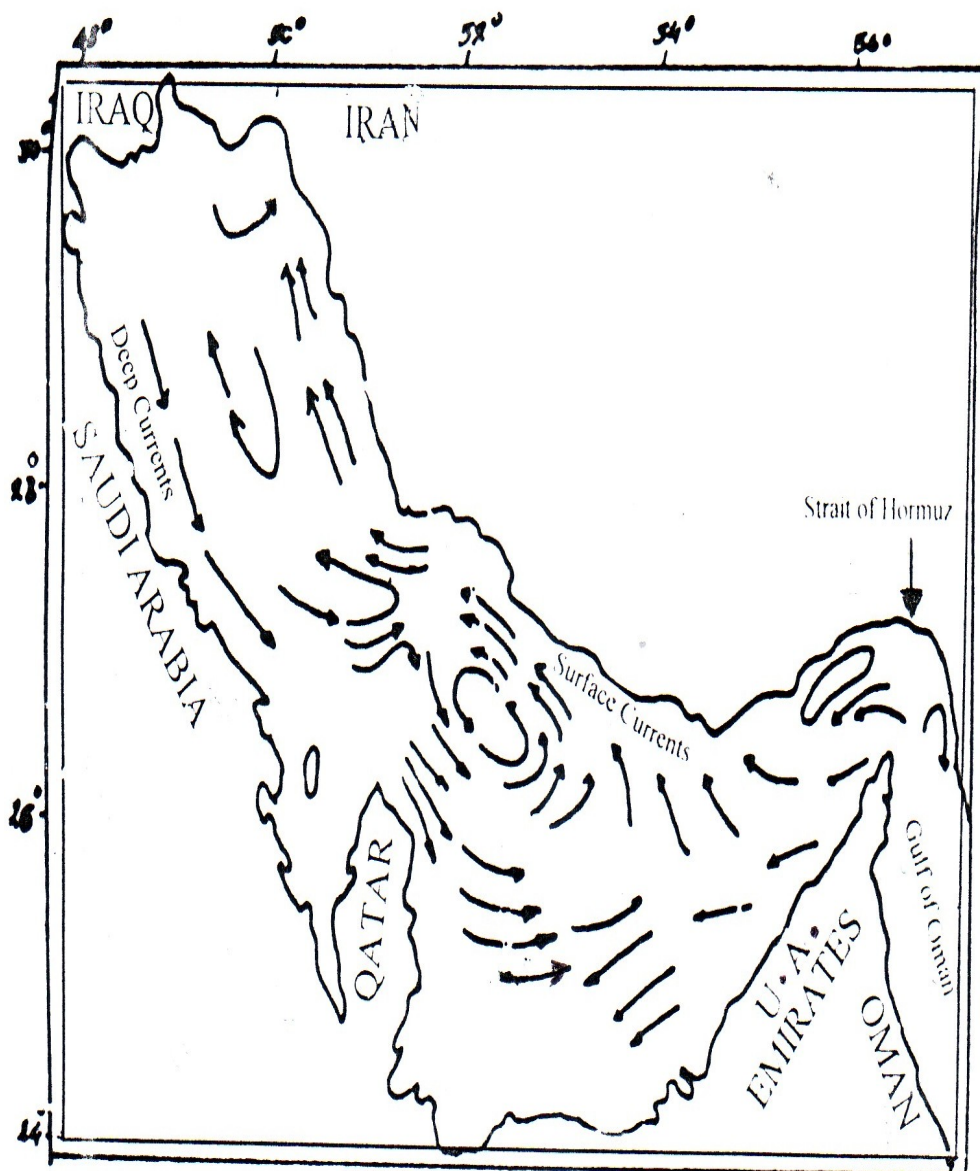


Fig.2. General circulation of surface (Iranian coast) and deep currents .(Arabian coast)

Results and Discussion

Tidal Regime

Tidal regime in the Arabian Gulf is very complex because of the semi-enclosed arm at strait of Hormuz. The Arabian Gulf illustrates two major oscillations of diurnal and semi-diurnal tides, driven primarily due to propagation of the tidal energy through the strait of Hormuz from the Gulf of Oman.

Generally, the tide in the Arabian Gulf is consisted of adversity of the tidal fashion as shown in fig. 3. which characteristics with semi-diurnal and predominantly semi-diurnal types.

