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SOME OCEANOGRAPHIC MEASUREMENTS IN THE GULF WATERS AROUND QATAR PENINSULA

By

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ABSTRACT

During the winter of 1979/1980 four cruises were made to the study area. Salinity, temperature and current speed and direction were measured. The areal distribution, as well as the vertical distribution of these parameters and the factors which affect them, are discussed. Fresh water seepage, dissolution of evaporitic deposits and desalination plants, together with evaporation, affect the vertical and horizontal distribution of salinity. Variations in water temperature are mainly due to solar heating. Current system may be mainly wind driven. Tides and bottom configuration may have decisive influence on it.

INTRODUCTION

The Arabian Gulf is a very shallow semi-enclosed basin with an area of about 240,000 sq.km and an average depth of only 35m. It connects with the Gulf of Oman through the narrow Strait of Hormuz, which has a maximum depth of 100m.

The Gulf is the drainage basin for almost the whole of Arabia and Iraq and a large part of Syria, Turkey and Iran. Most of these areas are very arid and small amounts of fresh water flow into the Gulf at Shatt Al-Arab, where the Tigris, Euphrates and Karun rivers discharge their waters. Rainfall into the Gulf very seldom exceeds three inches/year. Evaporation from the Gulf is much greater than the fresh water influx (about 50 inches/year), and thus, there is a net flow of water fom the Indian Ocean into the Gulf through the Strait of Hormuz (Sverdrup *et al*; 1942). The inflowing water moves slowly over the surface of the gulf towards its margins, where it becomes more concentrated due to intensive evaporation. Increasing density eventually causes it to sink to lower levels, where it flows out again below the incoming water. The density on the sea water in the open ocean is primarily a function of temperature and, to a lesser extent, salinity. However, in the Gulf salinity is much more important, due to the very large evaporation rates, which occur in the region (Sugden, 1963).

Several authors have given values and distribution maps of salinity and temperature in the Arabian Gulf (Schott, 1908; Schultz, 1914 and Emery, 1956). Emery (1956) prepared the first adequate maps from data obtained in August 1948.

The area around Qatar Peninsula has been the subject of sveral geological and sedimentological studies (for complete bibliography, see Beltagy, 1981). However, except for the bays of Salwa and Bahrain, west of the peninsula, hydrographic studies of the Gulf waters around Qatar are lacking.

This study invesigates the circulation of the Gulf waters around Qatar through some measurements, taken during the winter season 1979-1980.

SAMPLES COLLECTION AND METHODS OF ANALYSIS

Measurements at the study area east of Qatar Peninsula were made during the period of November 1979 - February 1980. Water samples were collected, using an insulated plexiglass water sampler, at , 5, 10 and 15 meter depths. When waterdepth allowed, samples from 25m depth were also taken. Additional samples were collected from the near shore waters west of Qatar.

Water temperatures were recorded in the field. Salinities of the samples were determined, using an inductive salinimeter.

Velocity measurements were made at 0.5 and 5.0m depths, using a Braystoke direct reading current meter. The recording time varied between 5 and 15 minutes. Figure 1 gives locations of the oceanographic stations, that were occupied during the present study.

