The effect of water imports and tidal movement on the hydrochemical properties of the Shatt al-Arab.

Abdalrda Jassim Oleiwi[1], Ali Hamdhi Dheyab[1] and Mohammed Nasser Fares [3]

[1]Department of Soil Science and Water Resources-College of Agriculture- University of Basrah– Republic of Iraq.

[3]Chemical Engineering- College of Engineering- University of Basrah– Republic of Iraq.

Correspondent author Email: agripg.abdalrda.jasim@uobasrah.eud.iq

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Abstract

A field study was conducted on the course of the Shatt al-Arab for the period from September 2021 to August 2022. to track the space-time changes in the quality of moving water in the course of the Shatt al-Arab under the influence of the movement of tidal cycles and their interference with fresh water coming from the Tigris River. through four study stations located in the areas of Al-Sada Al-Nour, the paper factory, Al-Ashar, and Sehan. and the study aimed to find out the extent of variation in the values of salinity. the concentration of dissolved solids and concentrations of some Cations and anions spatially and temporally and the extent to which they are affected by the movement of tides. Aquatic samples were collected from the study stations according to the four seasons of the study period and from three depths and three repeats from each depth. The results of the statistical analysis showed significant differences in the values of all studied vocabulary, namely EC, pH, Ca^{+2}, Mg^{+2}, TH, Na^{+1}, $HCO3^{-1}$, Cl^{-1}, $SO4^{-2}$ based on the stations and seasons studied, and the values of the studied vocabulary showed a spatial and temporal variation, as the salinity values increased as we headed south towards the mouth of the river and the ranges of values reached 1.92-8.45 dS^{-1}.The pH values tended to be light basal and ranged between 7.79 – 8.06, and the concentrations of cations and anions varied spatially and temporally as they were affected by the movement of the tides and the values of the concentrations ranged between 116.43 - 661.67, 35.16 -147.62, 167.67 - 1118.91, 221.43-2337.53 and 344.88 - 1073.68 mg L^{-1} for ions Ca^{+2}, Mg^{+2}, Na^{+1}, Cl^{-1}, $SO4^{-2}$ respectively.

Keywords: salinity, spatial and temporal variation.

Introduction

The Shatt al-Arab River is the main source of surface water in Basra Governorate and one of the most important major rivers in Iraq, because of its economic and social importance as well as the various uses of its water in agriculture, industry, navigation, and fishing, and this river has been exposed to many pollution activities, most of which are household waste and the discharge of industrial and agricultural waste, as these residues are placed directly in the river without any treatment (24). The pH values of natural water change when industrial wastewater resulting from factories and factories such as paper factories, oil production plants, fertilizer production plants, oil refineries, and others are discharged to rivers because of the substances that affect the pH values, (27). Al-Saad, et al.(14) explained that there were significant differences in pH values, ranging from 7.00 cadence to 8.91 during the fall and winter, respectively, and 8.21 in the summer. Al-Malikey, (12) showed that there was a weak negative correlation between pH and salinity and the values ranged between 7.03 and 8.99 and average. Total 8.13 overall. The salinity of the Shatt al-Arab water was affected by the tides, especially in areas near the mouth, and decreases when it becomes far from the mouth, and there is a significant impact of the leakage of seawater salinity and at a distance of 65 km downstream of the Karoun River and there is an approach to the salinity of seawater at the end of the tide period, and the salinity system varies greatly along the axis of the mouth of the Shatt al-Arab River, and the decrease in salinity with the distance from the sea at a fixed point in time is associated with water discharge Freshwater and Tidal Phase (19). Al-Taher,(16).showed in her study of the northern part of the Shatt al-Arab and six stations, namely Qurna, Al-Shafi, Al-Deir, Nahran Omar, Al-Hartha, and Al-Jazeera Al-Muhammadiyah, there is a spatial and temporal variation of the values of the studied Cations, as the lowest values of the rates for the calcium ion was recorded at 52.10 mg L^{-1} at Al-Qurna station and during April, while the highest values were recorded at Al-Jazeera Al-Muhammadiyah station during August and amounted to 380 mg L^{-1}, and the lowest values of magnesium ion rates reached 24.1 mg L^{-1} in Al-Deir and Nahran stations. Omar during March, while the highest values were recorded in Al-Shafi station, and during January amounted to 277.71 mg L^{-1}, as well as the values of sodium ion rates 978 and 110 mg L^{-1} as the highest and lowest value in Hartha and Qurna stations during September respectively. Mohammed and Al-Chalabi, (23).mentioned through their study to assess the environmental impact of the Shatt al-Arab as a river that receives industrial wastewater and for three stations, namely the paper factory, the Hartha power station, and the Najibiya power station, there are differences between the concentrations of sodium, potassium, calcium, and magnesium ions amounting to 372, 375, 532 mg L^{-1}, 14.85, 18.88, 16.48 mg L^{-1}, 90.32, 63.48, 82.92 mg L^{-1}, 107.22, 127.75 and 142.97 mg L^{-1} for ions and stations respectively. The values of the negative ion concentrations studied in the waters of the Shatt al-Arab varied for the period from December 2012 to November 2013, reaching (524.5-788.18), (499.26-1224.50) and (172.13-786.9) mg L^{-1}.for chloride, sulfate, and bicarbonate ions respectively (9). Dawood, et al. (19) found five sampling sites on the Shatt al-Arab that stretched from Karma Ali to FAO, There is a spatial and temporal variation of the values of sulfate and

chloride ion concentrations, ranging from 1075.00 mg L^{-1} during the winter season and respectively and 360.00 -1200.00 mg L^{-1} and 494.00 -16150.00 mg L^{-1} during the summer and respectively .The results of a study of six sites on the Shatt al-Arab stream for the years 2014 and 2015 showed that the average concentration of chloride, bicarbonate, and sulfate was (308-300-405),(284-249-315),(71-53-100) mg l^{-1} respectively for the north, near and south of the Hartha station, while it amounted to (209-368-509), (442-515-436), (278-169-275) mg l^{-1} respectively for the north, near and south of the Najibiya station(25). The study aimed to find out the extent of variation in the values of salinity, the concentration of dissolved solids, concentrations of some positive and anions spatially and temporally, and the extent to which they are affected by tidal movement

