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Hydrochemical properties and water quality for Shatt Al-Arab river in Basrah

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Abstract

The assessment of water quality is one of the important issues in managing water resources, the great pollution that this water encounters, this study was conducted to assess the water quality of the Shatt Al-Arab on the basis of the chemical, physical and qualitative characteristics taken for the river, following standard methods and indicating the extent of pollution in its waters. Sixteen stations were selected on the Shatt al-Arab from north to south for the period from (October 2021-September 2022), and the measurements were monthly. Eight properties of water quality were calculated, such as electrical conductivity, calcium, magnesium, sodium, potassium, chloride, sulfate, carbonate and bicarbonate. The results were evaluated graphically using Piper chart for four seasons, presenting the chemical analysis with diagrams and numbers makes the understanding of the complex water system simpler and faster. The arrangement of the cations was approximately in Mg^{+2}>K^{+} (Ca^{+2}>K^{+}), as for the concentration of the anions, it was in the order (Cl^{-} > SO_4^{-2} >CO_3^{-2}+HCO_3^{-}). The study showed that there are seasonal and regional variations depending on the time and place of sampling, the water quality of most of the stations is alkaline ground water with an increase in the levels of sulfates or chlorides, and the rest of the stations mentioned, the quality of its water was alkaline, contained high levels of calcium and magnesium ions, and a mixture of sodium and potassium. The dominance of sulphate ions or chlorides at high concentrations exceeded the Iraqi standards, which determined (200 $mg.L^{-1}$) for chloride and sulfate in the system for protecting rivers from pollution in 1967 and the system of Ayers and Westcot 1985, determined the concentration of chlorine (149 and 9 $meq.L^{-1/2}$ (SAR), meaning that it was polluted water and not suitable for irrigation in most stations.

Keywords: Piper Digram, Pollution, Shatt Al-Arab, Water quality.

Introduction

Hydrochemistry represents the complete interaction of hydrological, chemical, physical and biological factors of ecosystems. Hydrochemistry focuses on investigating the chemical composition of surface water and its interaction with the terrestrial environment of the area it passes through (Kendall and Donnell, 1999; Nedewi and Al-Draji, 2021; Ahmed and Hassan, 2021).

Water quality depends on the geology of the watershed area studied and on a number of climatic factors, determining the water quality gives a clear idea of the extent of water pollution and the sources of this pollution, improves water quality for various purposes. The water change is compatible with the natural ecosystem, any change in the water quality is considered a disruption to the ecosystem and its natural cycles, and thus leads to pollution. The water quality of any area can be determined by adopting the physical, chemical and biological characteristics, graphic representations to determine the suitability of river water for a particular use, such as water quality indicators and trigonometric charts to represent data graphically, such as Pipers and Stiff diagrams, etc. (Healey, 2014; Ati *et al*., 2021)

Warren (1971) showed that water quality is a criterion for assessing and evaluating the suitability of water for various uses, the most important indicators affecting water quality are the chemical, physical and biological properties of water.

Ayers and Westcot (1985) noted that the quality of irrigation water depends on the chemical composition and total concentration of dissolved salts.

The foundations adopted for the purpose of evaluating irrigation water depend on the danger of that water on the soil, crop growth, and the human being, who in turn consumes those crops.

Material and methods

Study area description:

This research was conducted to assess the water quality of the Shatt Al-Arab, on the basis of chemical, physical and qualitative properties, statement of the quality and suitability of Shatt al-Arab water for irrigation, sixteen stations have been selected on the Shatt al-Arab from north to south (Fig. 1).

Figure (1): Map of water sampling sites along the Shatt al-Arab stream from Al-Qurna to Al-Faw.

