



Seasonal Variation of Salinity in Al-Ashar and Al-Qurna Stations of Shatt al-Arab River, Basrah city /Southern Iraq

Wissal Audah Hassan Alhilfi*, Nida Jassim Mohammad Al-Mousawi**, Sadiq Salim Abdullah***

*Marine Science Center, University of Basrah, Basrah, Iraq.

**Department of Biology, College of Science, University of Basrah, Basrah, Iraq.

***Marine Science Center, University of Basrah, Basrah, Iraq

wissal.audah@uobasrah.edu.iq

Nida.mohammed@uobasrah.edu.iq

Abstract. Salinity is one of the important environmental factor that expresses as the sum of the concentrations of positive and negative ions and dissolved salts in water, it has effects on the quality of water . This study examines the seasonal variation (2021-2022) of salinity in Al-Ashar and Al-Qurna stations within Al-Basrah city,. The salinity values ranged from 34932-35012 g/l at Al-Ashar station , While at the Al-Qurna station , Low salinity values were recorded ,ranging to 30668 – 35040 g/l. This study observes an increase in salinity during the summer season and a decrease during the winter at both research stations. There are no discernible differences between salinity values recorded during the day and night at both stations, however, Al-Ashar station consistently records higher percentages than Al-Qurna station.

Keywords: Salinity, Shatt al-Arab river, Al-Ashar, Al-Qurna.

المخلص. تعد الملوحة من اهم العوامل البيئية المؤثرة على الكائنات الحية والتي تشير الى التراكيز الموجبة والسالبة للأيونات والاملاح الذائبة في المياه، تم دراسة التراكيز الملحية





للفترة من 2021-2022 في محطتي العشار والقرنة عند مدينة البصرة جنوب العراق وقد سجلت قيم الملوحة (34932-35012) جزء بالالف في محطة العشار للفترة 2021-2022 على التوالي بينما سجلت محطة القرنة قيم متدنية للملوحة مقارنة بالمحطة الأولى وبلغت (30668 – 35040) جزء بالالف خلال فترة الدراسة 2021-2022 . لوحظ في الدراسة الحالية زيادة تراكيز الملوحة وخاصة" خلال فصل الصيف ويقابلها انخفاض الملوحة في فصل الشتاء في كلا محطتي الدراسة (العشار والقرنة) . كما لوحظ عدم وجود فروقات معنوية في قيم الملوحة المقاسة خلال الليل والنهار في كلا المحطتين . وقد سجلت محطة العشار القيم الأعلى مقارنة مع القرنة.

1. Introduction

Salinity is a critical environmental parameter that affects water bodies. The primary contributors to salinity are chloride, sulfate, and carbonate ions (Lind, 1979). The leading causes of these ions are sodium chloride, sodium sulfate, and sodium carbonate salts. Several factors influence the salinity of water bodies, including the volume, quantity, and freshness of water received during specific periods, as well as temperature, sunlight, rainfall, and evaporation (Kotta et al., 2014).

Chloride is widely distributed in nature, primarily in the form of sodium, potassium, and calcium salts. It constitutes approximately 0.05 percent of the Earth's crust, with the majority found in the world's oceans. Seawater, for instance, contains chloride at a concentration of about 19,000 g/l, while drinking water typically contains less than 100 g/l of chloride (NHMRC, 2011).

Basrah heavily relies on surface water for most of its domestic, agricultural, and industrial needs. The Shatt Al-Arab River serves as the primary source of surface water in this region of Iraq, flowing from north to south and ultimately into the Gulf (Abdul-Hameed & Hatem, 2021). The quality of water in the Shatt Al-Arab River reflects the combined influence of natural and anthropogenic factors (Al-Asadi & Alhello, 2019). Salinity in the Shatt al-Arab's waters is primarily attributed to the influx of seawater and contributions from saline water originating from sewage and drainage channels. It also originates from the marshes, which play a role in elevating the river's salinity levels.