Materials and methods

Work Study Area:

The study was conducted on the course of the Shatt al-Arab and after conducting a field survey of the course of the river, four representative stations were selected for the study, (Fig. 1 and Table 1) showing the locations of the stations and their events.

Table 1. The coordinates of the locations of the measurement stations.

Sq.	Stations	Longitude	Latitude
1	Syed Ali Al-Nour Bridge	$47^0$29'56.66'E	$30^0$54'6.52'N
2	Saad Bridge	$47^0$42'3.58'E	$30^0$44'41.82'N
3	Al- Ashar	$47^0$5035.01E	$30^0$31'15.49'N
4	Sehan	$48^0$11'42.69'E	$30^0$19'35.70'

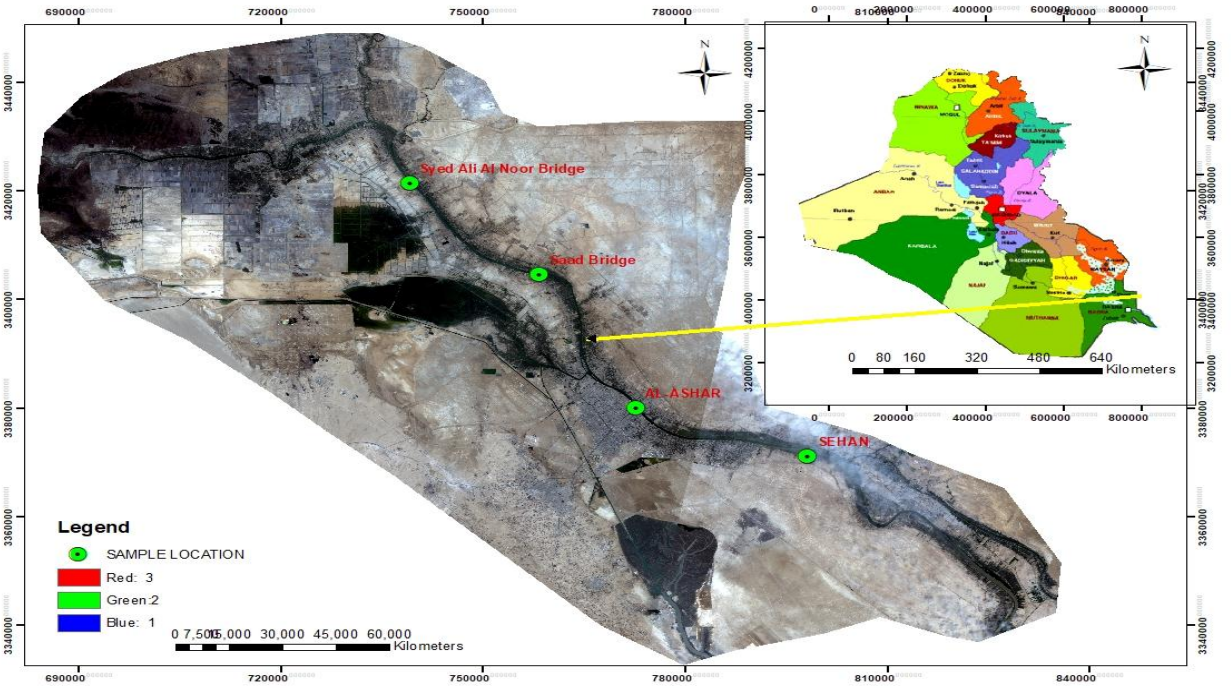

Figure 1. Locations of the study stations

The climate of the study area:

The prevailing climate in the study area is characterized by being a semi-tropical continental climate, as can be observed in the prevalence of two seasons mainly the winter season and the summer season, and despite the small amount of rain falling in this region, its fall is concentrated during the winter, and the summer season was characterized by high temperatures that exceed 50 C^{o} on some days, especially in July and August, that the prevailing winds in the region are the north and northwest winds (21). The study included three main factors:

The study station factor (four stations) is symbolized by (S). As the first station is located at the Syed Ali Al-Nour Bridge, south of Qurna, (S_1), the second station is in the Hartha area at Saad Bridge (S_2), and

the third station was at the city center, Al-Ashar area, (S_3) and the last station was at the Sehan area near the border station, (S_4) The time factor is symbolized by the symbol (T) and includes the study period for four seasons, namely, summer semester / September (T_1), autumn semester / October (T_2), winter season / December determined in the samples using a flame emitter type (ENWAY PFP7). Sulfate ions were estimated by turbidity method using UVD 3200 at a wavelength of 420 nm, chloride ions were estimated by flushing method with silver nitrate $AgNO_3$ 0.01N (17), bicarbonate ions were estimated by flushing method with a dilute solution of (T_3) for the year 2021 and Spring/April (T_4) semester for 2022.

