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Studies on Salt Distribution in the Northern Part of Shatt al-Arab Waterway, Iraq

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Abstract: The study was conducted to determine the salt distribution in the northern part of the Shatt al-Arab, and knowing the factors that led to high salinity values in the study stations. Water samples were taken from six stations, Al-Ezz River mouth (which represents the influence of the areas surrounding the river's waters), Mezaira River, which represents the influence of the Tigris River (a comparison station), Al-Swaib, Al-Shafi and Karma Ali and Sinbad Island area (represents the combined effect of all study stations). Samples were during January, April, August and October represents winter, spring, summer and autumn respectively during 2018. Samples were taken at three sites of river cross section, right bank, middle of river, and left bank. Samples were taken from the surface layer of water, the middle of the water column and 1 m from the river bottom. The study showed the rise of the EC and TDS values towards the south of the Shatt al-Arab waterway, as the values for the general average for Karmat Ali and Sinbad Island stations was 12.47, 12.37 dS m^{-1}, 8108 and 8031 mg l^{-1}, respectively, caused by the saline tide coming from the Arabian Gulf, decreased values in stations in the northern part of the Shatt al-Arab, for Al-Ezz, Maziraa, Al-Swaib and Al-Shafi stations, and TDS values increased during the autumn season over the rest of seasons. The rise of the EC and TDS values for the right bank on the middle of the river and the left bank. The EC and TDS values increased for the surface depth compared to the other two depths.

***Keywords*:** Salinity, Electrical conductivity, Total Dissolved solids, Shatt al-Arab

Shatt al-Arab is one of the important rivers in Iraq, its agricultural, commercial, economic and social importance, supplies water for drinking, irrigation, hunting, transportation and various industrial uses, the link between the fresh water from the Tigris and the Euphrates and salt water from the Arabian Gulf and was formed by the confluence of the Tigris and Euphrates rivers in the city of Qurna, north of Basrah, about 90 km south of Iraq, runs towards the southeast towards the Arabian Gulf on the eastern side of the city of Basrah, a length of about 204 km farther "5 km in the Arabian Gulf (Nomas 2006), with a width ranging from (400-2000) m and narrowing to 500 m near the city of Basrah (Al-Maliki 2010), depth reaches 8-15 m (Al-Katib 1970). Characterized by the presence of the tidal phenomenon, which is a near-uneven daily extent and phase (Abdullah 2002). It depends on its fresh water from the Tigris and Euphrates rivers, the volume of water revenues of the Tigris River decreased from 48 km^3 $years^{-1}$ in the water year 1978-1979 to about 15 km^3 $years^{-1}$ in the water year 2010-2011 (Al-Asadi and Khalaf 2015). The revenue rate of Shatt Al-Arab in Al-Maqal decreased for the years 1948-1960 (23 billion m^3. $years^{-1}$), while its discharge under the Karon was 37.5 billion m^3 $years^{-1}$, the contribution of the Tigris, Euphrates, Al-Swaib, and Al-Ezz rivers was (26, 25, 25, and 24%) respectively in the waters of the Shatt al-Arab (Nomas 2006). The revenue of the Shatt al-Arab fell to 18.2 billion m^3. $year^{-1}$ during the years 1990-2000 (according to data of the Ministry of Irrigation, Water Resources Directorate, Basrah), Shatt al-Arab's imports decreased after that it reached 44 m^3 sec. in the Shatt al-Arab for the year 2010-2011 (Al-Asadi et al 2015). The problem of the salinity of the Shatt al-Arab water has worsened since the 1970s when dams and reservoirs were built on the Tigris and Euphrates rivers, resulting in less water drainage and a high level of salinity there (Al-Ansari et al 2014). The salinity in the Shatt al-Arab sources, including tidal salt was coming from the Arabian Gulf during the period of the tide (Al-Mudaffar and Mahdi 2014). Al-Saad et al. (2015) clarified that the values of EC and TDS ranged between 1.29-3.22 dS m^{-1} and 891-2040 mg l^{-1}, respectively. Hamdan (2015) has shown that there is a monthly and yearly change in the TDS values for the Shatt al-Arab waters for the years 2009-2014. The high TDS values lead to lower discharge from feedstock sources, contribution of sewage and industrial effluent water discharged to the river, as well as "sewage discharged to the river (Abdullah et al 2016). Yaseen et al (2016) explain that the reasons for the high TDS values are caused by natural factors that include climate changes, droughts, and human such as puncture water that is dumped into the river, as well as "the impact of the water policy of neighboring countries that control the water imports of the Tigris and Euphrates rivers". Abowei et al (2010) showed a direct relationship between electrical conductivity and total dissolved solids in river water. Present study was conducted to study the effect of the sub rivers that flow into the northern part of the Shatt al-Arab of electrical conductivity, total dissolved solids.

