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Development of water stratification at the middle section of Shatt Al- Arab River, Basrah –IRAQ

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Abstract

Two stations, Al-Mehala and Al-Baradyea, at the middle section of Shatt Al-Arab river, detect water stratification formation. Turbidity, electrical conductivity, dissolved Oxygen, sodium ion, and chloride ion concentration were measured in both stations during tide and ebb at surface and bottom layers, from July 2019 to June 2020. The current results showed that the turbidity values ranged between (2-70) NTU, the electrical conductivity ranged between (5.54-2.91) µs /cm, and the dissolved oxygen results ranged between (2.7-6.2) mg/l, the results of the chloride ion ranged between (450-3649) mg /l, and Sodium results ranged between (309.11-1165.83) mg /l. Turbidity values were higher at both stations in the bottom layer at tide and ebb face due to the current of the Gulf salt wedge. At Al-Mehala station, weak halocline and chemocline developed due to stratification between surface and bottom layers. Higher sodium and chloride ions concentrations were detected at the bottom layer during tide and ebb compared to the northern station at Al-Baradyea. Stratification (Halocline) appeared during tide and disappeared in ebb at Al-Mehala station. AL-Baradyea station could represent the end effect of the Gulf salt wedge. The Arabian Gulf salt wedge extended in the Shatt Al-Arab river to cover the Al-Mehala station about 80 km to the north of the Arabian Gulf.

Key words: stratification, tidal, Shatt Al-Arab river, salt wedge, arabian gulf

1. Introduction

Shatt Al-Arab river formed by the confluence of Tigris and Euphrates rivers at Qurna city and continue to the South-west to empty in the Arabian Gulf. The Shatt river is the main source of freshwater for Basrah province besides its commercial and navigational importance for Iraq and Iran (Hussain *et al*., 1991).

The Shatt water parameters is a result of the physical, chemical, and hydrological of its tributaries (Jawed, 1994 and Rahi, 2018); they concluded that the decrease in freshwater discharge from the Shatt tributaries was the main cause of the gradual increase in salinity to reach a level similar to the Shatt estuary.

The Shatt environment suffers from several problems, mainly the drastic decline in the freshwater discharge from Tigris, Euphrates, and Karun rivers led to an increase of water salinity, discharge of untreated domestic sewage, and oil pollution from boats and small tankers moored in the Shatt, as postulated by Douabul *et al*.(1987) and Atee (2004). Al-Ramadan and Pastour (1987), Abdullah (2002 & 2014) studied the tidal phenomena in the Shatt and the ranges of tide and ebb and concluded it is a semidiurnal one with tidal peaks during spring and neap tides.

Iriart *et al.*, (2007) review the stratification in rivers in general. Miller (2004) described four types of stratification, thermocline, halocline, chemocline and pycnocline. He stated that stratification worked as a barrier to prevent the passing or exchange of material between layers.

Due to the immense importance of Shatt Al-Arab River, a great deal of researches were done on in shape of thesis or research articles mainly on the flora and fauna, biological productivity , water parameters and pollution levels .

The aim of the present article to detect the development of water stratification in the middle section of Shatt Al-Arab river.

2. Material and method:

Shatt Al-Arab river is semidiurnal oligosaline tidal river .The length of the Shatt is 196 km with, and width varies 250m to 750 m at Al-Qurna and Al-Fao, respectively.(Abdullah, 1990 and Rahi, 2018). The Shatt is the major source of potable water to Basrah province and other agriculture, industrial and recreational activities (Hussain *et al.*, 1991).

Two station were chosen in the middle part of Shatt Al- Arab by using Geological Positioning System (GPS) type Garman 62s, Water samples were taken monthly by using horizontal water sampler, from July 2019 to June 2020 to examine the stratification status in the Shatt Al-Arab River .

Fig 1: GPS reading of the two stations **Al-Baradyea** and **Al**- **Mehala** at the middle section of Shatt Al-Arab river.

Monthly samples were taken from each station at the surface (20 cm below) and the second near the bottom, during ebb and tide to cuver the tidal cycle. Samples were kept in plastic bottle for further examination in the laboratory. Turbidity, electrical conductivity, Dissolved Oxygen. Na ion and Cl ion were measured according to APHA (2003).

Field measurements:

1- **Dissolved Oxygen (DO):** Field instrument type EXTECH was used to measure dissolved Oxygen in water; results were expressed in mg/l.

Laboratory Measurements:

1- Turbidity: Turbidity was measured by turbidity meter made of HANNA model LP 2000 and was calibrated by standard solution, samples were shacked before measuring the unit NTU (Nephelometric Turbidity Unit) .

2- Electrical Conductivity: Electrical conductivity was measured by mean of E.C. meter made HANNA model EC 215, results were express in (µs/cm).

3- Sodium ion: Sodium-ion was measured after the method of APHA 2003 by using Flame photometer model PFP7 made by Jenway Co. on wavelength 589nm.

4- **Chloride Ion:** Chloride ion was measured after the method of APHA, 2003.