The issue of high salinity in the Shatt al-Arab River has worsened since the 1970s, when dams and reservoirs were constructed on the Tigris and Euphrates rivers. These infrastructural developments led to reduced water flow and increased salinity levels (Al-Ansari et al., 2014). So the decline in water



imports as a result of the construction of dams by neighboring countries such as Turkey, Syria and Iran contributed to the lack of water imports, also Iran's diversion of the course of the Karun River (the main feeder of the Shatt al-Arab with fresh water), all led to a decrease in the quantity of fresh water, and therefore to increase the salinity (Muttai, 2021)

Lateef et al. (2020) found that salt concentrations during the winter of 2018 were markedly different from other seasons in the confined area spanning from Al-Hartha station to Al-Seba station. To address this freshwater loss, the construction of an artificial dam upstream of Basra city to separate fresh and saltwater has been suggested (Abd-El-Mooty et al., 2016).

Hamdan et al. (2020) observed that with high flow, total dissolved solids (TDS) values ranged from 3000 to 4000 g/l during the lowest low tide and highest high tide, respectively. In contrast, with low flow, TDS ranged between 1000 and 2000 g/l, reaching 150 km from the river mouth when freshwater discharge increased to 103 m³/s. This increase effectively prevented salinity intrusion into the center of Basrah city, both during low and high tides. The study results provide a comprehensive description of TDS variation from the sea to the upstream portion of the Shatt Al-Arab River

2. Study objective:

The Shatt al-Arab has been suffering from a deterioration in its water quality during these recent years due to the increase in salinity values. This study aims to investigate the behavior of salinity in two stations for the period 2021-2022, and to determine the differences and factors affecting this on salinity values.

2.1. Study area descriptions:

The Tigris and Euphrates rivers converge at Al-Qurna town, located 70 km north of Basra in southern Iraq, forming the Shatt al-Arab River. This river flows for an estimated distance of 204 km until it discharges into the Arabian Gulf, south of Faw town, where an estuary is formed. The river's average width is approximately 400 meters, and its depths range from 8 to 20 meters. In addition to the Tigris and Euphrates Rivers, the Karun River, originating in Iranian territory, joins the Shatt al-Arab at Umm al-Rasas Island, further contributing to its water supply. Notably, tides originating in the Arabian Gulf impact the river as far north as Qurna, a unique feature of the Shatt al-Arab River.



The type of tides in the river is mixed, predominantly semi-diurnal (Abdullah, 2002) with tide ranges varying from 1.1 to 1.84 meters. The highest water level near Al-Faw is 1 meter (Abdullah, 2014)

The hydrological conditions of the river have changed over time. In the 1970s, the river's freshwater discharge occasionally exceeded 1000 m³/sec but has since declined to 50 m³/sec due to reduced freshwater supply from upstream sources, primarily a result of dam construction by countries upstream. To conduct this study, two stations were selected for salinity measurements: Al-Qurna and Al-Ashar stations, Figure (1). Al-Qurna Station: (30° 58' 7.24" N, 47° 28' 21.83" E)

This station represents the first area of the Shatt al-Arab River where freshwater enters. The areas surrounding the station are primarily agricultural, except for the residential area represented by the city of Qurna. Therefore, the sources of pollution in this place are few. The naked section of the river is characterized by a width of approximately 200 meters and a depth of no more than 1 meter, while the extent of the ebb and flow does not exceed 30 cm. Al-Ashar station: (30° 30' 40.17" N, 47° 51' 13.58" E)

This station represents the middle part of the Shatt al-Arab River and serves as the center of Basra, where approximately one million people reside. This high population density is a significant source of water pollution for the Shatt al-Arab River. In this region, the river's width can reach up to 400 meters, with depths exceeding 12 meters. The tidal range exceeds one meter.



Fig.(1) Study Area (Lafta , 2022)

3. Materials and methods



In this study, two stations were selected, Al-Ashar and Al-Qurna stations, there are two Hobo measuring stations in these two places, as shown in the figure (2), which were previously installed by the Marine Science Center - University of Basrah, these two stations measure some physical properties of water and air. However, in this study relied on the data measured in these two stations regarding water salinity and through a dedicated sensor as in the figure (2), The sensor's function is to measure the conductivity of the water and then automatically convert it into salinity values estimated in g/l, the time period of measurements of salinity included several months during 2021-2022, 69,944 and 65,708 reading were taken for Al-Ashar and Al-Qurna station respectively.