MATERIAL AND METHODS

Samples were collected during January, April, August and October 2018, represents winter, spring, summer and autumn, respectively. EC and TDS values were measured in the morning based on the tide time program by the reverse water sampler. Water samples were taken for three locations from the river, namely the right bank (R), the middle of the river (M) and the left bank (L), at three depths of the water column, surface layer (d1), middle of the river's water depth (d2) and 1m from the bottom of the river (d3), with three replicates. The samples were collected in plastic bottles of size 2 litters and were washed with alcohol and distilled water, EC, and TDS were estimated by CRISON Multi Meter. The drainage of the Shatt al-Arab water was taken from the data of the Directorate of Water Resources, Basra for the year 2018 (Fig. 2). Weather forecast data for Basra Governorate were also taken from the General Authority for Meteorology and Seismic Monitoring, Baghdad. The data were analyzed statistically by the Genastat (Ver. 10.3.0) statistical program.

RESULTS AND DISCUSSION

The water drainage of Shatt Al-Arab in Basrah Governorate (Water Resources Directorate data, Basrah 2018) are given in Fig. 2. The discharge decreased during the winter season (22.77 m^3 $sec.^{-1}$ in January), likewise during the spring semester was 52.60 m^3sec^{-1} April), and the values started to rise during the summer, reaching 64.67 m^3 sec^{-1}. Thereafter increased during the Autumn (71.10 m^3sec^{-1}), due to increased flood water.

There was a highly significant effect of the station factor on EC values. The high EC at Karma Ali station were shown as a general average compared to the rest of the study stations, as it reached 12.47 dS m^{-1}, followed by Sinbad island (12.37 dS m^{-1}) (Fig. 3). The reason for the high electrical conductivity in each of Karma Ali and Sinbad Island

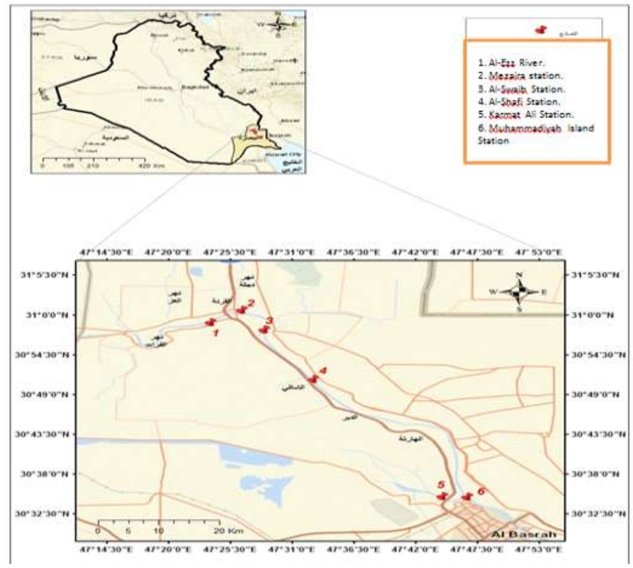

Fig. 1. The study area is drawn using the Arc GIS program-Eart

stations was due to the brine tidal water coming from the Arabian Gulf (Hameed et al 2013). The Mezaira'a station recorded the lowest values (2.37 dS m^{-1}), may be due to proximity of this station to the confluence of the Tigris and Euphrates rivers, which leads to the dilution of salts in this station. The percentage of increase in Karmat Ali and Sinbad Island stations, compared to Muzaira'a was 426.16 and 421.94%, respectively, as for Al-Swaib, Al-Ezz and Al-Shafi stations, varied according to the "quantities of tap water and wastewater discharged into the river without treatment. The values of EC were 2.85, 2.90 and 3.43 dS m^{-1}, respectively. These values rise towards the south of the Shatt al-Arab stream" (Abdullah et al 2016).