The four harmonic constituents of the tidal regime in Outer Bar station are M_2 , S_2 , K_1 , O_1 which are of order of 0.66, 0.18, 0.46 and 0.26 m. respectively. Subsequently, Abdullah (2002) founded that the type of the tide in the mouth of the Shatt Al-Arab Estuary (Outer Bar station) is mixed, dominant semi- diurnal. This postulate is corresponding to the form number value (F) which is 0.85 according to the classification of Smith, 1980. There are two high and low waters occurred daily, with inequalities in heights and a time of happens.

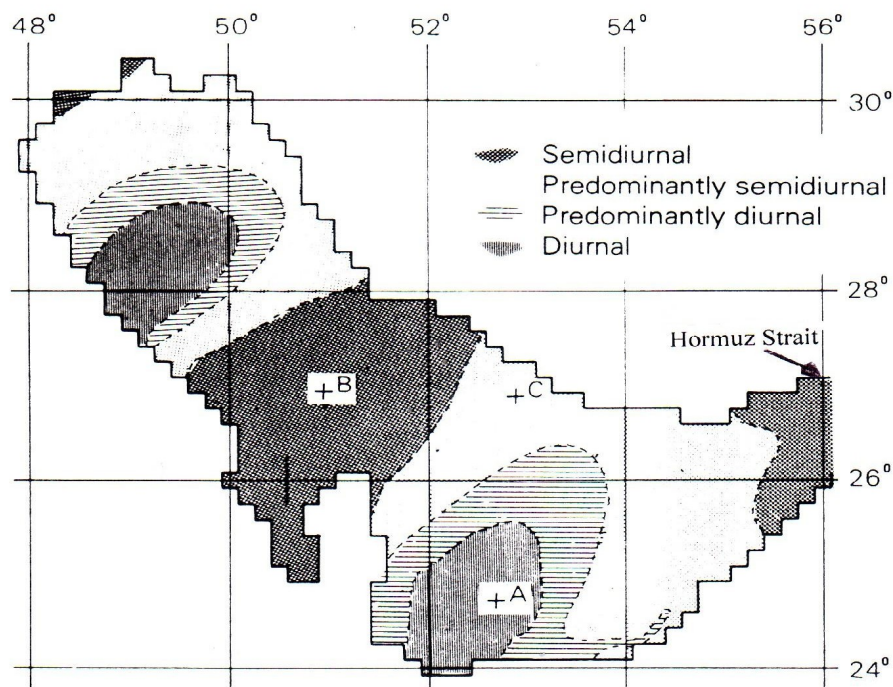


Fig . 3 . Tidal types classification .(From: Evans-Roberts 1979)

Tidal Range

Tidal range fluctuations in the Iraqi marine water are affected by two fundamental factors. The first is the prevailing Northerly winds tend to keep the tide dribble and Southerly winds have the opposite effect, especially in the open sea. The second and the monthly rhythm of springs and neaps which controlled on the inland area.

Tidal ranges are large in the study area being over 2.50 meter in the open water and exceeding occasionally 4.00 meter during spring tide in Khor Al-Zubair.

Table (1) shows the mean of the tidal ranges at both phases of tide (neap – spring). Because of the interest subject of the tidal range, data of Mahdi (1990) is used for comparative in Um Qasser and Khor Al-Zubair area. Table (1) exhibits that the high values were recorded in Um Qasser port during spring tide (4.30m) and neap tide (3.60m). This trend due to narrow width of the channel and increasing of depths which to be 18.0 meter at high water. Then tidal range on the decreases as propagation to wards north due to relative extension of the cross section area and fall depths gradually, the type of the tidal ranges are consider as meso tide according to (smith,1980). Generally, the tidal range in the open sea is lesser than that in the Khor Al-Zubair area for the previous interpretation and more than in Fao station.

From the filed observations of the study year, the highest tide occur during summer months (Jul.-Aug.) and the lowest tide during winter months (Dec.-Feb.).

In the summer months the high tide tend to occur during the day and the low tide occur through the night .So, the shore line is largely exposed at night and covered by the tide at day. This circumstance is inversely mutated during the winter months.

Table 1. Mean the tidal Range at both Neap and Spring Tide.

Station	Mean Tidal Range (m)	
	Spring	Neap
Fao Port	3.00	2.40
Outer Bar	3.50	2.52
Khor Abdullah	3.25	2.60
Um Qasser*	4.30	3.60
Khor Al-Zubair Port*	3.70	3.30

* after Mahdi.1990

Salinity Variations

Salinity distribution in the Iraqi marine water are mainly affected by freshwater discharge of Shatt Al-Arab River. Where as, the other parameters such as precipitation, evaporation and phase of tide are less stage influence on salinity fluctuations. It is known that Shatt Al-Arab River have two periods of flood. The first wave from Karun River during Feb.- Mar., which followed, by the second wave from Tigris and Euphrates Rivers during Apr.-June. (Sudgen, 1963).