Fig. (2) HOBO Station and Aua TROLL Sensor Conductivity

3.1. Statistical Analysis

The statistical analysis was conducted by Iraqi center for research services; using the SPSS program. A one-way ANOVA or T-test was used to determine significant differences between the results of the two stations and months at the probability level ($P < 0.05$). The salinity of water samples from both stations was measured in situ during the study period from 2021 to 2022.

4. Results:

The highest salinity value in 2021 was recorded at Al-Ashar station, where it reached 34,932 mg/l, while the highest salinity value in 2022 was nearly equal at both Al-Ashar and Al-Qurna stations (Fig.3).

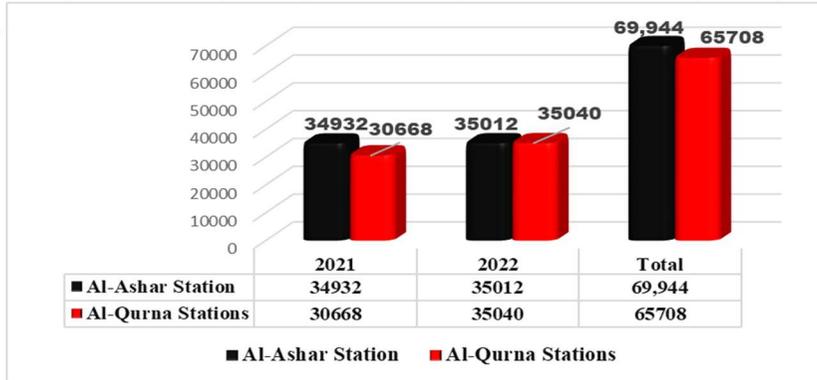


Fig.(3): Annual average salinity values (mg/l) at study stations in the years 2021–2022

The results of the statistical analysis of salinity showed significant differences between the study stations at a probability level of 0.001 in 2021 and 2022 at Al-Ashar station compared to Al-Qurna station (Table 1). Additionally, Table 2 shows that salinity significantly increased ($P < 0.001$) in 2021 at both Al-Ashar and Al-Qurna stations compared to 2022.

Table (1): Statistical analysis of salinity in Al-Ashar and Al-Qurna stations using a T-test based on years.

| Variables | Al-Ashar stations Mean±SD | Al-Qurna stations Mean±SD | P- Value |
|------------------------|------------------------------|------------------------------|----------|
| Salinity 2021 (g/l) | 1.81±0.912 | 1.06±0.247 | <0.001 |
| Salinity 2022 (g/l) | 4.06±2.66 | 0.905±0.212 | <0.001 |

Table (2): Statistical analysis of salinity in 2021 and 2022 by using a T-test, categorized by stations

| Variables | 2021 Mean±SD | 2022 Mean±SD | P- Value |
|-------------------------------------|-----------------|-----------------|----------|
| Salinity Al-Ashar stations (g/l) | 1.81±0.912 | 4.06±2.66 | <0.001 |
| Salinity Al-Qurna stations (g/l) | 1.06±0.247 | 0.905±0.212 | <0.001 |



Figure (4) indicates an equal amount of salinity during both day and night hours for both study stations. However, salinity at Al-Ashar station was higher than at the second station, Al-Qurna.

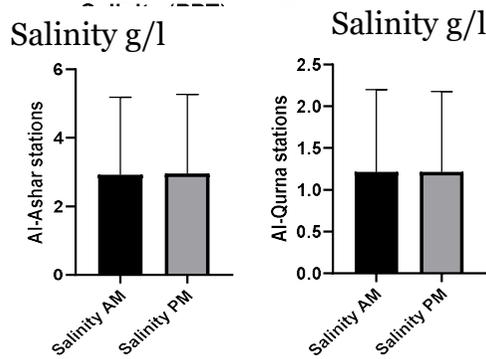


Fig.(4): Annual average salinity values during day and night hours for study stations during 2021–2022.

Table (3) showed significant differences between the two study stations during both day and night hours.