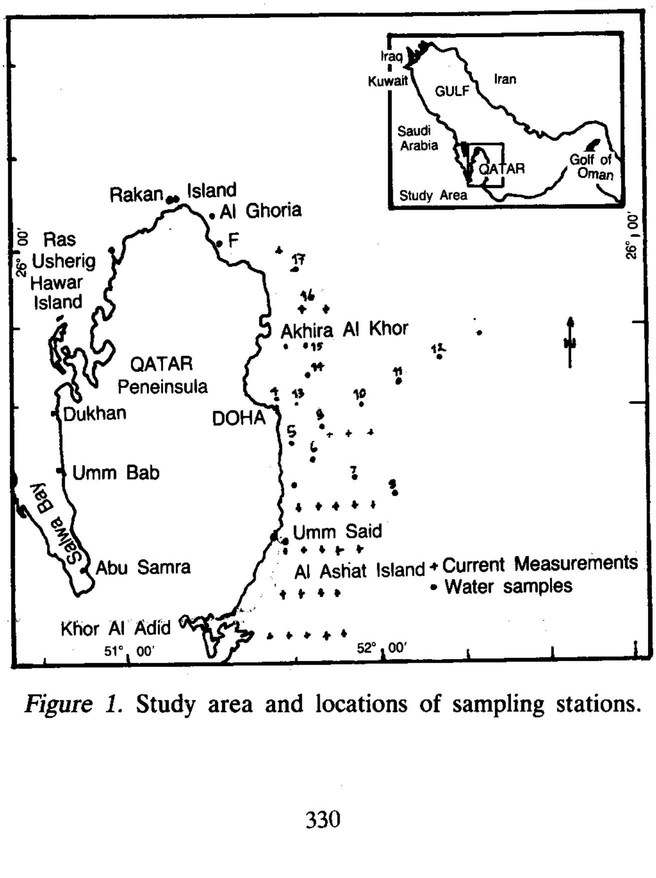

Figure 1. Study area and locations of sampling stations.

RESULTS

a. Salinity

The areal distribution of surface salinities is shown in Figure 2. From the distribution, it is evident that the salinity of the waters in the north-eastern part of the area is much lower than the salinity of the waters in the southern and south-western parts of the area. Along the section between Halul Island and Doha, the surface salinities increased progressivley from $40.40^{\circ}/_{oo}$ at Halul to $42.19^{\circ}/_{oo}$ near Doha. Salinities also increased from $40.67^{\circ}/_{oo}$ at station 17 in the north to $42.50^{\circ}/_{oo}$ at station 1 in the south. At station 3, a maximum salinity of $45.05^{\circ}/_{oo}$ was recorded. The surface waters in the vicinity of staion 3 had higher slainities than any other area east of Qatar.

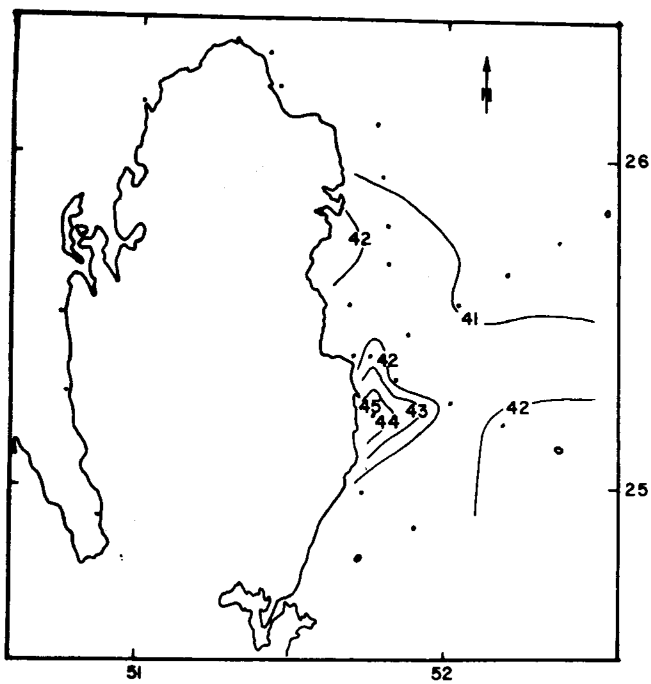

Figure 2. Distribution of surface salinities (salinity in ppt).

Towards te open Gulf, the coastal water at Al-Gharia had high salinities of $44.0^{\circ}/_{oo}$. The salinity of the coastal waters increased to the west.

West of the peninsula, from the Bay of Salwa northward to the open Gulf, the water had much higher salinities than the Gulf waters east of the peninsula. At Abu-Samra in the south, the water had a salinity of $58^{\circ}/_{oo}$. It decreased gradually northward, where salinities of $55^{\circ}/_{oo}$, $53^{\circ}/_{oo}$ and $46^{\circ}/_{oo}$ were recorded at Umm Bab, Dukhan and Ras Usheirig, respectively.