The head of the Shatt Al-Arab Estuary (Fao station) considered as a control station due to oncoming to the freshwater source. So, mean surface salinities were plotted against the annual discharge at Fao station, Fig.4. This figure shows two inverse peaks, the first peak was recorded during June which associated with the high discharge ($1863 \text{ m}^3/\text{sec}$) and low saline (1.03 ‰). While, the another peak was noted during August which compatibility with low discharge ($580 \text{ m}^3/\text{sec}$) and relative high saline (3.12 ‰). Fig. 4 exhibits that the lowest salinity was recorded during Feb., which is of order of 0.84 ‰.

This tendency may be due to Karun River flood during this period which characteristics with low saline and temperature. Because of the freshwater occupation to the whole of this location (Fao station) over the year, the range of the surface salinity is very little (1.1 – 3.9 ‰) and (0.98 – 1.80 ‰) during the low and high discharge, respectively.

The impress of freshwater in the Outer Bar station is limited throughout the ebb period on the first meter of the water column during the low discharge. But, during the high discharge the invasion of freshwater are incessant up to the middle depth. So, there are an insignificant fluctuations in surface salinities during the low discharge (34.5 – 36.4 ‰) and wide changes during the high discharge (21.5 – 33.8 ‰).

Khor Abdullah station was recorded the highest salinity over the study year comparative with the other stations.

The increment of salinity values were due to waney effect of Shatt Al-Arab inflow as well as Corioles effect. However, the freshwater is very impressive on the surface layer during the flood season. The lowest and the highest surface values were of order of 32 ‰ and 37.55 ‰ during the high and low discharges, respectively.

Generally, surface salinity near the shore is more than offshore, especially during the Summer season which outreaches 40‰, this circumstance is due to high rates evaporation during the summer season which produced by high air temperature and Northern wind (Locally called Shamal) beside the shallow effect. But no extreme salinity (more than 45 ‰) were recorded in the Iraqi marine water as that documented in the other parts of the Arabian Gulf (Arelelini et al. 1978).

Table 2 explains the vertical salinity gradient during the low and the high discharges as well as the typical tide of Neap (19.10.1993) and Spring (29.4.1994).

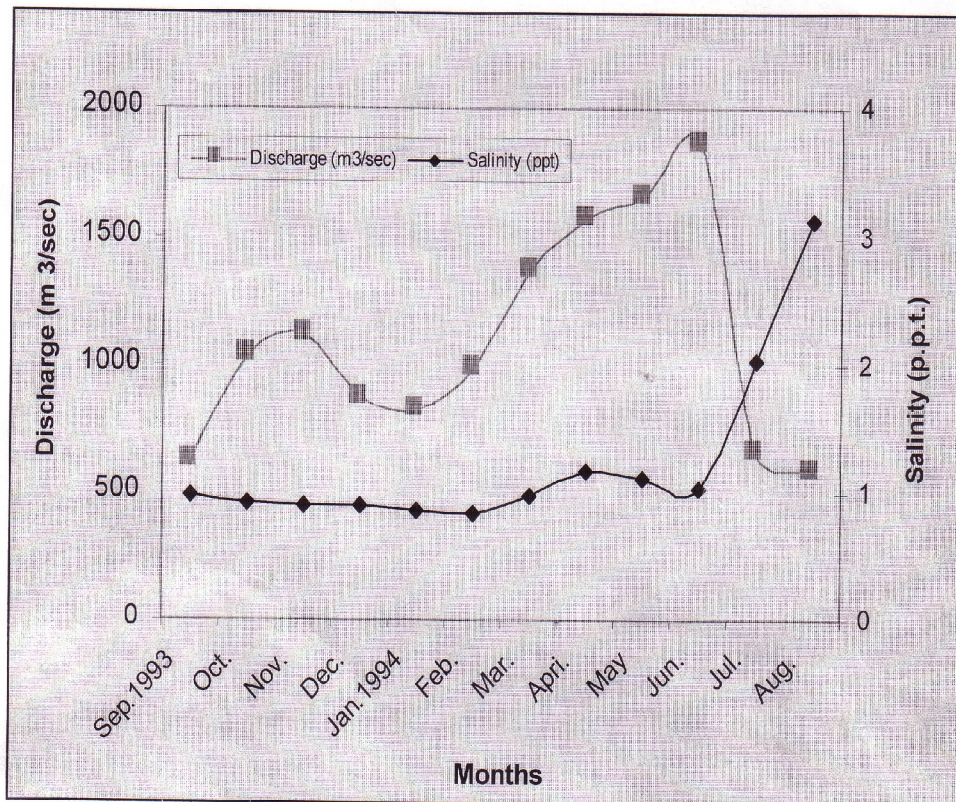


Fig. 4. Relationship between surface salinity (p.p.t.) and discharge (m³/sec) at Fao staion.