Table (3): Statistical analysis of salinity at Al-Ashar and Al-Qurna stations using the T-test, categorized by AM and PM times.

| Variables | Al-Ashar stations Mean±SD | Al-Qurna stations Mean±SD | P- Value |
|----------------------|------------------------------|------------------------------|----------|
| Salinity AM (g/l) | 2.92±2.27 | 0.948±0.253 | <0.001 |
| Salinity PM (g/l) | 2.96±2.31 | 0.978±0.239 | <0.001 |
| P- Value | 0.030 | <0.001 | |

The results indicated an increase in values (p -value = 0.001) at Al-Ashar station in both AM and PM times compared to Al-Qurna station. It also showed a significant (P -value = 0.030) increase in AM time at Al-Ashar station compared with PM time at the same station and a significant (P -value < 0.001) increase in AM time compared with PM time at Al-Qurna station. As shown in Figure (5), the salinity percentage increased during the summer and was followed by the autumn season at both stations, respectively. The winter season



recorded the lowest salinity percentage at both stations, with the Qurna station turned her below of salinity.

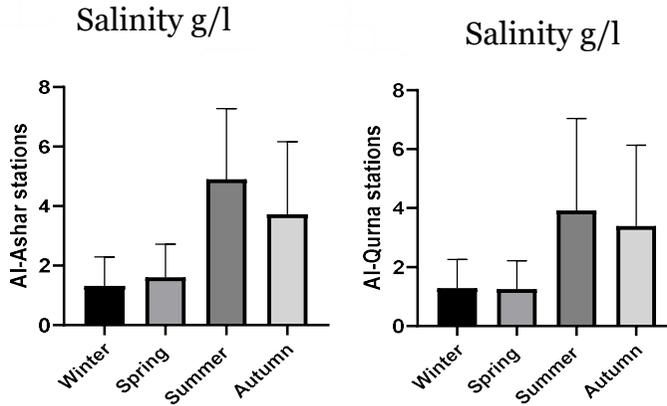


Fig. (5): Semester variations in the salinity ratio of the studied stations during the semesters of the academic year 2021-2022.

Table (4) shows significant differences between the two study stations during the seasons. Salinity was significantly lower (<0.001) in Al-Ashar stations in all seasons (spring, summer, and autumn) compared to Al-Qurna stations, except in winter, where the P-Value = 0.164. It also showed significant differences (P-value < 0.001) in all seasons when comparing Al-Qurna stations.

Table (4): Statistical analysis of salinity in Al-Ashar and Al-Qurna stations by T-test and ANOVA test during the 2021 season.

| Variables | Al-Ashar stations Mean±SD | Al-Qurna stations Mean±SD | P- Value |
|-----------------------|------------------------------|------------------------------|----------|
| Salinity Winter (g/l) | 1.43±0.112 | 1.43±0.178 | 0.164 |
| Salinity Spring (g/l) | 1.51±0.342 | 1.18±0.277 | <0.001 |
| Salinity Summer (g/l) | 2.86±1.26 | 0.892±0.0881 | <0.001 |
| Salinity Autumn (g/l) | 1.43±0.280 | 0.928±0.0401 | <0.001 |
| P- Value | <0.001 | <0.001 | |

Meanwhile, Table 5 shows that salinity significantly increased (P-Value < 0.001) in Al-Ashar stations in all seasons compared to Al-Qurna stations. It also showed significant differences (P-Value < 0.001) in all seasons when



comparing each other in Al-Ashar stations and significant differences (P-Value < 0.001) in all seasons when comparing each other in Al-Qurna stations.

Table (5): Statistical analysis of salinity in Al-Ashar compared to Al-Qurna stations by T-test and ANOVA test during the 2022 seasons.

| Variables | Al-Ashar stations Mean±SD | Al-Qurna stations Mean±SD | P- Value |
|-----------------------|------------------------------|------------------------------|----------|
| Salinity Winter (g/l) | 1.11±0.160 | 1.05±0.139 | <0.001 |
| Salinity Spring (g/l) | 2.13±0.993 | 1.06±0.190 | <0.001 |
| Salinity Summer (g/l) | 6.93±1.21 | 0.880±0.0535 | <0.001 |
| Salinity Autumn (g/l) | 6.00±1.21 | 0.635±0.0538 | <0.001 |
| P- Value | <0.001 | <0.001 | |

An increase in salinity values per month was observed at Al-Ashar station compared to Al-Qurna station (Fig. 6), with the highest values recorded in July, and the lowest in January. Salinity values was recorded the lowest one at the second station (Al-Qurna), except for March and April, which increased and recorded the highest values of salinity.