Surface water samples were collected from the Shatt Al-Arab in the city of Basra at sixteen stations from the north to the south of the river, they are (Al-Qurna S1, Paper Mill S2, Al-Hartha S3, Najibiyah S4, Ports S5, Al-Ashar S6- Al-Baradiyah S7- Presidential Palaces S8, Al-Bahadriya S9, Al-Muhaila S10, Abu Al-Khasib S11, Seyhan S12, Al-Siba S13, Al-Duwaib S1, Al-Faw S15 and Al-Naqaa S16) respectively, from 10/2021 to 9/2022, for each month, according to what is shown in Figure (1). The samples were placed in clean plastic containers with a capacity of (1 liter), it was kept in the refrigerator at a temperature of 4 °C to make the remaining required measurements of chemical properties in the laboratories of the Soil Heights and Water Resources Department.

The electrical conductivity (E.C) and the concentrations of positive and negative ions were measured for samples taken from Shatt Al-Arab water based on the methods described in APHA (2017), of these ions (chloride Cl^{-1}, sulfate SO_4^{-2}, carbonate and bicarbonate (CO_3^{-2}+HCO_3^{-1}), calcium, Ca^{+2}, magnesium-Mg^{+2}, Na^{+1} and sodium-potassium (K^{+1}).

Statistical analysis:

The statistical analysis of the data was based on the statistical program (SPSS Ver.1.7) (Statistical Package for Social Science) and below the level of significance 0.05, and the Least Significant Difference Least (LSD) test (Al-Rawi and Khalaf Allah, 1980).

Results and Discussion

Chemical properties of water

Electrical conductivity (E.C):

Figure (2) shows the variation in electrical conductivity values locally according to the stations under study and according to the season in which the measurement was made. The northern stations of the Shatt Al-Arab (Al-Qurna, Paper Mill, Al-Hartha, Al-Najibia, and Ports) recorded low values compared to the northern stations. The lowest rate was in the first station (Al-Qurna) in four seasons (which were autumn, winter, spring and summer). The averages were recorded in the order (1.9, 1.4, 4.2 and 4.4 $ms.cm^{-1}$), followed by the second station (Paper Mill) recording the rate (2.3 and 1.5 $ms.cm^{-1}$) during the autumn and winter seasons, respectively. It shared with the first station the same size during the spring and summer seasons (4.4 and 4.2 $ms.cm^{-1}$). The distance of these stations from the salt tongue coming from the Gulf, in addition to the lack of pollutants dumped in the river at the beginning of the city, while the stations located in the southern part of the Shatt Al-Arab (Al-Seyhan, Al-Siba, Al-Duib, Al-Faw and Al-Naqaa) recorded high values of electrical conductivity, as it reached its highest value in the fifteenth station (Al-Faw) in the autumn and summer seasons, which is (27.6 and 21.5 $ms.cm^{-1}$), respectively, and the sixteenth station (Al-Naqaa), recording averages during the winter and spring seasons, also in order (13.8 and 16.3 $ms.cm^{-1}$). The reason for this is due to the increased influence of the salty waters of the Gulf on these stations and what they throw during the tides, in addition to increasing the effect of sewage waste dumped in the river and the dissolved salts it contains at high concentrations, it was confirmed by Al-Mahmoud et al. (2015) in his study by analyzing the discharge and salinity data in the Shatt Al-Arab from the high salt concentrations in the Shatt Al-Arab, especially in the years from 2009-2018, especially in the southern part of the river between Seyhan and Al-Faw, reached by Moyle (2010) in his study of the Shatt Al-Arab was a discrepancy in the electrical conductivity values between the stations located in the north of the river, and it was the lowest in the northern stations and increases with the progress of the river towards the middle, as for the seasonal changes in electrical conductivity rates, it was evident during the study period, as all stations recorded the lowest rates during the winter season and the highest rates were in the summer season. The first station (Al-Qurna) recorded the lowest rate of electrical conductivity during the winter season (January, February and March), which is (1.4 $ms.cm^{-1}$), then the second station (Paper mill) registered the average (1.5 $ms.cm^{-1}$). The reasons for this are due to the dilution of the salinity of the water due to the increase in water discharge and the low evaporation rates as a result of the low temperatures, while the stations under study recorded high rates of electrical conductivity during the summer (June, August and July), especially in the Faw-Naqaa stations. The (Al-Faw) recorded the highest rate, which was (27.6 ms.cm-1), followed by the last station (Al-Naqaa), which recorded the average (27.5 ms.cm-1) during this season. The lack of drainage of the Shatt al-Arab is due to the low water levels of the Tigris and Euphrates rivers and the closure of some tributaries such as the Karun River.