Statistical Analysis:

In this paper, all Statistical Analyses were done, using SPSS software.

Station	GPS reading
Al-Baradyea	N: 30° 30' 13 , E: 47° 51' 27
Al-Mehala	N: 30° 28' 6 , E: 47° 55' 40

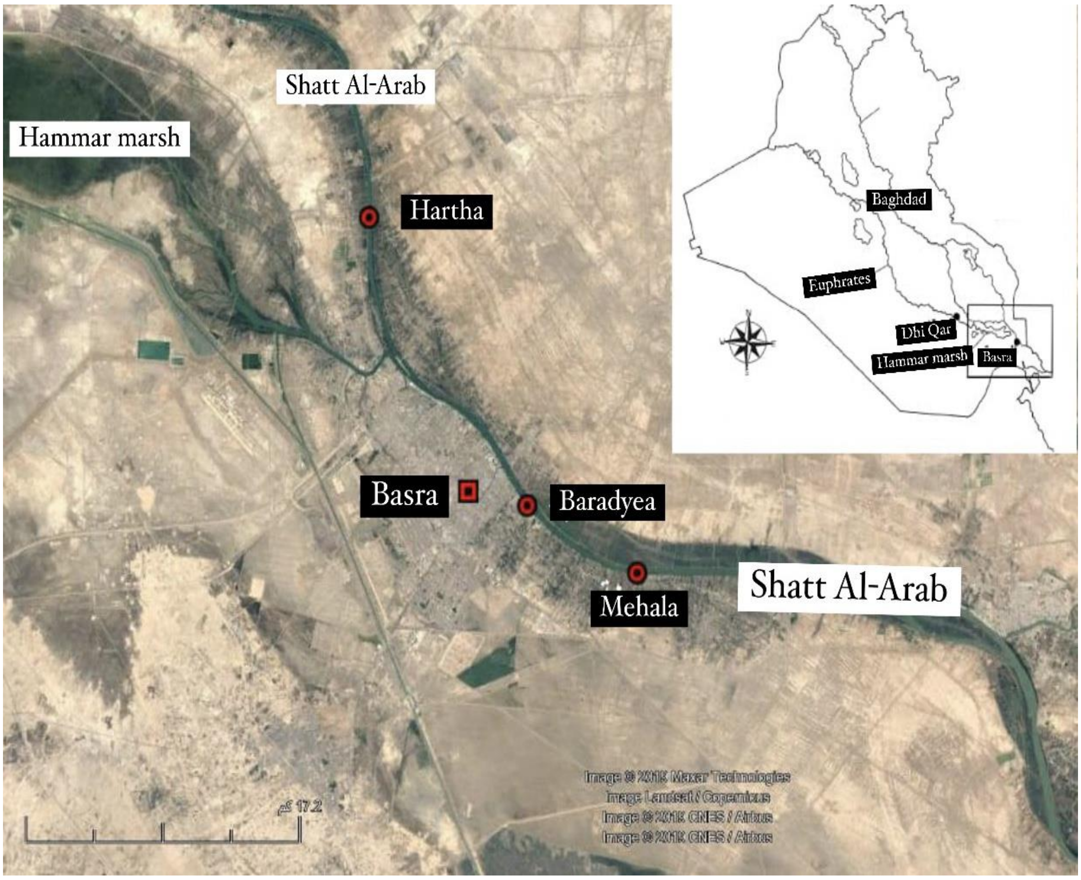

Fig 1: Map of the middle section of Shatt Al-Arab River showing the two stations, northern Al-Baradyea and southern Al-Mehala, south to Basrah city.

3. Results

1- **Turbidity**:

The lowest turbidity value was 2 NTU at surface in Al-Mehala station during tide in June 2020 and the highest was 70 NTU during tide at the bottom of Al-Mehala station. In both stations, values of the bottom layer was higher than the surface during ebb and tide (Fig.2&3).

Statistical analysis proved a significant difference between stations, months and surface and bottom samples during ebb and tide.