The areal distribution of salinities at a depth of 5m showed patterns quite different to those of the surface salinities (Figure 3). The salinities off the east coast of Qatar increased from north to south. North east of Doha, a pocket of low salinity was observed (lowest salinity of 39.48‰ was measured at station14). The reason for this lower slainity water in unknown.

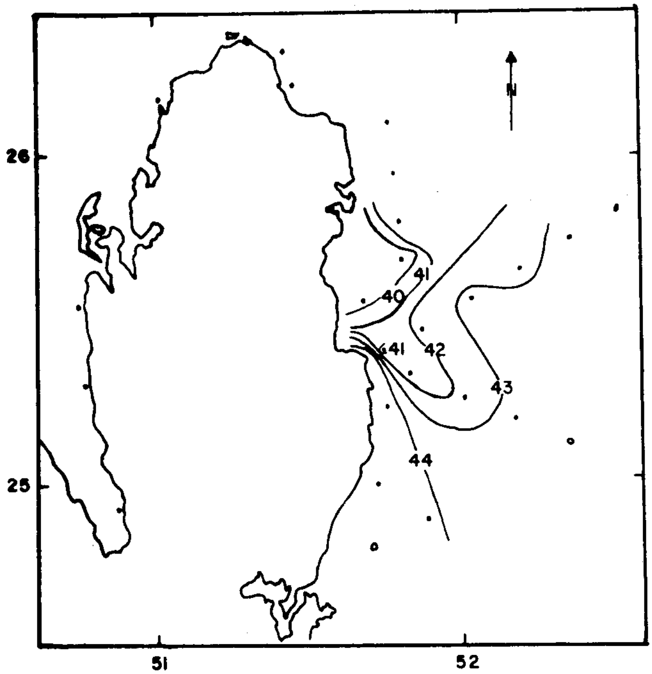

Figure 3. Distribution of salinity at 5m depth (salinity in ppt).

At the 15m depth, a tongue of high salinity wter invaded the region southeast of the penisnula. The highest salinity measured in this water body was 56.9‰ in what seemed to be a small shallow trough, which lies in the area between Doha and Halul Island.

The effect of the low salinity water, observed at a depth of 5m at station 14, which was shallower than 15m, was not detected in any other station, except probably at station 13, where a salinity value of 41.0% was measured (Figure 4).

b. Temperatures

Water temperatures in the area showed little change during he winter of 1979-1980 (Figures 5 and 6). Temperatures varied between 20°C and 22°C and in general increased south-wards and east-wards. Near shore, water temperatures were about 20°C and did not vary with depth. South of Umm Saiid, the water temperatures were uniform, both at the surface and at 15m depth; the temperature recorded was 21°C.

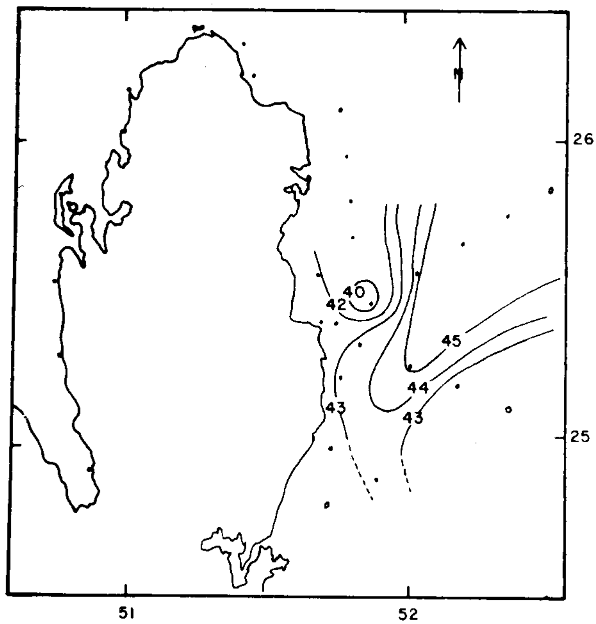

Figure 4. Distribution of salinity at 15m depth (salinity in ppt).