Table 2. Mean Salinity Gradient During Low and High Discharges and Through Typical Neap and Spring Tides.

Station	$\langle \tilde{S} \rangle \text{‰}$							
	Discharge				Typical Tide			
	High		Low		Spring		Neap	
	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.	Sur.	Bot.
Fao	1.03	7.00	3.12	22.00	1.45	2.80	0.96	0.96
Outer Bar	25.00	36.00	35.50	36.80	35.90	37.00	34.40	36.75
Khor Abdullah	34.00	36.90	36.25	36.90	36.00	37.55	35.0	37.25

Table (2) shows that during the low discharge intelligible changes in salinity structure comparative with the high discharge at Fao station. Whereas, Outer Bar station seem close to well homogenous during the low discharge and high stratification during the high discharge which increased from the surface up to the mid - depth ($Z/h=0.50$). Khor Abdullah station present a dribble vertical salinity gradient during the high discharge which limited at the surface layer ($Z/h=0.05$) and well mixed during the Low discharge. This result is nearly agreement with the (Abdullah *et al.*, 1999) which refer to low salinity during winter and spring seasons Table 2 seems that there is no significant vertical salinity gradient at all stations during the typical spring and Neap tides. But during the neap tide, there is a slight gradient more than in the spring tide in the marine stations and well mixed at Fao station.

In general, changes inflow river create a large scale of salinity gradient comparative with the mutation of the tidal phase.

Longitudinal salinity gradient is evident in the study area as show in Table 2. But the intension of the gradient increasing largely between Fao and outer Bar station.

Halocline was evident in deeper Iraqi marine water especially at Khor Al-Kafka and Khor Al-Amaya (Fig. 1) during the spring flood of the Shatt Al-Arab River which induce a strong halocline even in shallow area of the Shatt Al-Arab Estuary . While, during the rest of the year a weak halocline develop in the Shatt Al- Arab Estuary (Hussain *et al.*, 1999).

Water Temperature:-

Generally, the maximum and minimum surface temperatures (Table 3) were recorded during Aug. and Jun. months respectively at all stations. This behavior is related with the study area climate which charactersitic with semi tropical climate. Table 3 shows that highest values of the water surface temperature (32.7 C°) was recorded at Fao Port station comparative with the other stations, this variation may be is due to the difference of the stations location. So, the first station (Fao Port) is effect by the Land(Earth radiation), where as the other stations are influence by the sea breeze when usually in tension afternoon .

During the summer season (Aug., month) at both marine stations (Outer Bar and Khor Abdullah) surface water temperature is relatively more than the bottom with exception Fao Port station. Where as, during the winter season (Jun., month) at all stations the bottom water temperature is close to the surface.

Table (3) refers that there is a light vertical gradient during the water column which of order of 0.8 C° in the Fao station, this result is due to the lowest amount of River discharge(580 m³/sec).

While, there is an incisive horizontal gradient during the summer season which increase toward the Land.

Table 3. Maximum and Minimum Water Temperatures Through the Water Column

Station	Water Temperatures C°			
	Max.		Min.	
	Surface	Bottom	Surface	Bottom
Fao Port	32.7	33.5	12.9	13.1
Outer Bar	29.9	29.6	12.7	12.8
Khor Abdullah	29.4	29.0	12.5	12.9

Currents

Currents in the Iraqi marine water result from the effect of tidal force, density variations, wind driven, slope differences, coriolis effect and current of Oman Gulf. It is known that surface current in the Arabian Gulf seem to be counter clockwise, moving along the Iranian side in the north west direction and recessing along the Arabian side in the south east direction. This movement cause a density current driven along Iraqi coast (Hunter, 1986).

Density differences resulted from Shatt Al – Arab River runoff in the Arabian Gulf provided force to generate currents.

In the Iraqi marine water, in addition to the density current. Caused by evaporation and high water temperatures. These density driven currents are strong and effective but seasonally variable. Shatt Al-Arab River flow in the northern Arabian gulf induce a cyclonic circulation there that would otherwise be anticyclonic (Al-Mahdi & Abdullah, 1999).