During season the electrical conductivity was highly significant. The maximum was in the autumn season (7.67 dS m^{-1}) followed by the summer. The high electrical conductivity in the summer and autumn seasons was due to the high temperatures during these two seasons, which cause an increase in the evaporation of water on the one

Table 1. The coordinates of the study stations located in the northern part of the Shatt al-Arab

Stations	Coordinates		Notes
	E	N	
Al-Ezz	47° 23' 03.72"	30° 58' 47.90"	Effect of Al-Ezz River
Mezaira	47° 26' 29.87"	31° 00' 23.81"	Effect of Tigris (Comparison Station)
Al-Swaib	47° 28' 33.33"	30° 58' 30.10"	Effect of Al-Hawizeh marshes
Al-Shafi	47° 32' 31.79"	30° 31' 15.77"	Effect of Al-Hammar marshes
Karmat Ali	47° 43' 59.48"	30° 34' 54.56"	Effect of Al-Msahab and Al-Salal Rivers
Sinbad Island	47° 46' 29.24"	30° 34' 50.48"	Aggregate effect of previous stations

hand and the high solubility of salts therein due to the low viscosity of the water on the other (Anitha et al 2013). The EC during the winter and spring seasons were 4.95 and 4.41 dS m^{-1} respectively, as lower temperatures lead to less solubility of salts (Moyel and Hussain 2015).

There was a significant increase in EC values in the right bank (R) compared to other sites (6.17 dS m^{-1}), as well as the left bank (L), which was 6.16 dS m^{-1}, which were higher than the values of the middle of the river (M), (6.06 dS m^{-1}). The high electrical conductivity in the two banks of the river compared to the middle of it is due to the movement of the renewable water stream in the middle of the river, depending on the speed of water flow during the islands period and the movement of boats, the effect of bank soil that contributes to the rise in values on both sides of the river and the effect of puncture and sewage water that contribute to raising salinity values in it (Al-Saadi 2006).

The highest values were at the surface (d1) of 6.12 dS.m^{-1} with significant differences with the mean depth (d2) of 6.06 dS m^{-1}, and the bottom (d3) of 6.02 dS m^{-1}. The percentage of low values of electrical conductivity of the middle and bottom depths was 0.98 and 1.63% compared to the surface depth of the water, respectively. This may be due to the high temperatures, which leads to a decrease in the viscosity of water, which contributes to a greater dissolution of salts by breaking chemical bonds between molecules.

The significant differences between the EC for the north stations (Al-Ezz, Mezaira, Al-Sweib and Al-Shafi) during the winter season and values were 4.61, 3.50, 4.68, and 6.64 dS m^{-1}, respectively, a low EC value was at the Mezaira, due to its location near the confluence of the Tigris and Euphrates rivers. The EC value of Karmat Ali and Sinbad Island stations is approximately 5.40 and 4.88 dS m^{-1}, respectively, a decrease in the convergence of the EC values is observed in the stations north of the stream (El-Ezz, Mezaira, Al-Sweib and Al-Shafi) during the spring semester and decreased during the summer in stations north, whereas, the value of EC increased in Karmat Ali and Sinbad Island stations. EC values continued to decrease in stations north of the study area during the autumn. The differences were more pronounced "during the winter and less during the spring and summer, while the variations were as low as possible between EC values during the Autumn season, the reason for the lower EC values is the higher water discharge during these seasons, which leads to reduce the concentration of salts in these stations

There was increase in EC in Karmat Ali and Sinbad Island stations during the autumn (19.51 and 20.08 dS m^{-1}) (Fig. 7), respectively. The percentage increase in spring, summer and autumn seasons compared to the winter for Karmat Ali and Sinbad Island stations was 57.03, 205.37, 261.29 and 28.68, 273.77 and 311.47%, respectively. This is due to the brine tidal wave coming from the Arabian Gulf and the arrival of these two stations clearly (Yaseen et al 2016). TDS was an indication of river salinity and represents all substances dissolved in water, whether ionized or not, which are an indication of water quality.