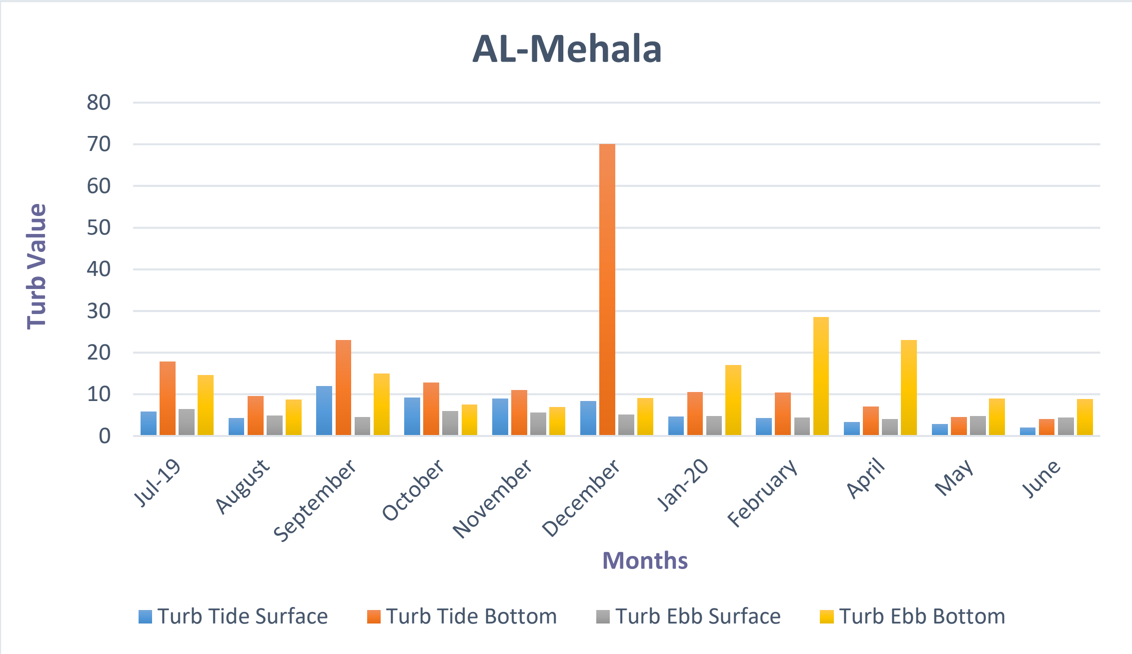

Fig 2: Monthly variations in turbidity (Turb) values recorded at surface and bottom layers in Al-Mehala station during the period from July 2019 to June 2020.

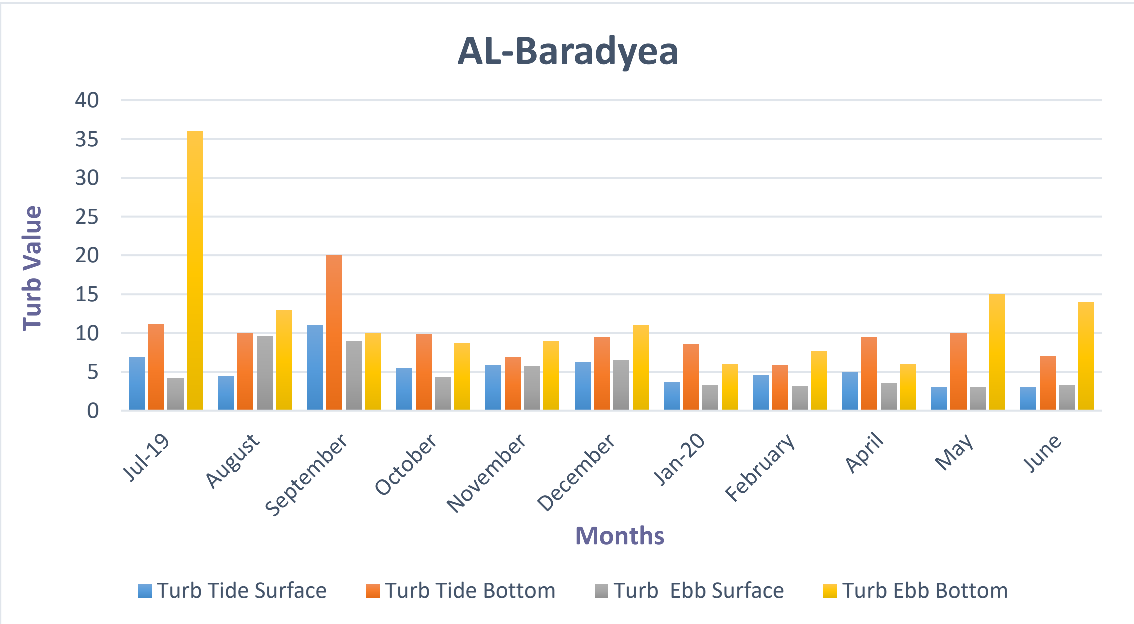

Fig 3: Monthly variations in turbidity (Turb) values recorded at surface and bottom layers in Al-Baradyea station during the period from July 2019 to June 2020.

2- Electrical Conductivity :

The highest electrical conductivity value recorded was 5.54 µs/cm at surface in Al-Mehala during ebb in January 2020. The lowest was 2.91 µs/cm at bottom in Al-Baradyea during tide in October. Statistical analysis proved significant difference between stations, surface and bottom samples during ebb and tide ($p<0.05$). Variation between surface and bottom layer were detected especially in Al-Mehala station at surface layer during July , August, September, October, December 2019 and January 2020 during tide and in August ,February, December and May at ebb. In Al-Baradyea station, surface layer values were lower than the bottom one in August , September, October, December 2019, January, February, May and June during tide.