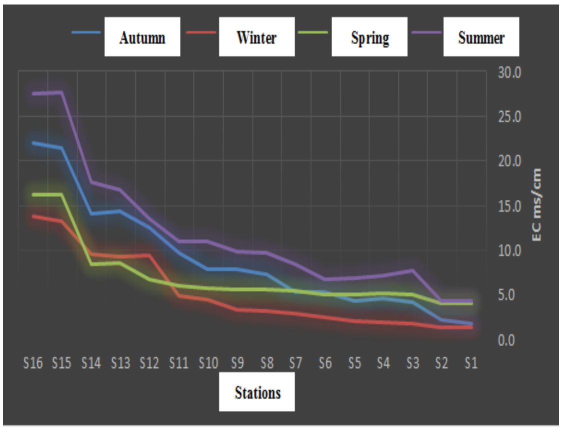

Figure (2): Electrical conductivity at the different stations during the four seasons along Shatt Al-Arab.

Calcium (Ca):

Figure (3) shows seasonal and local changes in calcium concentration according to the stations under study, as for the locational changes, the lowest rates were recorded in the stations located in the northern part of the Shatt al-Arab, and the highest in the stations located in the southern part of the Shatt Al-Arab. The second station recorded the lowest rates in the autumn-winter-summer season and it was as follows (149.6, 73.5 and 110.7 $mg.L^{-1}$), it was followed by the first station (Al-Qurna), which recorded the lowest rate in the spring season, and it was (114.3 $mg.L^{-1}$), while the fifteenth station (Al-Faw) recorded the highest rate during the winter-spring-summer season, and these rates were as follows, in order (479.0, 203.7 and 202.0 mg.L^{-1}), and the sixteenth station (Al-Naqaa) recorded the lowest rate during the autumn season (4253.mg. L^{-1}), these results were consistent with Dawood et al. (2018), its stations recorded calcium values between (680.0-87.0 mg.L-1) in his study on Shatt Al-Arab water for the year (2011-2014). The results showed a decrease in calcium values for the months from December to March, the reason for the decrease in concentrations in the stations located north of the river is because they are affected by discharged from the Tigris and Euphrates rivers and the quality of their water, in addition to the residues produced by civil and agricultural activities and the presence of islands and meanders in the river, which weaken the movement of water and thus reduce the penetration of sea water north towards the Qurna site (Al-Asadi and Alhello, 2019), in addition to the rise in water levels during the cold months, which dilutes the salts and decreases their concentrations, as for the stations located in the south of the river, which are greatly affected by the salt currents from the Gulf, especially when the discharge decreases in the summer season, which leads to the release of sedimented salts at the bottom, which forms a layer with high adsorption of calcium and magnesium ions due to the progression of salt currents towards the river (Moyle, 2010). The salt front may reach the center of the city of Basrah, because the hydrological system of the Shatt al-Arab was affected by the tidal phenomenon in the Arabian Gulf, leads to a rise in salinity to levels that do not allow it to be used for any purpose (Al-Asadi, 2016; Abdullah, 2016). The results of the statistical analysis showed that there were significant differences between the stations (P>0.05), as well as significant differences between the seasons (P>0.05).

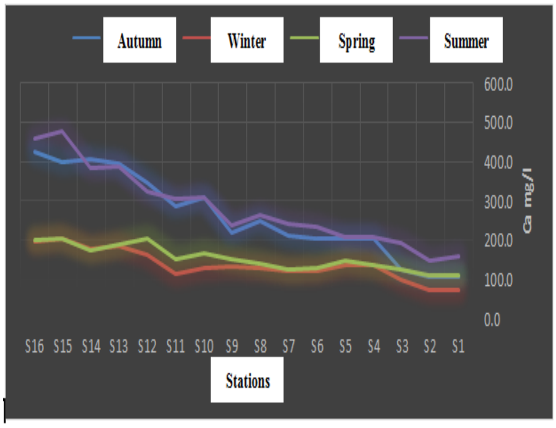

Figure (3): Calcium concentrations at different stations during the four seasons along Shatt Al-Arab.