The TDS vary significant among stations. TDS were observed in Karmat Ali and Sinbad Island stations, with average of 8108.2 and 8031.5 mg l^{-1}, respectively. The higher the EC values for these two stations were 12.47 and 12.37 dS m^{-1}, respectively (Fig. 3), where EC is an indicator of TDS values (Wetzle 2001). The TDS values for the water of Al-Ezz, Mazriya, Al-Swaib and Al-Shafi stations have converged, the values were 19959.6, 1617.6, 1920.0, and 2302.1 mg l^{-1}, respectively,

There were a significant difference in TDS which increased in the fall season (4905.5 mg l^{-1}) compared to the other seasons. This was due to the high temperatures that allow the opportunity to dissolve the salts as a result of low viscosity of water, in addition to the increase in the quantities of incoming water to the Shatt Al-Arab, which causes an increase in TDS. The percentage increase in values during the summer and autumn seasons compared to the spring was 53.40 and 61.96%. TDS values corresponded to the EC values, which amounted to 4.95, 4.41, 7.23, and 7.67 dS m^{-1}, respectively. TDS values decreased during the winter season and may be due to the lower temperatures, which lead to less salt solubility in water (Anitha et al 2013). The whereas, the lowest values were 3028.8 mg l^{-1}, due to the heavy rainfall during this season, which caused the salt concentration to be reduced during this season.

The Figure 10. shows the highly significant effect of the water sampling sites factor relative to the Shatt al-Arab cross-section on TDS values. The highest values in the right bank of the Shatt Al-Arab River were 4060.3 mg l^{-1}, followed by the left, the reason for the high values in the right bank is due to the presence of residential installations and complexes and two power plants in Al-Hartha and Al-Najeeb, which contribute to raising the values of TDS. The lowest values were in the middle of the river (3914.8 mg l^{-1}), due to the movement of the water currents and the movement of the boats that contribute to mixing the water, these values fit with the electrical conductivity values of the right bank, middle and the left bank which indicates the effect of electrical conductivity on total dissolved solids in water.

TDS was significantly higher at surface depth. The maximum was at d1 compared to depths d2 and d3 (4027.8, 3982.3, and 3959.5 mg l^{-1}, respectively), due to the higher evaporation of water from the surface compared to the other two depths.

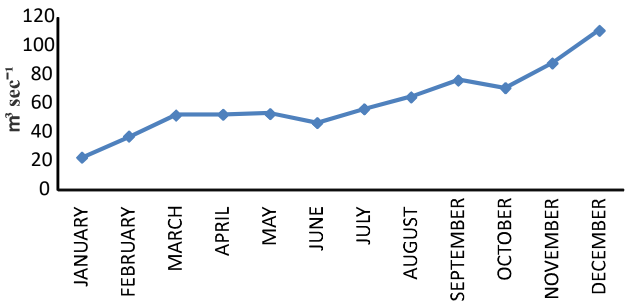

Fig. 2. Shatt al-Arab water drainage (m^3. Sec^{-1}) in Basrah city (Water Resources Directorate, Basrah data)

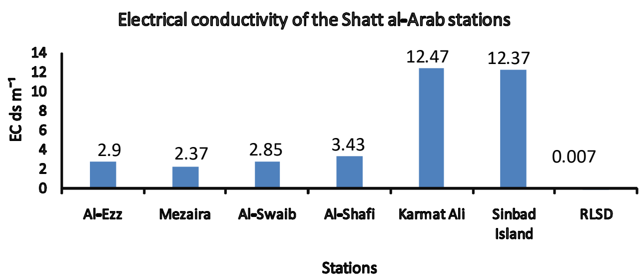

Fig. 3. Spatial heterogeneity of electrical conductivity values (dS m^{-1}) for Shatt Al-Arab stations