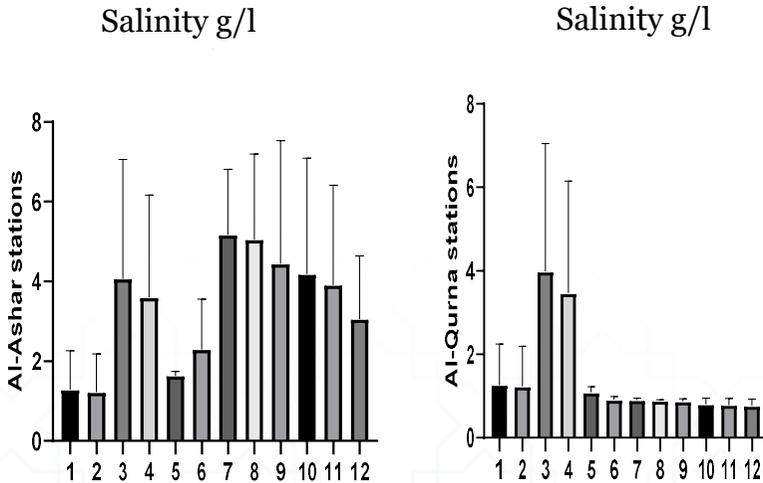


Fig.(6): Monthly changes in salinity values in study stations: A= Al-Ashar station, B= Al-Qurna station



5. Discussion

Water stands as the most essential and fundamental requirement for life, supporting various activities. Surface water sources, such as rivers, lakes, ponds, and dams, serve multiple purposes, including drinking, irrigation, and power supply (Penna et al., 2002). The Shatt Al-Arab River is one of the important rivers in Iraq due to its agricultural, commercial, economic, and social importance. It supplies water for drinking, irrigation, fishing, transportation, and various industrial uses, Hamza,(2023)

It is imperative that drinking water is devoid of chemical, physical, and biological contaminants, ensuring it remains colorless, tasteless, and odorless (Al-Fatlawi, 2007).

The exponential increase in population and economic activities within countries inevitably leads to a heightened demand for water across various applications. Several criteria are employed to evaluate the quality of drinking water. One effective and straightforward method is to measure electrical conductivity, which assesses water's capacity to conduct electrical current. Each body of water possesses its unique salinity value (Al-Sabah, 2016).

The findings from the Al-Qurna stations indicated the lowest salinity rates in 2021–2022 compared to the Al-Ashar stations (Figs. 3 and 6). The increase in water releases by the Ministry of Water Resources in response to the growing demand in Basrah city resulted in decreased salinity at the Qurna station (Figure 6). In contrast, the Al-Ashar station recorded a significant salinity increase for two reasons: its distance from the water release source and its proximity to the sea, which constitutes the primary source of salinity in the Al-Basrah area's waters.

It is important to note that water salinity is not solely determined by a single type of salt but rather reflects the percentage of total dissolved salts, including potassium, magnesium, calcium, and sodium.

Iraqi drinking water standards stipulate a maximum desirable total dissolved salt content of 500 mg/l, with a maximum permissible limit of 1500 mg/l ,Al-Salihy et al., (2011).