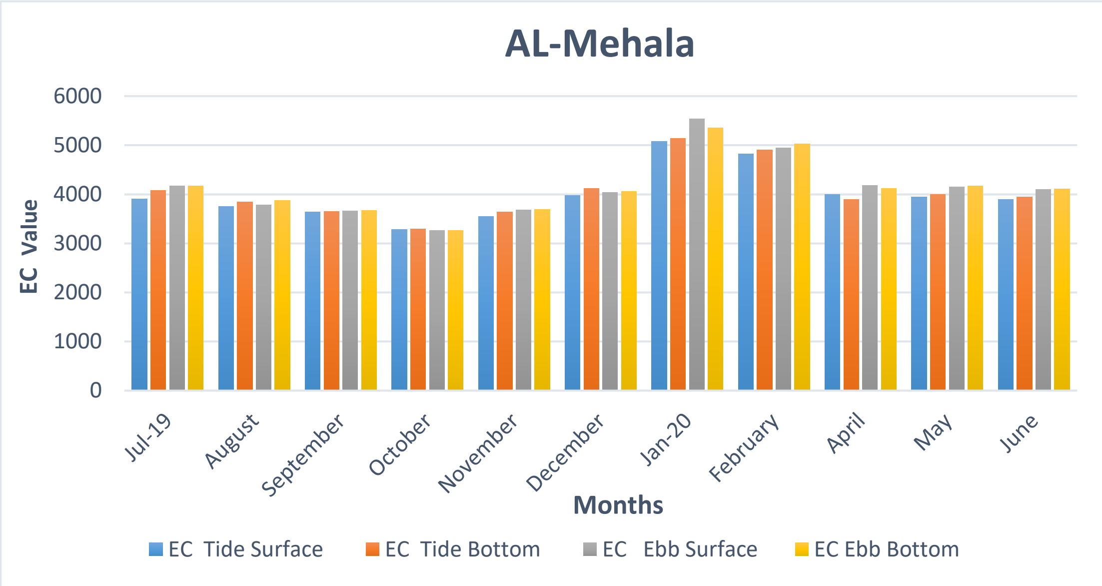

Fig 4: Monthly variations in electrical conductivity (EC) values recorded at surface and bottom layers in Al-Mehala station, during the period from July 2019 to June 2020

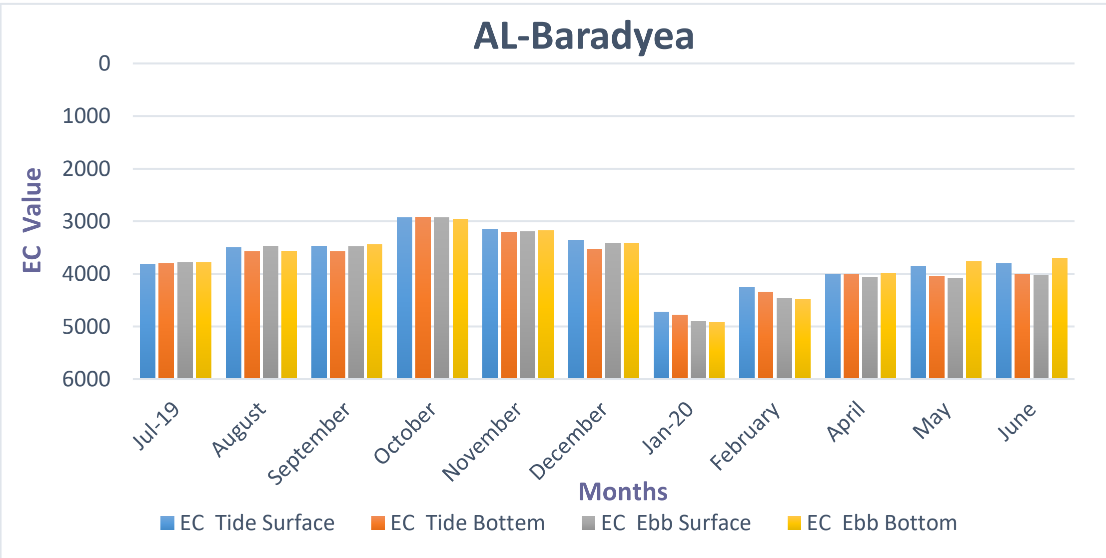

Fig 5: Monthly variations in electrical conductivity (EC) values recorded at surface and bottom layers in Al-Baradyea station, during the period from July 2019 to June 2020.

3- Dissolved Oxygen:

The highest dissolved oxygen value (6.2 mg/l) was recorded at Al-Baradyea station during tide in January and February 2020.The lowest value (2.7 mg/l) was obtained at the bottom of Al-Mehala station at ebb in August 2019**.** Dissolved oxygen values in Al-Mehala station showed a reversed trend where the surface layer was lower than bottom during tide in July ,August,September, October, December 2019 ,April ,May and June 2020 .In Al-Baradyea station surface values of DO were higher than the bottom layer in tide and ebb .

Statistical analysis proved a significant difference between stations and months ($p<0.05$), but not for surface and bottom samples during ebb and tide ($p<0.05$).