Depth factor:

It included dividing the water column in each stretch into three equal depths, taking water samples from each depth (D_1), the second depth (D_2), and the third depth (D_3). A bottle with a tight stopper was used, the opening of the bottle was controlled by a wire and the bottle was lowered to the required depth using a tape measure.

Laboratory work: - After bringing the samples to the laboratory and keeping them in the refrigerator, some chemical and physical analyzes were carried out on them as described by APHA, (17). The calcium ion was determined by dispelling with 0.01M Na_2 – EDTA solution and using the Murxide index, and the results were expressed in mg-1. The total hardness of the water samples was estimated by abrasion method with Na_2- EDTA 0.01M solution (17). Magnesium ions were estimated by the computational method after calculating total hardness and calcium hardness. Sodium and potassium ions were

sulfuric acid $H2SO_4$ 0.01N. The pH of the Shatt al-Arab water was measured directly in the field by pH - meter type 3 - AMTAST) and the degree of temperature is 25 "°C. The statistical analysis was performed using the statistical program SPSS, and the value of the least significant difference is the average RLSD (13).

Results and Discussion

Hydrogen Acid:

The results in Table 2 show that there are significant differences in pH values

between the studied stations, with all values tending to light to medium basicity, due to the predominance of some ions with basic or alkaline hydrolysis, such as bicarbonate salts and magnesium salts, and this is a characteristic of Iraqi water (8). The highest values were recorded in the paper factory station, which amounted to 7.972, followed by Sehan station 7.957, then Al-Sadah Al-Nour station, and finally Al-Ashar station, which amounted to 7.851. From the results in Table 2, it was found that there were significant differences in the values of pH for the studied periods (four seasons), as the values reached 7.884 and 7.980. and 7.932 and 7.886 and for the summer, autumn, and winter seasons of 2021 and spring of 2022 respectively. The reason for the high values in the summer-autumn seasons is that this season falls within the period of scarcity, as the discharge of Shatt al-Arab, which results in an increase in the concentration of salts due to the effect of the tide movement coming from the Gulf, which leads to a rise in the pH of the water due to the entry of water during the tide, which contains high concentrations of bicarbonate and magnesium salts (15). As for the effect of the depths, the results of the statistical analysis showed that there were no significant differences between the pH values, due to the state of mixing and blending that occurs to the water due to the daily tidal movement, as well as the movement of ships and fishing boats in the course of the river and the movement of the wind. The interaction between the time factor and the station factor has a significant impact on the pH values of the Shatt Al-Arab water, and the variation in the pH b

Table (2) Effect of triple interference between stations and seasons and depth on the pH values of the waters of the Shatt al-Arab.

S	T	D_1	D_2	D_3	S X T	S
S_1	T_1	7.833	7.823	7.873	7.843	7.902
	T_2	8.063	8.053	8.057	8.058	
	T_3	7.913	7.920	7.857	7.897	
	T_4	7.803	7.813	7.817	7.811	
S_2	T_1	7.980	7.963	7.967	7.970	7.972
	T_2	8.043	8.037	8.053	8.044	
	T_3	7.977	7.980	7.980	7.979	
	T_4	7.887	7.913	7.887	7.896	
S_3	T_1	7.827	7.800	7.793	7.807	7.851
	T_2	7.860	7.940	7.893	7.898	
	T_3	7.827	7.830	7.827	7.828	
	T_4	7.870	7.887	7.860	7.872	
S_4	T_1	7.947	7.907	7.893	7.916	7.957
	T_2	7.930	7.927	7.907	7.921	
	T_3	8.047	8.043	7.987	8.026	

	T_4	7.987	7.960	7.950	7.966	RLDS of S=0.026	
Avr. T		7.884	07.98	7.932	7.886	RLSD of S*T =0.031	RLSD of T=0.028

values between the seasons of the year varies according to the study station, as the highest variations showed at Al-Sadah station to decrease to its minimum at Al-Ashar and Sehan stations, and this is due to the difference in the prevailing water source at Al-Sadah Al-Nour stations. The

Electrical conductivity:-

The results of Table 3 showed that there are significant differences between the values of electrical conductivity of the studied stations, as the values increase as we head south towards the mouth of the river, as the highest values reached Sehan station and amounted to 8.454 ds m^{-1}, while the lowest values reached 1.898 ds m^{-1} at Al-Sadah Al-Noor station, and this is due to the effect of water movement during the tide and coming from the Gulf and according to the proximity and distance of the stations from the mouth of the river, the values of electrical conductivity are high in the areas near the mouth and decrease Values whenever we head towards the upper river due to the low impact of tide movement in those areas as well as their impact on the brackish water coming from the Tigris River, (2). When comparing the increase in the electrical conductivity values of the stations of the paper factory, Al-Ashar and Sehan with Al-Sadah Al-Nour station (as a comparison station), the increase rate was 9.6%, 104%, and 345% respectively, this indicates that the increase in the values of electrical conductivity towards the south of the Shatt Al-Arab is an increase in combined at the stations of the paper factory and Al-Ashar sourced from puncture water and the branches associated with the Shatt Al-Arab. While the exponential increase at the Sehan station due to the presence of a paper mill in which brackish water predominates, while the predominance of salt tidal water with increased water accumulation at the Ashar and Sehan stations has reduced the variation between the seasons. (Table 2).