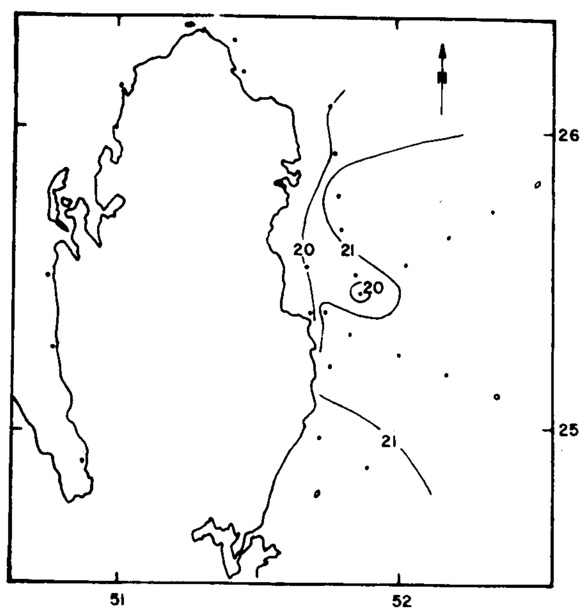

Figure 5. Distribution of surface water temperatures (Temp. in°C).

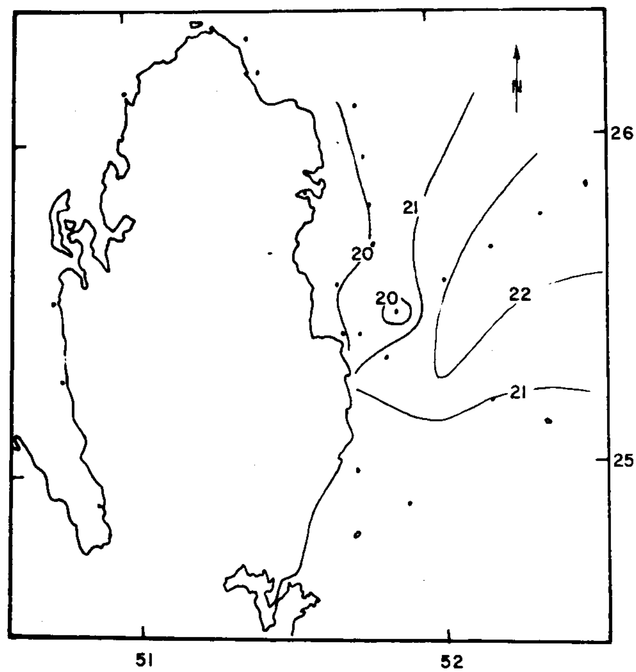

Figure 6. Distribution of water temperature at 15m depth (Temp. in °C).

At the 15m depth a tongue of relatively warm water (22°C) appeared. It appeared in the same area, occupied by the high salinity water. Between Doha and Halul Island, at station 9, was a lens of colder water witth a temperature of 20°C.

c. Current Measurements

Current measurements were carried out between Ras Laffan and Khor Al-Adid along lines, extending up to 20km east-wards from the coast. Figures 7 and 8 show the current regime in the area at 0.5 and 5m depth, respectively.

Currents in the area showed marked variations, both in velocity and direction from one station to another. These variations were more pronounced in the southern part of the study area and particularly at 5m depth.

The most conspicuous trend was a surface current, moving almost parallel to the coast; the width of this stream became narrower to the south, where it was restricted to the coastal 7km south of Doha. The outer boundaries of this current exhibited perturbations which varied from a few degrees of deflection to complete reversal of flow. The current speed at the 0.5m depth was between 4.7cm/sec. and 58.1cm/sec.

Figure 7. Current directions at 0.5m depth.