Seasonal comparisons reveal an increase in salinity during hot seasons (summer and autumn) in both study stations (Fig. 5), with a decline during cold seasons (winter and spring). This observation aligns with the findings of (Abdul Nafi and Salman, 2011) and may be attributed to climate change. Months characterized by significant temperature increases, such as summer months with high temperatures, experience heightened evaporation rates,



leading to increased salt concentrations and greater pollutant concentrations, resulting in elevated electrical conductivity values. This result agreement with Al-Saedy,(2021) and Saki,(2022). The increase in the evaporation processes of the river water during the hot months of the year because the EC increases with the increase in temperature, and the increase in the concentration of ions in the water, which are carries of high concentration of. (Xia, et al., 2019) and (Hamza,2023)

(Nomas and Hashem, 2021) pointed out that most of the water filtration plants that take water from the Shatt al-Arab, the resulting water is unfit for drinking use according to the World Health Organization index. As for the filtration plants that take water from the Al-Bada Canal, the resulting water is water suitable for human use according to that index.

The researchers (Nomas and Hashem, 2021) indicated that The quality of water in water projects that depend on the Bada'a canal for their recharge falls within the internationally permissible limits for the quality of potable water according to the specifications of the World Health Organization, while the rest of the water projects that are recharged from the waters of the Shatt al-Arab are higher than the permissible limits for human consumption.

6. Conclusions

The salinity significantly increased ($P < 0.001$) in 2021 at both Al-Ashar and Al-Qurna stations compared to 2022. the salinity percentage increased during the summer while The winter season recorded the lowest salinity percentage at both stations, According to the month the July was recorded the highest values of salinity and the lowest in Januar at Al-Ashar station compared to Al-Qurna station

Acknowledgements

We extend our gratitude to Marine Physics department at study station, especially the head of the department Prof. Dr. Ali Abdulridha for providing us with salinity value data.

References

- [1] Abd-albaky, M.A. (2019). The reality of water liquefaction plants in the city of Mosul. Al-Rafidain Engineering Journal (AREJ), Vol. 24, No 2, pp. 138-145.(In Arabic) doi : 10.33899/rengj.2019.164330
- [2] Abd El-Mooty,M.;Kansoh,R. and Abdulhadi, A. (2016). Challenges of



- water resources in Iraq. Hydrology Current Research, 7(4), 1-8. doi:10.4172/2157-7587.1000260
- [3] Abdul Nafi, Y. R. and Salman, S. A. (2011). Bacteriological and chemical study of liquefied water and reservoirs in some neighborhoods of Baghdad city. Al-Nahrain University Journal, Volume 14 Issue (1) March, pp. -38 45 Science.(In Arabic)
- [4] Abdul-Hameed, S. A. Q. and Hatem, A. J. (2021). Effect of Shatt Al-Arab salinity on the groundwater of Al-Fao and Al-Siba in Southern Iraq. The Iraqi Geological Journal, 114-122. doi:10.46717/igj.54.1E.10Ms-2021-05-31
- [5] Abdullah, S. S. (2002). Analysis of Tide Wave in Shatt Al-Arab Estuary, South of Iraq. Marine Mesopotamica, 17(2), 305-315.
- [6] Abdullah, S. S. (2014). Tide phenomenon in the Shatt Al Arab River, South of Iraq. Journal of Arabian Gulf, 42(3-4), 133-155.
- [7] Al-Ansari, N., Ali, A. and Knutsson, S. (2014). Present conditions and future challenges of water resources problems in Iraq. Journal of Water Resource and Protection, 6(12), 1066-1098. doi:10.4236/jwarp.2014.612102
- [8] Al-Asadi, S. A. and Alhello, A. A. (2019). General assessment of Shatt al-Arab river, Iraq. International Journal of Water, 13(4), 360-375.
- [9] Al-Fatlawi, Y. F. (2007). Study of drinking water quality for some Baghdad water liquefaction projects, PhD thesis, College of Science, University of Baghdad. (In Arabic). DOI: 10.4236/jwarp.2014.614124
- [10] Ali, S. S. A. (2021). Study of bacterial contamination and some physical and chemical properties of selected bottled water production plants in Karbala Governorate – Iraq. Master's thesis, College of Science - University of Karbala, 150pp.
- [11] Al-Nuaimi, H.J.M. (2010). Study of the extent of raw water pollution and its impact on the quality of liquefaction water for Al-Kasr station / northern Iraq. Journal of the Iraqi National Journal of Earth Sciences, University of Mosul. . Volume 1 Issue 23-32. DOI: 10.13140/RG.2.2.15161.21603
- [12] Al-Sabah, B. J. (2016). Application of water quality index to assessment of Tigris River. International Journal of Current Microbiology and Applied Sciences, 5(10), 397-407. doi:10.20546/ijcmas.2016.510.045
- [13] Al-Salihiy, A. I., Sadeq, S. N., and Al-Jumaily, H. A. (2021). Hydrochemical Evaluation of Raw Water and Treated Water in the