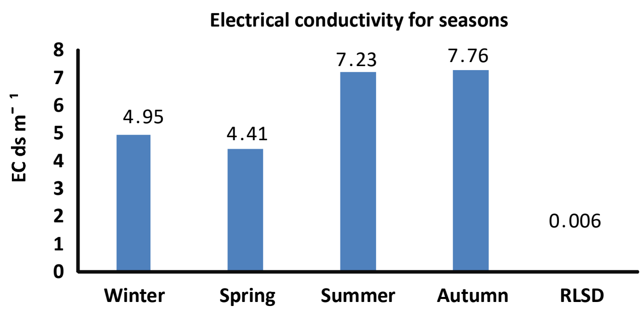

Fig. 4. Seasonal variation of the EC values (dS m^{-1}) for the Shatt al-Arab stations

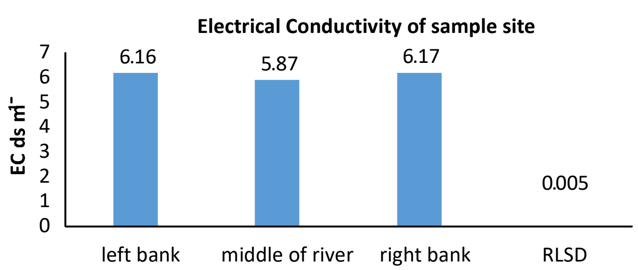

Fig. 5. Electrical conductivity (dS m^{-1}) for the sampling site

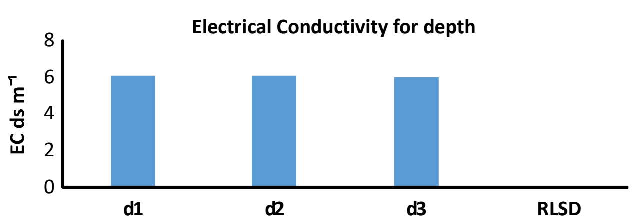

Fig. 6. Electrical conductivity (dS m^{-1}) for the sampling depth

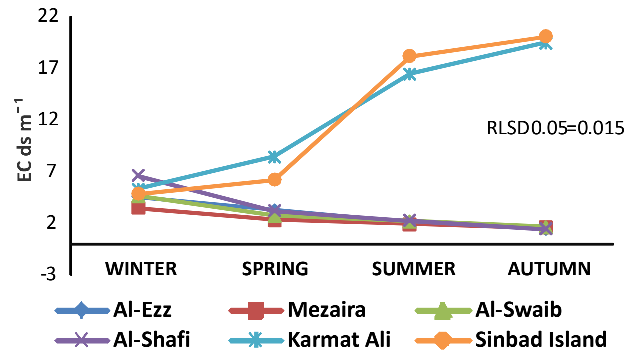

Fig. 7. EC values (dS m^{-1}) for interaction between stations and seasons

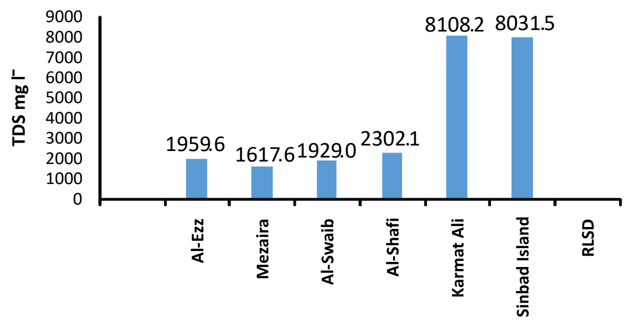

Fig. 8. Spatial heterogeneity of total soluble solids (mg l^{-1})

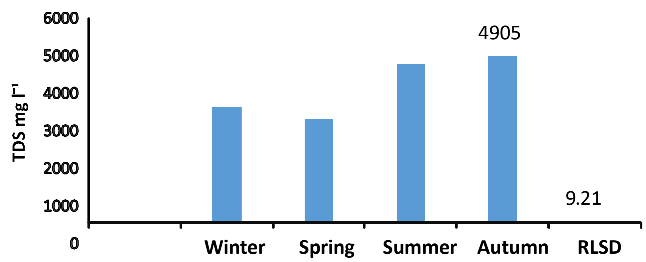

Fig. 9. Quarterly variation of total soluble solids (mg l^{-1})