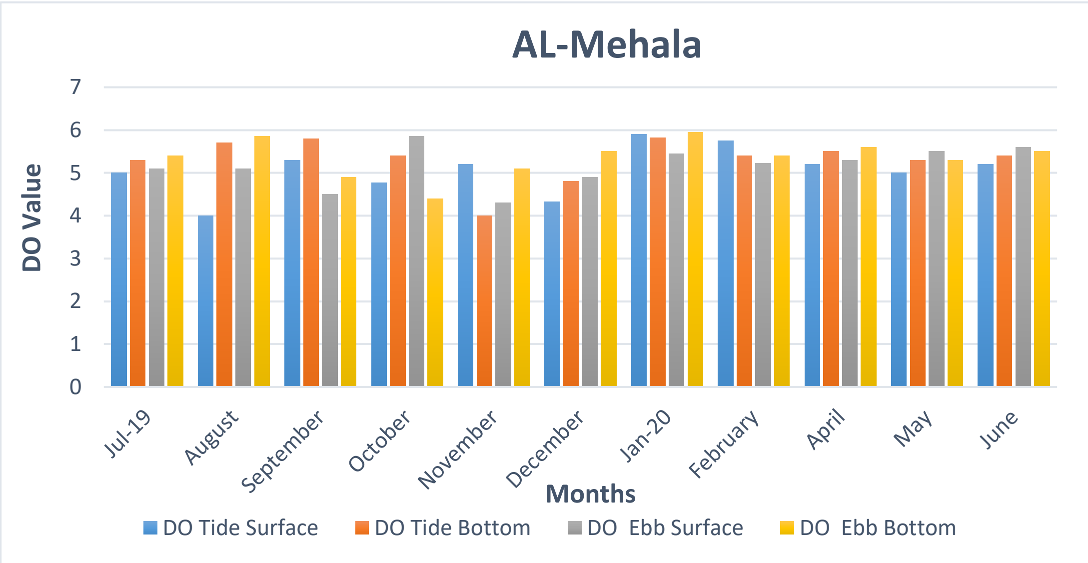

Fig 6: Monthly variations in dissolved Oxygen (DO) concentrations recorded at surface and bottom layers in Al-Mehala station, during the period from July 2019 to June 2020.

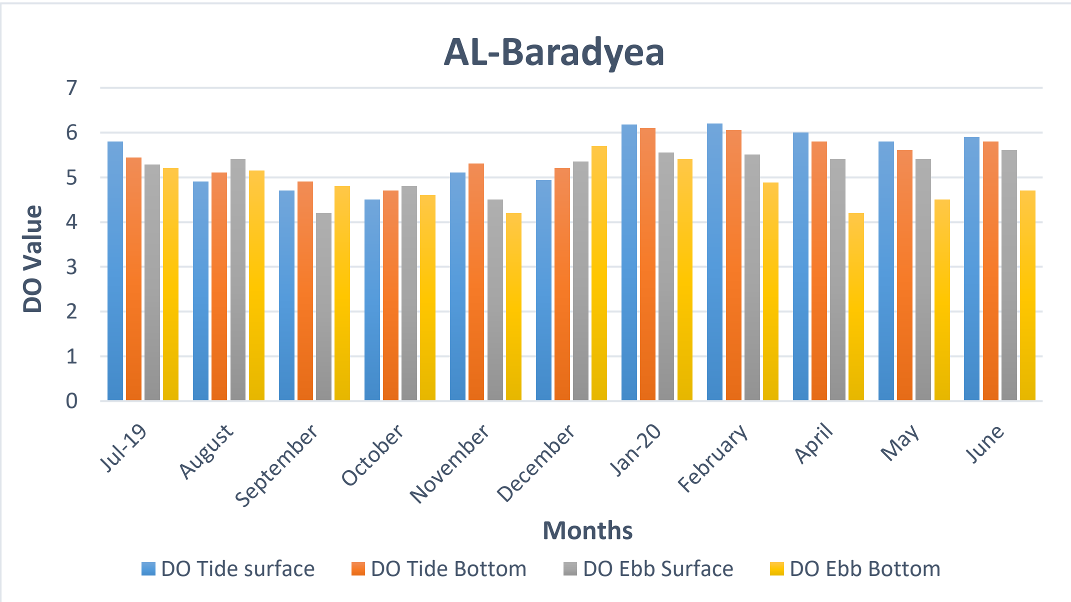

Fig 7: Monthly variations in dissolved Oxygen (DO) values recorded at surface and bottom layers in Al-Baradyea station, during the period from July 2019 to June 2020.

4-Sodium ion:

The highest sodium concentration was 1156.83 mg/l on surface layer in Al-Mehala at tide in June 2020 and the bottom layer in Al-Baradyea station in ebb during April and May. The lowest value 309.11 mg/l was recorded at bottom layer in Al-Baradyea during ebb in December 2019. In Al-Mehala station values of sodium ion at surface layer was lower than the bottom in tide and ebb in July, August and February. In Al-Baradyea station during tide and ebb, sodium values at surface layer was lower than the bottom one in September ,October ,December ,April,May and June.

Statistical analysis indicated seqenficant differences in monthly samples and between stations at level ($p<0.05$).On contrary no significant differences recorded between surface and bottom samples during tide and ebb (fig.8, 9).