Liquefaction Plant of Kirkuk Unified Water Project Using WQI Technique, Northern Iraq. The Iraqi Geological Journal, 78-87. doi:10.46717/igi.54.1E.7Ms-2021-05-28

- [14] Hamdan, A. N. A., Al-Mahdi, A. A. J., and Mahmood, A. B. (2020). Modeling the effect of sea water intrusion into Shatt Al-Arab River (Iraq). Journal of University of Babylon for Engineering Sciences, 28, 210-224.
- [15] Hamza, H. (2023). Impact of sub-rivers feeding the Shatt Al-Arab River on its water quality, Water and Environmental Sustainability, 3(3):59-64, DOI:10.52293/WES.3.3.5964
- [16] Hussein, E., Radha, M. and Sabah, Z. (2014). Quality assessment of various bottled-water and tap-water in Kirkuk-Iraq. Int J Eng Res Appl, 4(6), 8-15.
- [17] Kotta, J., Möller, T., Orav-Kotta, H. And Pärnoja, M. (2014). Realized niche width of a brackish water submerged aquatic vegetation under current environmental conditions and projected influences of climate change. Marine environmental research, 102, 88-101. doi:10.1016/j.marenvres.2014.05.002
- [18] Lafta, A. A. (2022). Numerical assessment of Karun river influence on salinity intrusion in the Shatt Al-Arab river estuary, northwest of Arabian Gulf. Applied Water Science, 12(6), 124. doi:10.1007/s13201-022-01640-4
- [19] Lateef, Z. Q., Al-Madhhachi, A. S. T. and Sachit, D. E. (2020). Evaluation of water quality parameters in Shatt Al-Arab, Southern Iraq, using spatial analysis. Hydrology, 7(4), 79. doi:10.3390/hydrology7040079
- [20] Lind, O. T. (1979). Handbook of common methods in limnology. The CV Mosley Company, pp.199.
- [21] Mutai, I. B. (2021). Responsible entities for contamination of Basra water and their range of civilian responsibility. Journal of the Education College – Wasit University. 45(1).
- [22] NHMRC, N. (2011). Australian drinking water guidelines paper 6 national water quality management strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra, 5-7.
- [23] Nomas, H. B. and Hashem, A. A. (2021). The Al Bada Canal water project: Its Construction Aspects and importance for Drinking water Supply projects of Basrah Province. Journal of Education College -





- Wasit University , Volume 1, Vol. 44, pp:205-230.(In Arabic)
- [24] Penna, V. T. C., Martins, S. A. M. and Mazzola, P. G. (2002). Identification of bacteria in drinking and purified water during the monitoring of a typical water purification system. BMC Public Health, 2(1), 1-11. doi:10.1186/1471-2458-2-13
- [25] Xia, L.; Xinyi, Xiang; Guoy, Huang; Xiaru, Song; Perjia Wang & Kaidao, Fu (2019). Bacterial abundance and physiochemical characteristics of water and sediments associated with hydroelectric Dam on the Longang River, China. Int. J. Res. Public Health, 16(11):2031-2053.
- [26] Saedy, R.N.Y.(2021).Study of the abundance of benthic diatoms and impact of temperature and salinity on their survival in the Shatt Al-Arab Estuary . M.s.c. thesis college of science university of Basrah,(107) pp.
- [27] Saki,S.H.(2022).Water quality evaluation for the southern Al-Hawiza marsh using ecological and diatom water quality indice. M.s.c. thesis college of science university of Basrah, (151)pp.
- [28] Fao(2021) "Soil salinity refers to the presence of high concentrations of soluble salts in the soil water. Salts can accumulate due to natural processes or as a result of improper irrigation practices."
- [29] <https://www.fao.org>