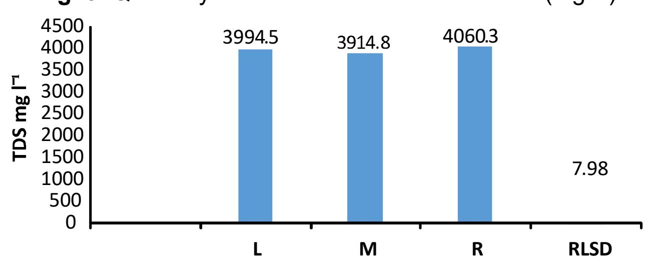

Fig. 10. TDS values (mg l^{-1}) as a general average for the sampling sites for the Shatt al-Arab stations

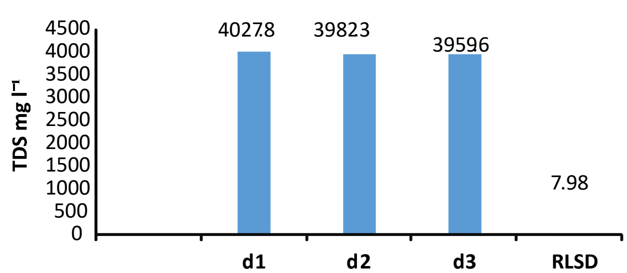

Fig. 11. TDS values (mg l^{-1}) for depths in Shatt Al Arab stations

There were significant differences between the TDS of the interaction (Fig. 12). TDS decreased and their convergence with each other for the stations located to the north of the study area (Al-Ezz, Mezaira, Al-Sweib and Al-Shafi)> The high values in the stations south of the study area, as the values of the stations of Karma Ali and Sinbad Island reached 12507.4 and 12821.3 mg l^{-1}, respectively. The high TDS during autumn season were attributed to the human activities in these two stations, where the large number of residential areas and the wastewater, agricultural wastes and sewage discharged into the river are dumped to the river, the waste generated by Al Hartha and Al Najeebiya stations in the river water, in addition to the effect of the saline tide with the most effective effect, the effect of which reaches these two stations (Hassan et al 2011). The TDS in Al-Ezz, Mezaira, Al-Sweib, and Al-Shafi stations decreased towards the advance of the winter, spring, summer and autumn seasons respectively, as the percentage of decrease in TDS in these stations during the autumn compared to the winter and may be due to the increase in water discharge during this season, which leads to a decrease in the values due to the dilution effect. The decrease in TDS corresponded to the decrease in the EC values in these stations during the autumn season, as the percentage of decrease in the fall season compared to the winter reached 68.02, 53.41, 63.46 and 67.24%, respectively, while the results show that the TDS at Karmat Ali and Sinbad Island stations showed opposite behavior of the previous stations, as the highest values in the fall and autumn in summer, spring and winter. The values of Karmat Ali and Sinbad Island stations increased during the fall season, the percentage of increase in these two stations compared to winter was 239.33 and 282.15%, respectively, due to salt tide coming from the Arabian Gulf. The rise in TDS corresponded to the EC values in these two stations, as the percentage of increase reached 261.29 and 311.47%, indicates that the electrical conductivity is a reflection of the values of the total dissolved solids.

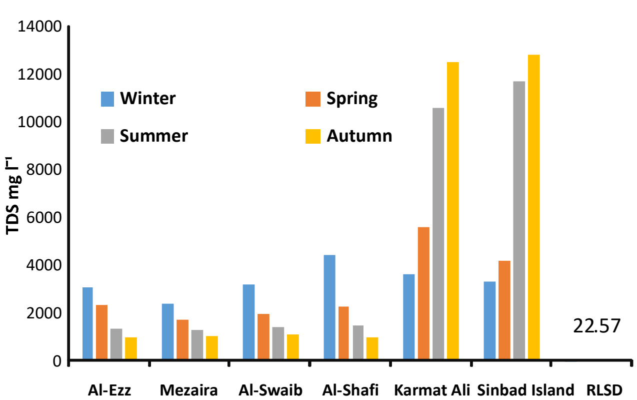

Fig. 12. TDS values (mg l^{-1}) for the interaction between the Shatt Al-Arab stations and the seasons of the year

CONCLUSIONS

High values of EC and TDS in Karmat Kali and Sinbad island stations, as a result of salt tidal water coming from the Arabian Gulf, Low EC values at Meziara station, due to proximity to the juncture of the Euphrates and Tigris River. High EC and TDS values in the summer and summer semesters, because of the high temperatures, which causes more water evaporation, and the high solubility of salts due to the low viscosity of water. The high value of EC and TDS at the surface compared to the medium and deep, because of the high temperature, leads to less viscosity of water, contributes to greater dissolution of salts, by breaking up chemical bonds between molecules.