highly concentrated water source sourced from the tide coming from the Gulf, (6). The table shows that there are significant differences in the values for the seasons studied and that the highest average values were recorded in the summer season and amounted to 4.918 ds m^{-1}, followed by the autumn season 4.389 ds m^{-1} and then the winter season 3.972 ds m^{-1}, while the lowest values in the spring season amounted to 3.024 ds m^{-1}, and the reason for the high values in the summer and autumn is due to the decrease in drainage and the decline in revenues of the Shatt al-Arab stream, which allows the entry of salt water during the movement of water in the event of the tide (11). On the other hand, it is due to high temperatures and increased evaporation rates, which contribute to increasing the concentrations of dissolved salts (20). As for the vertical gradient of salt concentrations, the results of the statistical analysis showed a significant difference at the level of 0.05 between the surface depth (first) and the last depth (third) only, as the values reached 4.030, 4.084, and 4.113 ds m^{-1} for the first, second and third depths, respectively. This is due to the increase in the density of salt water, which settles in the lower depths of the riverbed, while the less saline water rises to the surface, so this difference in values occurs, especially when the distance or separation between the depths is large, i.e. the salt concentrations in the river water column increase with increasing

depths (26). While there are no significant differences between the first and second depth, as well as there are no differences between the second depth and the third depth, due to the proximity of the distance between these depths and the activity of the mixing process that takes place in the Shatt Al-Arab River, (6), who showed through their study that the Shatt Al-Arab is characterized by strong mixing and weak stratification. The variation in the conductivity values between the seasons of the year varies according to the study stations, as it showed the highest variations in the EC values between the seasons of the study at Sehan station, then decreases significantly in the Al-Ashar and the paper factory stations, and the differences in values disappeared at Al-sadah Al-Nour station, and this is due to the impact of Sehan station in the months of scarcity by the movement of the tide and the progress of salt water more than other stations, so we find that the EC values rise in the summer and autumn seasons and there is a greater variation In the EC values between the seasons of the year for this station because this station is affected during the seasons of abundance (winter and spring) by the brackish water coming from the upper river and from the Karun River, which discharges some of its water during intermittent periods of the abundance season, (18).

Table (3) Effect of triple interference between stations, seasons, and depth on salinity values of Shatt al-Arab water.

S	T	D_1	D_2	D_3	S X T	S
S_1	T_1	1.933	1.945	1.958	1.946	1.898
	T_2	1.935	1.940	1.947	1.941	
	T_3	1.857	1.857	1.865	1.859	
	T_4	1.835	1.850	1.860	1.848	
S_2	T_1	2.300	2.312	2.330	2.314	2.080
	T_2	2.048	2.053	2.062	2.054	
	T_3	2.028	2.038	2.045	2.037	
	T_4	1.905	1.913	1.925	1.914	
S_3	T_1	4.048	4.088	4.148	4.095	3.870
	T_2	3.920	3.975	4.007	3.967	
	T_3	3.887	3.913	3.928	3.909	
	T_4	3.425	3.535	3.565	3.508	
S_4	T_1	11.063	11.390	11.495	11.316	8.454
	T_2	9.498	9.588	9.690	9.592	
	T_3	7.982	8.117	8.147	8.082	
	T_4	4.812	4.825	4.843	4.827	RLDS of S=0.17
Avr. T		4.918	4.389	3.972	3.024	RLSDOF S*T =0.34 / RLSD of T=0.20

Total hardness and calcium, magnesium, and sodium ions:

The results of the statistical analysis showed significant differences between the average values of calcium, magnesium, and sodium ion concentrations and the total hardness of the stations and seasons studied, and it is clear from Figure 1 that the highest rates of the above ion concentrations values were recorded in the fourth station (Sehan) and amounted to 480.45, 118.15, 931.77 and 1508.53 mg L^{-1} for the above ions respectively, while the lowest values at the first station (Al-Sadah Al-Nour) were 120.14, 44.87, 185.15 and 487.70 mg l^{-1} respectively for the above ions. Figure 1 shows that the highest values by season studied were recorded in the summer and amounted to 294.12, 74.70, 489.48, and 1040.64 mg L^{-1} for ions Ca, Mg, Na, and TH respectively, while the lowest values were recorded in the spring of 178.47, 53.11, 336.06 and 674.42 mg L^{-1} for the same ions respectively. The results of the statistical analysis also showed that there were no significant differences between the average values of the concentrations of both magnesium and sodium ions for all depths studied, while there was a significant difference between the first and second depths of the values of calcium ion concentration rates and total hardness. The high values of hardness and concentration of calcium, magnesium, and sodium ions at Sehan station is due to its proximity to the mouth of the river compared to other stations and its impact on the movement of the tide, which results in the entry of salt water coming from the Gulf, which raises the values of hardness and ion concentration above, and on the other hand the lack of water revenues received by the Shatt al-Arab from the Tigris River (10) and (22). As for the high values during the summer, it is due to the decrease in river discharge and lack of rain, as well as to high temperatures and increased evaporation rates, which lead to an increase in the concentration of salts and thus increase the concentrations of calcium, magnesium and sodium and high hardness values (1). The bilateral interaction between the station and time factors in the averages of the values of the concentrations of Ca, Mg, Na ions and the total hardness has a significant effect, as Figure 3 shows that the variation in the above hardness and ion values between the seasons of the year varies according to the measurement station, as we find in Figure 3-A that the highest variations occurred at Sehan station, and they were between the spring season on the one hand and the rest of the studied seasons on the other hand, and there were no significant variations in the values of Na between other seasons of the year, and it also decreases Variations between all seasons of the year at other stations. Figure 3-B showed that the highest variations in TH values between the seasons of the year occur at Sehan station, especially between spring and winter on the one hand and summer and autumn on the other, and between summer and autumn, while there is no significant variation between spring and winter, and these discrepancies decrease significantly in Al-Ashar and Al-Sadah Al-Noor stations, and discrepancies appear between summer and the rest of the seasons at the paper lab station. . As for the Ca values, Figure 3--C showed that the highest variations between the seasons appeared in Sehan station between the summer and spring seasons, which is the largest variation, and between these two seasons on the one hand and the autumn and winter seasons on the other hand in this station, while the variations in other stations decrease significantly. The matter differs

slightly in the values of Mg, The highest variations appear at Sehan station, especially between summer and spring and between these seasons and other seasons, then the variations between the seasons decrease slightly for the other stations and the differences between the seasons remain clear between the seasons for all stations, (Figure 3-D). Thus, we note that the highest variations of the studied