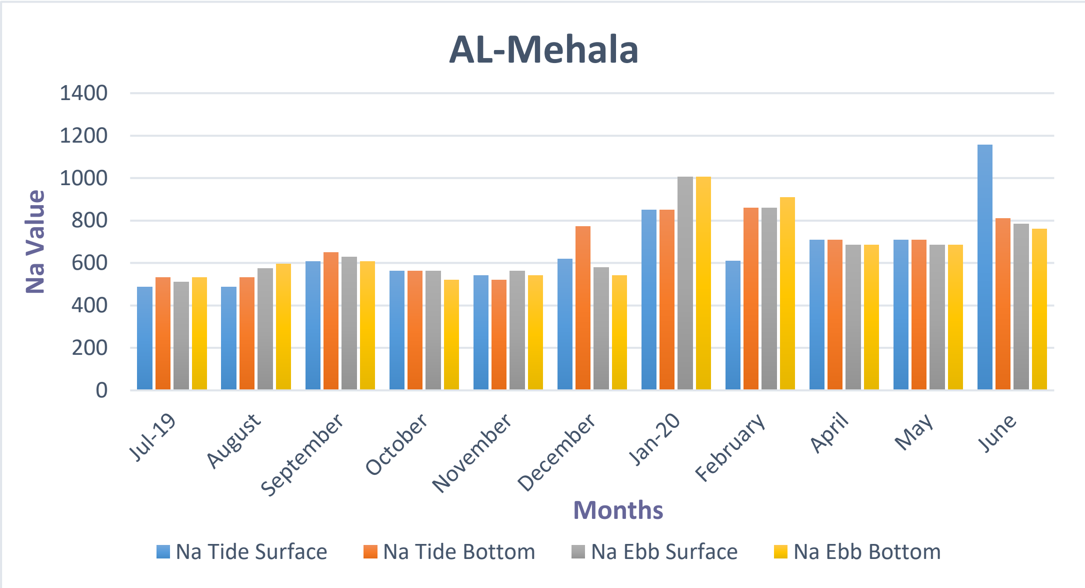

Fig 8: Spate-temporal variations in Sodium ion (Na) concentrations at surface and bottom layers in Al-Mehala station during the period from July 2019 to June 2020.

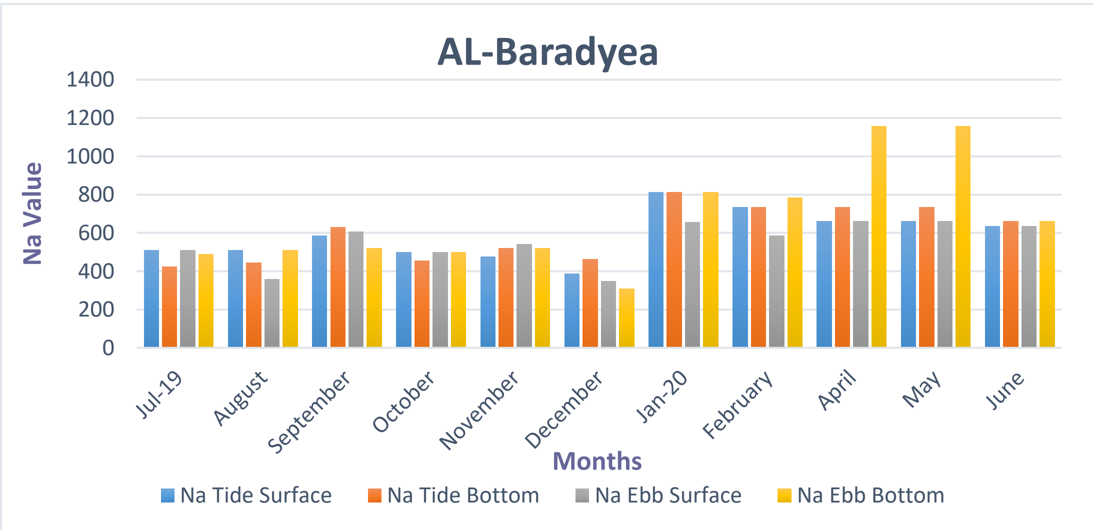

Fig 9: Spate-temporal variations in Sodium ion (Na) concentrations at surface and bottom layers in Al-Baradyea station during the period from July 2019 to June 2020.

5-Chloride ion:

The highest Chloride ion values was 3649 mg/l at surface layer in Al-Mehala station during ebb in January 2020 and the lowest 450 mg/l at the bottom layer in Al-Baradyea station during July 2019. Statistical analysis indicated significant differences in monthly samples and between stations at level ($p<0.05$).On the contrary, no significant differences were recorded between surface and bottom samples during tide and ebb (fig.10, 11).