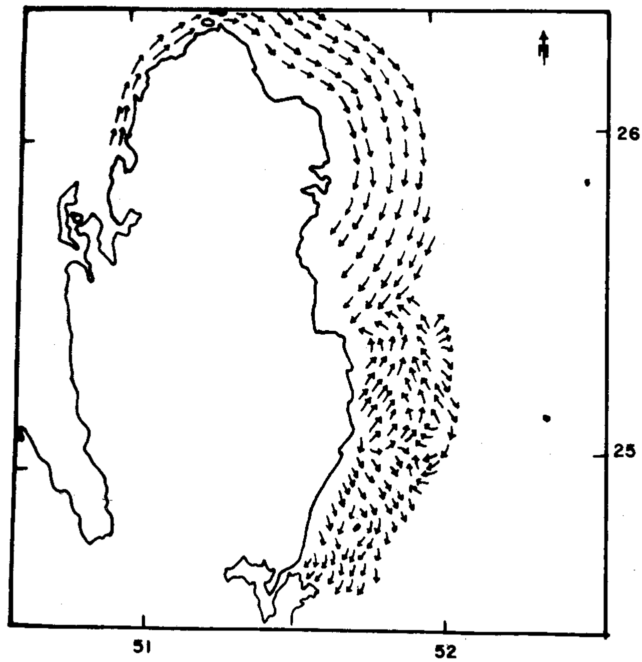

Figure 8. Current directions at 5m depth.

The southward moving coastal current is reduced in extent south of Doha. The current in general had a very complicated pattern, which can be attributed to the irregular bathymetry of this area. The current speed at the 5m depth varied between 15.7cm/sec and 56.2cm/sec.

Currents in the northern part of the area invariably had lower velocities than currents in the southern part.

DISCUSSION

The average salinity of ocean water is about 34.6‰ and rarely reaches values greater then 36.3‰. The salinities of Gulf waters in general are much higher than this value, with 60% of its waters having salinities greater than 40‰. The area around Qatar Peninsula and U.A. Emirates Coast in particular have the highest salinities in the Gulf region (Beltagy, 1981). This can be attributed to high rates of evaporation, which occur in semi-enclosed areas with restricted water exchange, like the area between Qatar and Bahrain. Coral reefs between Bahrain and Qatar act as a barrier, which restricts the water exchange between Salwa Bay and the Gulf proper. Water enters the Bay of Salwa, mainly through the Bay of Bahrain. However, depending on the wind effect, surface waters may enter the Bay west of Qatar Peninsula to the north Howar Island.

This is indicated by the gradual decrease of salinity moving northward from Abu-Samra to Ras-Usheirig. However, the very high salinity of 58‰, found at Abu-Samra, pointed to the fact that the flushing rate of Salwa Bay is relatively slow.

High salinities of the waters on the tip of Qatar may be the result of the mixing processes between the open Gulf water and the outgoing waters from Slawa Bay. This is indicated by a gradual change in salinity along the West Coast. It may also have resulted due to evaporation processes in local shallow khors and lagoons; their water could spread out from time to time and affect the whole water body in the area.

The area east of Qatar is open to the Gulf. Bottom topography in the southern part, however, plays an important role in the water exchange process between the coastal waters and the Gulf proper. It also has a major influence on the current regime of the area. The high rate of evaporation can also be observed in the area east of Qatar. Salinity increases away from the Gulf proper and in areas of restricted water exchange, as Al-Khor, where salinity of 43.0‰ was observed.

Unlike the area west of Qatar, where evaporation and water exchange are the main factors which affect the water's salinity, the area east of Qatar is influenced by several other factors. First are the brines discharge from the major desalination plants south of Doha. These brines spread out on the surface, covering a relatively large area with salinities averageing up to 45.05‰.

This water, due to its higher density, sinks to deeper layers. Vertical mixing, coupled with a net drift with currents moving south-ward result in a subsurface layer of salinity of about 44‰ at 5m depth. At deeper depths, the salinity is diluted and at a depth of 15m the salinity is only 43‰. As can be seen in Figure 2, the effect of the brines is not limited to the nearby areas, but extends to the whole area south of Doha.