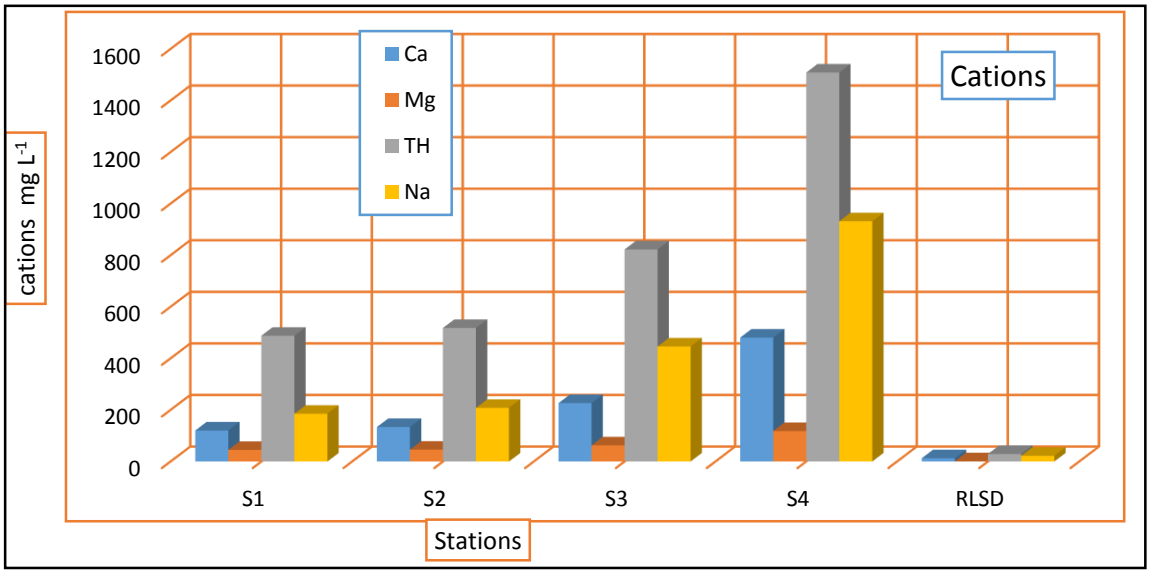

Figure (1) Concentrations of Cations and total hardness in Shatt al-Arab water for the studied stations

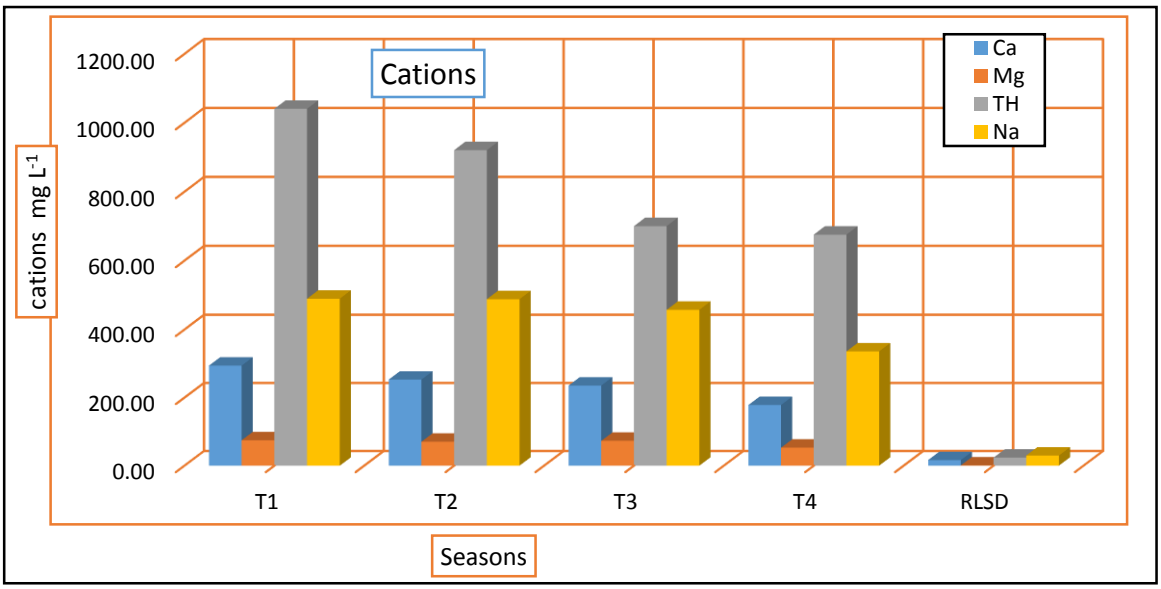

Figure (2) Concentrations of Cations and total hardness in Shatt al-Arab water for the studied seasons.