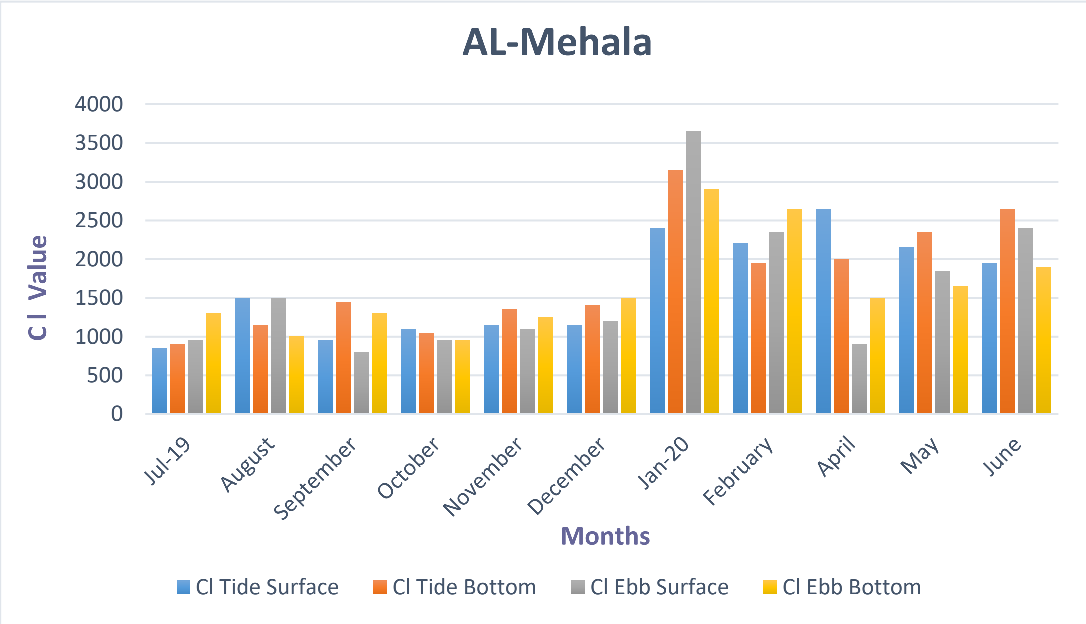

Fig 10: Spate-temporal variations in Chloride ion (Cl) concentrations at surface and bottom layers in Al-Mehala station during the period from July 2019 to June 2020

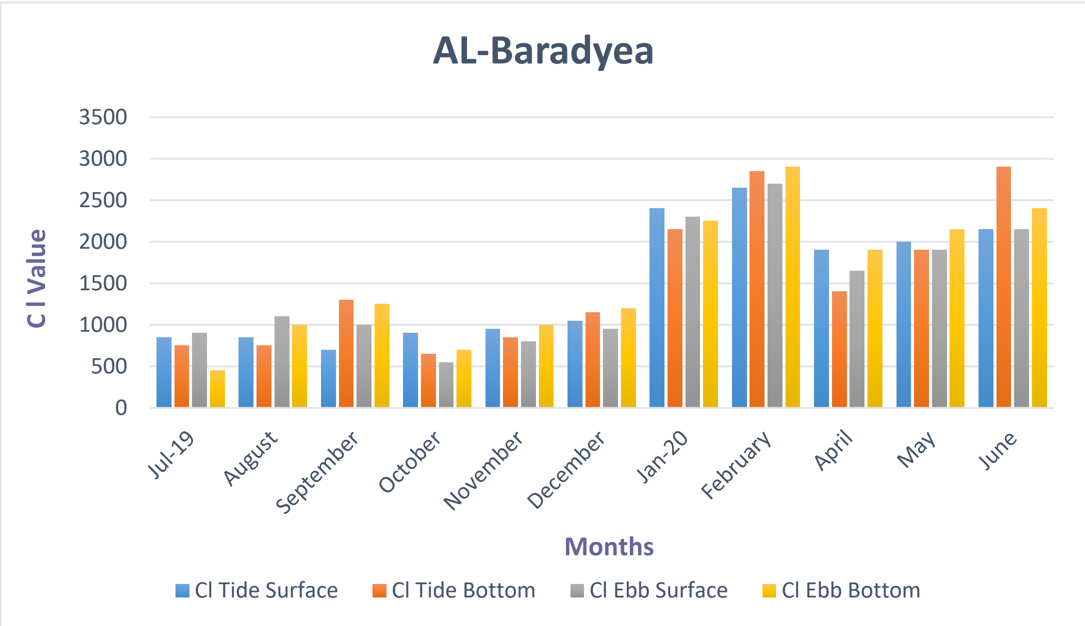

Fig 11: Spate-temporal variations in Chloride ion (Cl) concentrations at surface and bottom layers in Al-Baradyea station during the period from July 2019 to June 2020.

4. Discussion:

Mohammed (1965) concluded that Shatt Al-Arab river water column was uniformed thermally and chemically from surface to the bottom from Al-Basrah to Al-Fao and no stratification existed.

Later several surveys were conducted on the Shatt but unfortunately concentrated on the surface layer and at ebb. Water characteristics of Shatt water differ fundamentally depending on the tide periods, whether it is flood or ebb.