REFERENCES

Abdullah AD, Gisen JI, Zaag PV, Savenije HG, Karim UF, Masih I and Popesceu I 2016. Predecting the salt water intrusion in the Shatt Al-Arab Estuary using analytical approach. *Hydrology and Earth System Sciences* **20**: 4031-4042.

Abdullah SS 2002. Analysis of tide wave in Shat Al-Arab Estuary. South of Iraq. *Marina Mesop* **17**(2): 305-315.

Abowei JF, Davis OA and Eli A 2010. Physico-chemistry, morphology and abundance of fin fish of Nkoro River, Niger Delta. *International Journal of Pharma and Bio Sciences* **6**(2): 112-117.

Al-Ansari N, Ali A and Knutsoon S 2014. Present condition and future challenges of water resources and problems in Iraq. *Journal of Water Resources and Protection* **6**:1066-1098.

Al-Asadi A, Abdulla SS and Mahmood HK 2015. Estimation of Minimum amount of the net discharge in the Shatt Al- Arab River (South of Iraq). *Journal of Adab Al- Basrah* **2**: 285-314.

Al-Katib MT 1971. Shatt al-Arab and History, Iraqi Ports Authority Press, Basrah.

Al-Maliki AS 2010. Drought phenomenon and its environmental effects, a geographical study. New Iraqi Environment Journal, a special issue for the Third International Conference *Research Baghdad Journal* **2**(1): 55-61.

Al-Mudaffar NF and Mahdi BA 2014. Iraq's inland water quality and their impact on the North Western Arabian Gulf. *Marsh Bulletin* **9**(1): 1-22.

Al-Saad HT, Al-Hello AA, Al-Kazaeb DK, Al-Hello M, Hassan WF and Mahdi S 2015. Analysis of water quality using physical and chemical parameters in Shatt Al-Arab Estuary, Iraq. *International Journal of Marine Science* **5**(49): 1-9.

Al-Saadi HA 2006. Basics of ecology and pollution. Al-Yazouri Scientific Publishing and Distribution House, Amman, Jordan.

Anitha G and Sugirtha PK 2013. Physiochemical characteristics of water and Sediments in Thengapattan Estuary, South West Coastal Zone. *International Journal of Environmental Science and Technology* **4**(3): 205-222.

Asadi HB and Khalaf KK 2015. The hydrological characteristics of the Tigris River in the lower basin. *Basra Literature Magazine*. Number **72**: 259-284.

Davies S and Dewiest R 1996. Hydrology John Wiley, Inc. New York.

Hamdan AN 2015. Variatio on effect of discharge on total dissolved solids in Shatt Al-Arab River. *The 2nd International Conference of Building, Construction and Environmental Engineering* (BCEE 2).

Hameed AH and Al-Joorany H 2011. Invistigation on nutrient behavior along Shatt Al- Arab River Basin, Iraq. *Journal of*

Applied Science and Research **7**(8): 1340-1350.

Hassan WF, Hassan IF and Jassim AH 2011. Effects of industrial effluents on polluting water near discharge in Basra Governorate, Iraq. *Basra Research Journal (Operations)*. **33**(1): 42-53.

Moyel MS and Hussain N 2015. Water quality assessment of Shatt Al-Arab River, Southern Iraq. *Journal of Coastal Life Medicine* **6**: 459-465.

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Nomas HB 2006. The future of water and alternative development projects. *Basra Literature Magazine* **41**:181-206.

Wetzle RJ 2001. Application of Environmental Chemistry. Lewis Puplishers, London, New York: 276.

Yaseen BR, Al-Asady KA, Kasem AA and Chaichan MT 2016. Environmental impact of salt tide in Shatt Al-Arab Basra/ Iraq. *Journal Environmental Science, Toxicology and Food Technology* **10**: 35-43.