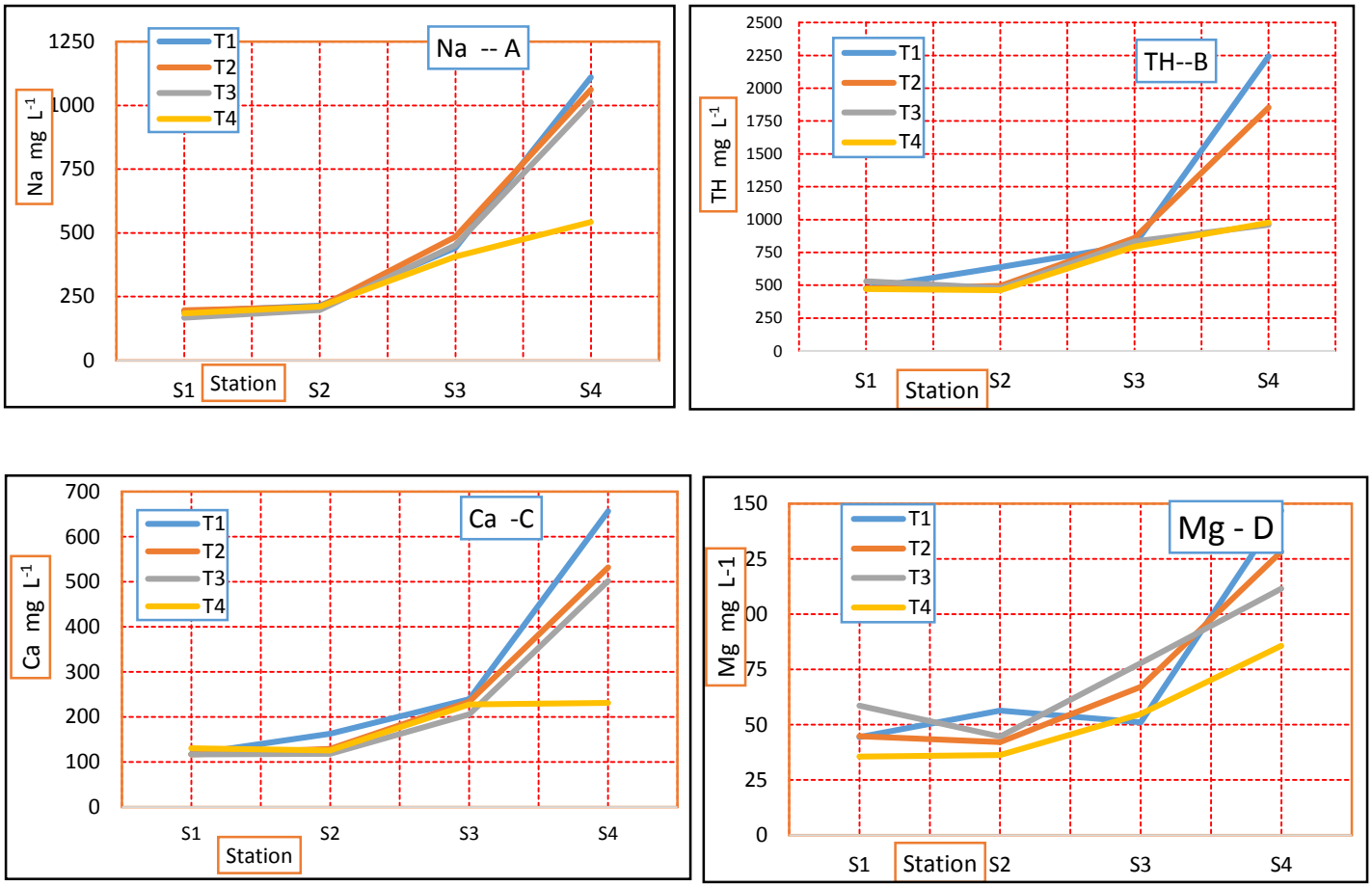

Figure 3. Binary Interference of Station and Time Factors in TH, Na, Ca, and Mg Values in Shatt al-Arab Water.

vocabulary are in the Sehan station, this may be due to the impact of this station on the phenomenon of tide and the arrival of salt water to this station, especially in the summer, when ion concentrations increase, as well as its impact in the spring season of abundance with water coming from the upper river and from the Karun River, which drains its water intermittently in the course of the Shatt al-Arab during the abundance season, and then dilutes the concentrations of salts, thus obtaining a variation in the values of these ions between seasons The year, especially the stations where the variation is low or weak due to the low impact of the tide compared to the Sehan station, and the local source of water is from river recharge water, puncture water or household waste, (12) and (5).

The anions :

The results of the statistical analysis showed significant differences between the average values of the concentrations of chloride, bicarbonate, and sulfate ions for the stations and seasons studied, and it is clear from Figure 4 that the highest rates of the values of the above ion concentrations were recorded at Sehan station and amounted to 1883.33, 285.53 and 844.87 mg L^{-1} for the above ions respectively. While the lowest values at Al-Sadah Al-Nour station were 245.79, 187.49, and 396.68 mg L^{-1} for the same ions above and respectively. Figure 5 shows that the highest values according to the seasons studied were recorded in the summer and amounted to 882.51, 256.47, and 644.83 mg L^{-1} for the ions CL, HCO_3, and SO_4

respectively. The lowest values were recorded in the spring at 490.49, 199.66, and 503.16 mg L^{-1} for the same ions, respectively. The results of the statistical analysis also show that there are no significant differences between the values of the studied depths for all ions. . The high concentrations of Cl, HCO_3, and SO_4 ions in Sehan station compared to other stations are due to the participation of this station with other stations with water sources such as feedwater, sewage, agricultural and industrial water, which eject the riverbed, in addition to saline marine water containing high concentrations of these ions, which reach this station as a result of its proximity to the mouth of the river and its impact on the movement of the tide significantly compared to other stations, (7) and (4). In the values of HCO_3, Cl, and SO_4 ions, Figure 6 showed that the variation in the values of these ions between the seasons of the year occurs according to the stations studied, as it was found that the highest variation in the values of bicarbonate ion between the seasons of the year is at Sehan station, and the highest variation between spring and summer is at this station, and