Reynold, (1997) postulated the northern Gulf circulation is predominantly wind driven, this is a true case since north western wind is dominant in the area by more than half of the year (55%). These winds are attended oriental the waves and the surface current to north east direction (Purser and Seibold, 1973).

Because there is available data of currents at Fao station, Current Speed(m/sec) are drawn with partial depth(z/h) of the water column as shown in Fig. (5).

Generally this figure shows that the speed values during the high discharge more than during the low discharge. During the high discharge, ebb speed



values are great than the flood. The maximum ebb and flood speeds were of order of 1.6, 0.8 (m/sec) respectively. These high velocities were noted near the surface layer only which extend from the surface to $z/h = 0.25$.

The ebb and flood duration are close to 8 and 5 (hours) during the flood season. Widely, the fashion of the speed distribution seem to be widely homogenous from the surface to the bottom, with the exception of the typical ebb period.

While, during the low discharge the status will be mutata. Figure (5) infers that the flood speed values are more than during the ebb. This figure shows that there is a conspicuous gradient in speed values at both phases of tide. The values of the flood speed are crecive with the depth which were closed to 1.0 m/sec.

Whereas, the maximum ebb speeds was recorded near the surface of order of 0.8 m/sec. which is decreasing with the depth.

The strong tidal currents of Khor Abdullah and the rest of Iraqi waters provide good turnover of water masses, flood tide current in general are faster than ebb currents .

However the flood and ebb tide current velocity in Khor Abdullah are strong and reach speeds of order of (1 – 2) m/sec.

Conclusions:

- 1-Tidal ranges are large in the Iraqi marine water being over 2.5 meter in the open water and reaching occasionally over 4.0 meter to land ward (Um Quser) during spring tide.
- 2-Salinity fluctuations are basically influenced by the fresh water discharge. Whereas, the others parameters such as precipitation, evaporation and phase of tide are less degree affect on salinity distributions.
- 3-The highest salinity was recorded at Khor Abdullah station over the study year and the surface salinity near the shore is more than offshore, especially during the summer season which outreach 40‰
- 4-There is no significant vertical salinity gradient at all stations during the typical Spring and neap phases. But longitudinal salinity gradient is very clear between the head the estuary (Fao station) and the mouth of it (Outer Bar station).
- 5-The highest (32.7 C°) and lowest (15.2 C°) values of the surface water temperature were recorded during the summer season (Aug., month) and winter season (Jan., month) at Fao and Outer Bar stations respectively. So, seasonal temperature differences play major role in the fluctuation of salinity especially during summer months .
- 6- Currents in the Iraqi marine water are complex, but the most majors factor are tidal current which provide good turnover of water masses.
- 7-Tidal currents in Khor Abdullah station during the flood are faster than

the ebb. While, in Fao station the ebb speed values are great than the flood speed during the high discharge and the status mutates during the low discharge.

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بعض معالم الأقيونوغرافيا الفيزيائية للمياه البحرية العراقية

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المستخلص

المياه البحرية العراقية تشغل جزءا هاما من مياه مصب شط العرب شمال الخليج العربي. مركبات المقومات المدية المسجلة في محطات السد الخارجي (M2, S2, K1, O1) من مرتبة 0.46, 0.18, 0.66 و 0.26 مترا على التوالي. إن نمط نظام المد والجزر في المياه البحرية العراقية هو من نوع النمط المختلط الذي يسوده النصف اليومي حيث يتراوح مدى المد والجزر فيها ما بين 1-3 متر. قيم الملوحة المسجلة في منطقة الدراسة تتراوح ما بين 0.4‰ الى 39‰ والتي تتأثر بعاملين اساسيين هما تصريف شط العرب وحالة المد. درجات حرارة المياه السطحية تنذبذبا خلال فصلي الشتاء والصيف والتي تصل الى 12.5 و 33.5 م° على التوالي. لوحظ في منطقة الدراسة منحدر ملحي وحراري ويعتمد ظهوره على فصل الجريان وطول فترة المد. تتأثر المياه البحرية العراقية بالعديد من التيارات كالتيار المدي والتيار الكثافة والتيار الرياح والتيار الخليج العربي والتيار المتولد بفعل ظاهرة كوريوليس، إلا ان تيارات المد والجزر هي السائدة في منطقة الدراسة والتي تتراوح سرعتها ما بين 0.8 الى 2.0 م/ثا

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