Recently the freshwater flow to Shatt Al-Arab from the tributaries declined substantially due to expansion in irrigation projects in Turkey, Iran, Syria and Iraq, leading to a decrease in freshwater flow and led to intrusion of the Gulf salt wedge inside the Shatt Al-Arab River, as demonstrated by Al-Mahmood *et al.* (2015) and Al-Tememi, *et al.* (2015).

Turbidity values increase in winter due to the increase in Shatt Al -Arab inflow from its tributaries and perception. High riverine discharge increase bank erosion and i.e. increase turbidity. Tidal current plays a major role in the resuspension of bottom sediments, ultimately increasing turbidity. Differences in turbidity values indicated the stratification status between the surface and bottom layers of the Shatt in different months and during tide and ebb periods. Higher turbidity values in both stations at the bottom layer in tide and ebb resulted from penetration of the Gulf salt wedge current, resulting in resuspension of bottom sediments.

Electrical conductivity values increased toward the Shatt estuary at the northwest of the Arabian Gulf as shown by Jassim (1999).due to advancing salt wedge from the Gulf. On the other hand, the release of untreated domestic sewage also contributed to this issue.

In the Al-Mehala station, weak halocline chemocline developed due to stratification between surface and bottom layers. Al-Mehala station displays a stratification case between surface and bottom layers in the Shatt Al-Arab river due to the variation in salinities between the surface and bottom layer.

Dissolved oxygen concentrations at Al-Baradyea station were higher at the surface than the bottom layers (opposite chemocline) could be due to the Shatt current flow on the surface and the weak effect of bottom salt wedge tidal current. In general, low dissolved oxygen values were recorded compared to that of Mohammed (1965), implying an increase in the deterioration of Shatt water quality.

Halocline developed in both Al- Mehala and Al-Baradyea stations due to lower sodium ion concentrations at the surface layer compared with the bottom one as an indication of Shatt stratification.

Chloride ion values increase as the Shatt water moves to the Gulf, mainly due to the decrease in flow of freshwater from the tributaries and advancing the Gulf salt wedge (Hussain *et al.*, 1991, Al- Hello *et al.*, 1997 and Al-Obaidy 1997). Generally, there is an increase in Chloride value compared to previous studies, implying an increase in the effect of the Gulf salt wedge.

Chemocline developed due to the difference between surface and bottom layers in Chloride value at Al-Mehala station. The surface layer values were lower than the bottom during tide and ebb periods. Chemocline also developed In Al-Baradyea at ebb period. The chloride values at the surface was lower than the bottom in eight months.

It seems that the Arabian Gulf salt wedge effect extended inside the Shatt Al-Arab river to cover at least the Al-Mehala station 80 km north from the Gulf. At the same time, the Al-Baradyea station been affected partially by the salt wedge. We concluded that the Shatt Al-Arab river is partially stratified depending on the tidal period every six hours. The physical and chemical properties of Shatt Al-Arab were changed accordingly.

We noticed that stratification appeared during tide and disappeared in ebb in Al-Mehala station as indicated by lower sodium values at the surface layer. AL-Baradyea station could represent the end of stratification as the sodium ion concentration was higher in the bottom layer than the surface one.

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تطوير التقسيم الطبقي للمياه في القسم الأوسط من شط العرب ، البصرة - العراق

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المستخلص:

اختيرت محطتي محيلة والبراضعيه في القسم الأوسط من شط العرب للكشف عن تكوين طبقات المياه وتم قياس العكارة والتوصيلة الكهربائية والأكسجين المذاب وأيون الصوديوم وتركيز أيون الكلوريد في كلا المحطتين أثناء المد والجزر في الطبقات السطحية والسفلية، خلال الفترة من يوليو 2019 إلى يونيو 2020. وأظهرت النتائج الحالية أن قيم العكارة بين (2-70) NTU، تراوحت قيم التوصيلة الكهربائية بين (5.45-2.91) ميكروسمنز/سم، وتراوحت نتائج الأكسجين المذاب بين (6.2-2.7) ملغم / لتر، وتراوحت نتائج أيون الكلوريد بين (3649-450) ملغم / لتر وتراوحت نتائج ايون الصوديوم بين (1165.83-309.11) ملغم/ لتر. كانت قيم العكارة أعلى في كلا المحطتين في الطبقة السفلية عند المد والجزر نتيجة لاختراق اللسان الملحي. تطور منحنى ملحي ضعيف في محطة المحيلة نتيجة للاختلاف بين الطبقات السطحية والقاعية. نتيجة للاختلاف التراكيز في أيونات الصوديوم والكلورايد في الطبقة السفلية أثناء المد والجزر مقارنة بمحطة البراضعية الشمالية. ظهر التطبق أثناء المد ويختفى جزئيا في الجزر في محطة محيلة. يمكن أن تمثل محطة البراضعية نهاية تأثير اللسان الملحي القادم من الخليج العربي. يبدو أن اللسان الملحي القادم من الخليج العربي امتد في شط العرب ليغطي محطة المحلة على بعد 80 كم شمال الخليج العربي.