The second factor influencing salinity is the fresh water seepage in the area south east of Al-Khor. At staion 13 and 14 at a depth of 5m, salinities of 39.48‰ were measured.

Evidence of this fresh water influx comes from:

i) decrease in salinity at 5m depth at stations 13 and 14 from the surface salinity at the same stations (41.13‰ and 41.15‰ respectively),

ii) negative values for hydrogen isotope, D_2 measured for this area (Beltagy, 1981),

iii) mangrove swamps appear along Zakhira near these stations.

The amount of fresh water influx, its characteristics and the location of the spring are yet to be determined.

The third factor, which affects the salinities of this region, are the bottom water of the central area. Bottom waters at station 11 and 12 had salinities of 56.9‰ and 52.3‰ respectively. This bottom water spreads, as a tongue of warmer saline water over the south-eastern part of the area. Waters with such high salinity seem to be anomalous to this area. However, this phenomenon may be explained as a function of:

i) evaporation of water at the surface, followed by sinking of this water to deeper levels, or

ii) the presence of some evaporite deposits on the bottom of the sea at this area; dissolution of these evaporites leads to the formation of high salinity bottom water.

The existance of this high salinity waters at the bottom, without a gradual increase of salinity from the surface to the bottom, favours the second hypothesis. Thus, the water with higher salinities produced at the bottom, could only move as creeping layer on the bottom. Its higher density, may act as a barrier and inhibit mixing processes between this layer and the upper water masses.

Water temperature during the period of study showed a simple pattern, where isotherms were parallel to the coast and increased in temperature in a seaward direction. Temperature throughout the water column was uniform, probably due to mixing.

Current regime in the area has a rather complex nature. The prevailing wind, which is mainly N-NW direction and attains a force between 7 and 10 on Beaufort scale during he winter months, supply much of the energy which drives the surface water movements. The speed of surface currents set up by winds is about 2% of the speed of the wind which caused them; in shallow waters, wind generated currents are not deflected as much as predicted theoretically for an infinitely deep ocean. Throughout most the year, however, the wind speed rarely exceeds 20 knots in a north-easterly direction. This creates a current, which moves towards the south and southwest. This current is greatly affected by the tidal currents in the area, which, in narrow khors, attain a speed of more than 3 knots.

More complications are introduced due to the very complicated topography of the bottom in this very shallow area. This can be seen in the southern part of the area, where several islands and coral batches occur. These subsurface outcrops deflect the water current at shallow depths, causing the current pattern shown on Figure 7. Density currents, due to difference in water salinity, also exist. At Khor Al-Adid; this is particularly true, where strong surface currents move into that area, while a relatively week current outflows from it. Bottom topography and the configuration of the coast also affect the speed of currents; the surface currents, close to the shore in the southern part of the area (Figure 8) and higher speeds than the surface current in the northern area.

The current systems in the area proved to be very important, regarding the oil slick movement in the Qatari waters (Beltagy, 1980). It is also a very important factor in transporting and distributing other pollutants. Detailed study of the current systems in the area is urgently needed.

CONCLUSIONS

The salinity distribution in the area of study is very complex, due to high evaporation rates, fresh water seepage, dissolution of evaporitic desposits and brine discharge. All these factors affect the vertical and horizontal distribution of salinity.

Water temperatures during the cold season showed a simple pattern, where isotherms were parallel to the coast and variations were mainly due to solar heating.

The current systems in the area could be primarily wind driven; the speed and direction were largely affected by tides and bottom cnfiguration. The movement of the oil slick during Hasba 6 oil spill followed faithfully the curent movements in the area.

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ونظراً لعدم وجود أي تدرج في الملوحة بين السطح والقاع فانه من المعتقد ان هذه الطبقة من المياه قد تكونت نتيجة لذوبان بعض الرواسب الملحية من قاع الخليج في هذه المنطقة .