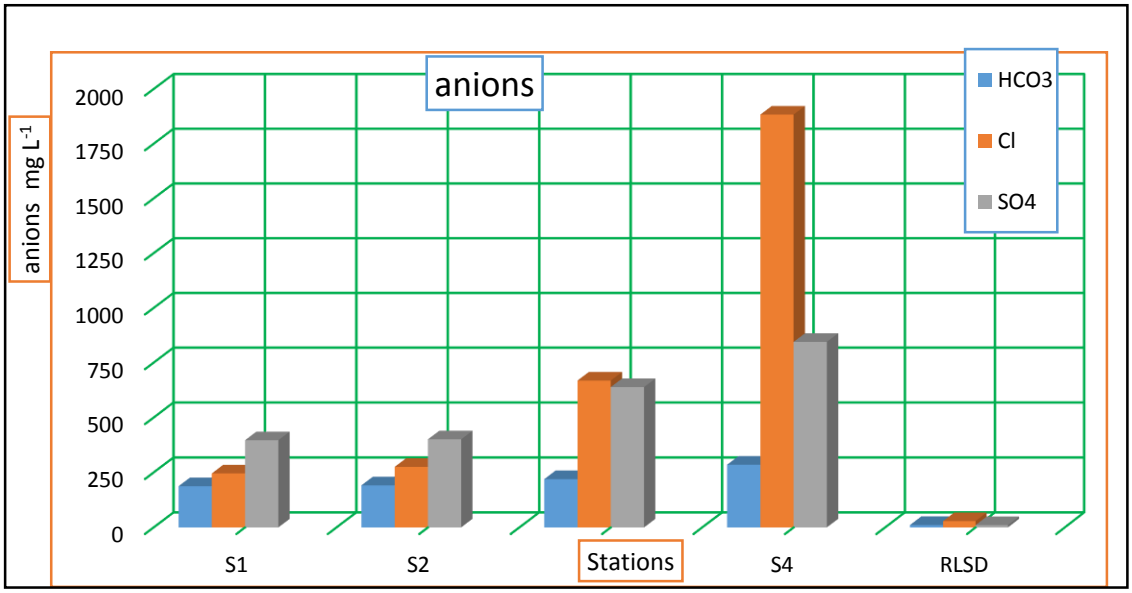

Figure 4. Concentrations of anions in Shatt al-Arab water for the studied stations.

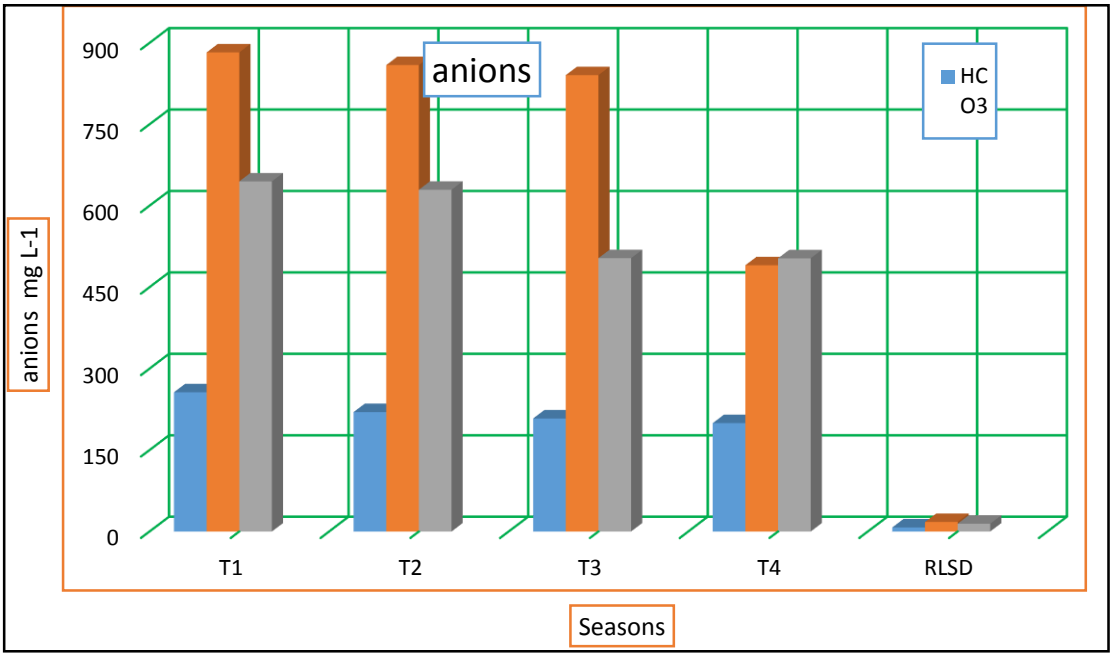

Figure 5. Concentrations of anions in Shatt al-Arab water for the studied seasons.

these variations decrease in Al-Ashar station and then decrease further in the two paper factory stations and the gentlemen of light, (Figure 6-A). Figure 6-B also showed that the highest variations in Cl values between the seasons of the year were in Sehan station, as there was a large variation between the spring season on the one hand and the rest of the other seasons on the other hand, and then these variations decreased significantly in the rest of the significant decrease in the variations in the paper factory and Al-Sadah Al-Nour stations, (Figure 6-C). These differences in values between the seasons at Sehan station are because this station is closer to the mouth of the river from other stations and be affected by the movement of tides and marine waters more than other stations, and the difference in this effect according to the seasons of the year, as the stations. The highest variations in the values of the SO_4 ion between the seasons of the year were at Sehan station, as there were large variations between the spring and summer, and autumn seasons, and there is less variation between the winter season and the summer and autumn seasons at this station, then the variations between the seasons decrease in the publican station, and then there is a

impact of the movement of the tide is greater in the summer and autumn seasons (seasons of scarcity) and this effect decreases in the spring (season of abundance) and obtaining a higher discharge of the river works to reduce concentrations, (3) and (19).

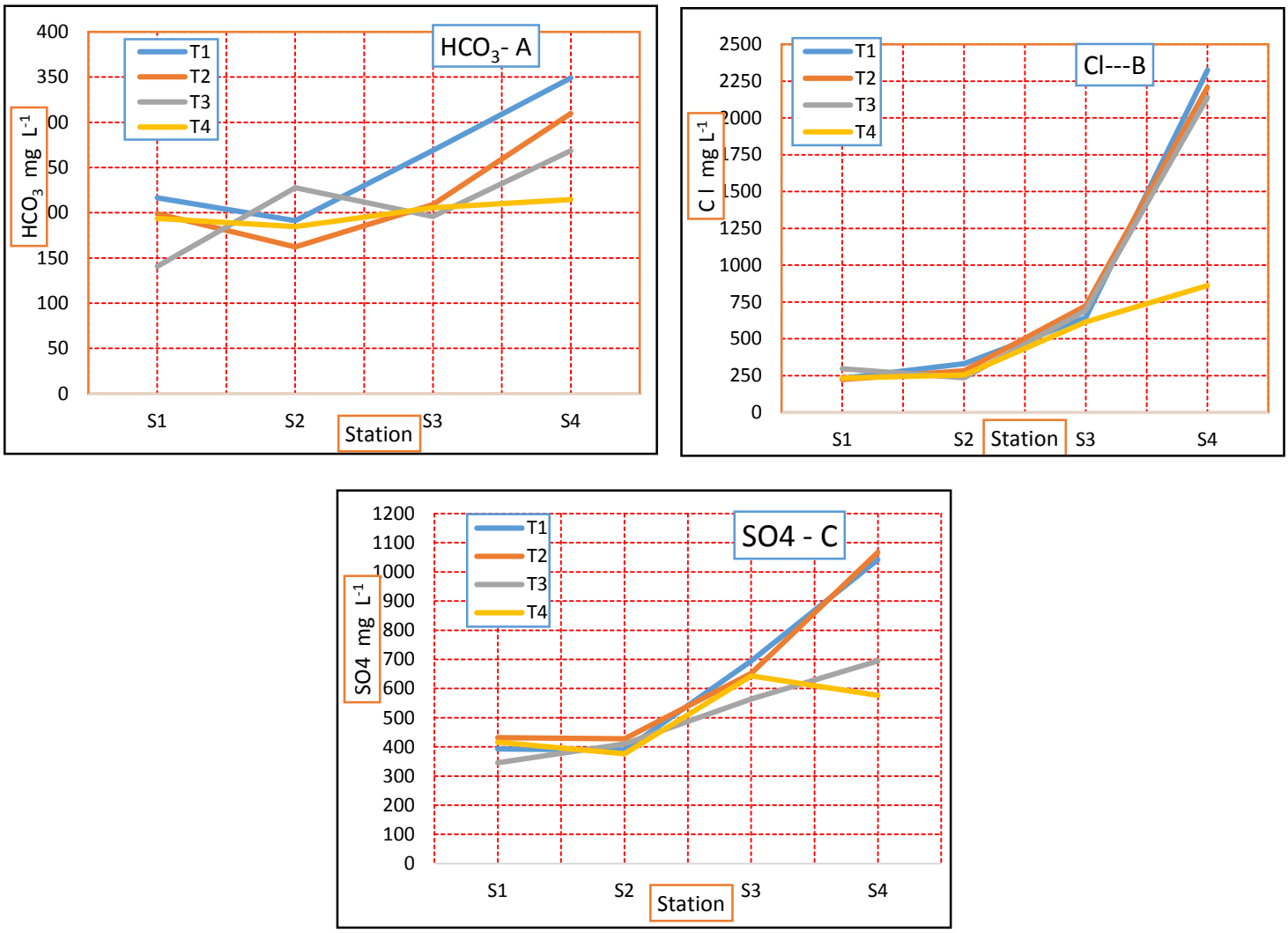

Figure (6) Binary interference of station and time factors in HCO_3, CL, and SO_4 values in Shatt al-Arab waters.

Conclusion

The study was conducted over four seasons and for four sites on the course of the Shatt al-Arab to find out the extent of changes that occur in the values of salinity and the concentrations of some cations and anions due to the movement of tides. The results showed that there is a spatial and temporal variation in the values of salinity and concentrations of cations and anions, depending on the influence of tidal currents coming from the Gulf and as a result of the lack of water supply from the Tigris River, which is the main source of Shatt al-Arab water, as the lower the water revenues, the greater the penetration of the salt tide into the Shatt al-Arab and the hydrochemical properties of the river water were affected, which leads to poor quality of water, which reflects negatively on the use of this water for domestic and agricultural purposes as well as its use as drinking water.

Conflict of interest

The authors have no conflict of interest.

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