أما بالنسبة لدرجات الحرارة فقد لوحظ ان توزيع درجات الحرارة يتميز بالبساطة ويعكس تأثير التسخين الناتج من أشعة الشمس ومواعيد تسجيل القراءات . ويلاحظ أن درجة الحرارة تزداد كلما اتجهنا من الشاطىء إلى داخل البحر وتبلغ درجة الحرارة في المياه الشاطئية حوالي ٢٠مْ تزداد إلى ٢٢مْ بعيدة عن الشاطىء وفي المياه العميقة نسبياً .

أما التيارات في المنطقة فقد لوحظ أن سرعة التيار تتراوح بين ٥ر٩ ، ٥ر٥٦ سم/ثانية وان اتجاه التيار الغالب هو شمال/جنوب ويكون التيار في هذا الاتجاه بعرض ٢٠ كيلو متر تقريباً في المنطقة شمال الدوحة يضيق إلى أقل من ٧ كيلو مترات جنوب الدوحة إلى خور العديد حيث تتعقد صورة التيار في هذه المنطقة بدرجة كبيرة جداً لوجود بعض الجزر والشعاب المرجانية والكثبان الرملية تحت سطح الماء مما يؤثر على سرعة واتجاه التيار . وقد لوحظ أن تحركات بقعة الزيت التي حدثت في شتاء ١٩٨٠م تتبعت بدرجة كبيرة جداً تحركات المياه في المنطقة من حيث السرعة والاتجاه .

بعض القياسات الاقيانوغرافية في مياه الخليج العربي حول شبه الجزيرة العربية

علي إبراهيم بلتـــاجي

في خلال شتاء ١٩٨٠م تم جمع عينات من مياه الخليج حول شبه جزيرة قطر كما أخذت قياسات لكل من درجات الحرارة وسرعة واتجاه التيار . وتشير نتائج الدراسة إلى أن درجة ملوحة المياه في الجانب الغربي من شبه الجزيرة القطرية أعلى بكثير من درجة الملوحة شرق شبه الجزيرة حيث بلغت درجة الملوحة في منطقة خليج سلوى ٥٨٫٠٠٪ في حين أن درجة الملوحة السطحية شرق الجزيرة بلغت اقصاها بالقرب من الدوحة وكانت ٤٥٫٠٥٪ وتعزى زيادة الملوحة في منطقة خليج سلوى إلى ارتفاع معدل التبخر في هذه المنطقة والذي يضاعف تأثيره بطء عملية تبادل المياه بين الخليج العربي نفسه ومنطقة خليج سلوى عبر خليج البحرين . أما في المنطقة شرق قطر فان ملوحة المياه تختلف من مكان لآخر ومن عمق لاخر فأعلى ملوحة على السطح وهى ٤٥٫٠٥٪ والتي تم تسجيلها في المنطقة المواجهة لمدينة الدوحة مباشرة تقع بالقرب من محطات اعذاب المياه . وتقل الملوحة السطحية كلما ابتعدنا عن هذه المنطقة وقد اعزى وجود هذه الملوحة العالية إلى تأثير المركزات التي تلقيها محطات الاعذاب إلى البحر .

وعلى عمق ٥ متر سجلت أقل ملوحة في المنطقة جنوب شرق منطقتي الخور والذخيرة حيث بلغت درجة الملوحة ٣٩٫٤٨٪ .

وتشير الدلائل إلى أن هذه المنطقة تتأثر بانسياب المياه الجوفية قليلة الملوحة من قاع البحر على هذا العمق ومن ثم تنتشر بعد ذلك ليظهر تأثيرها في مناطق أخرى قريبة منها على السطح .

وعلى عمق ١٥ متراً لوحظ وجود مياه قريبة من القاع تتميز بدرجة ملوحة عالية ٥٧٫٠٠٪ في المنطقة الواقعة بين الدوحة وجزيرة حالول .

علـــوم البحـــار