Magnesium

Seasonal and locational changes in magnesium levels in the selected stations were also variable (Fig. 4), The first and second stations recorded the lowest values in all seasons of the year. The first station (Al-Qurna) recorded the lowest rate in the autumn-summer semester and was as follows (133.4 and 77.7 $mg.L^{-1}$), the second station (Paper Mill) recorded the lowest rate in the winter-spring semester (90.7 and 30.7 $mg.L^{-1}$), while the fifteenth station (Al-Faw) recorded the highest rate of magnesium during the autumn, spring and summer seasons, and the rates were as follows, in order (1252.5, 330.6 and 546.9 $mg.L^{-1}$). The eleventh station (Abu Al-Khasib) recorded the highest rate (110.4 $mg.L^{-1}$) in the winter season, and these results are consistent with (Dawood *et al*., 2018), in studying and evaluating the quality of surface water and its changes in the Shatt Al-Arab River in Basra Governorate from (2011-2014). Magnesium values varied from (36 mg.l-(1) to ((1464$mg.L^{-1}$) recorded in 2013, and with the findings of (Gatea, 2018) in his study of the water quality of the Shatt Al-Arab in six stations: (Al-Qurna, Basrah and Al-Maqal, Abu Al-Khasib, Al-Siba and Al-Maqal), as the values of magnesium were confined between 1763-72 $mg.L^{-1}$. The reason is attributed to the superiority of magnesium rates over calcium rates, especially for the spring and summer seasons in most of the stations and some stations in the autumn season (Al-Hartha, Al-Ashar, Abu Al-Khasib, Al-Faw and Al-Naqaa), because these stations were affected by the salt front coming from the Gulf and containing high concentrations of magnesium ions more than calcium, also, with any increase in the concentration of dissolved salts, the hardness of magnesium increases faster than the hardness of calcium (Jaafar, 2010). The results of the statistical analysis showed that there were significant differences (P>0.05) between the stations under study, as well as significant differences (P>0.05) between the seasons.

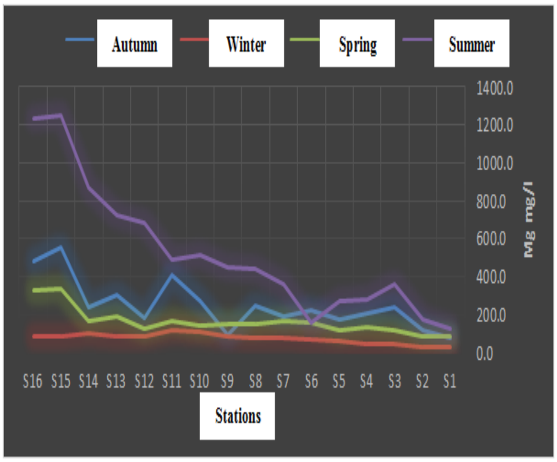

Figure (4): Magnesium concentrations at different stations during the four seasons along Shatt Al-Arab.

Sodium (Na):

The seasonal and local changes in the sodium values of the stations chosen in the study (Figure 5), the lowest rate was recorded in the first and second stations and in the four seasons. The first station

(Qurna) recorded the lowest rate during the winter and spring seasons, which is (645.1 and 154.0 mg.L^{-1}). The second station (the paper mill) recorded the lowest rate during the summer and autumn seasons, which is, in order, (183.1 and 502.9 mg.L^{-1}), while the stations located in the southern part of the Shatt Al-Arab recorded the highest levels of sodium, and the most severe ones were in the last two stations (Al-Faw and Al-Naqaa). The highest rate was recorded in (Naqaa) during autumn, winter and summer, as follows (3255.9, 2725.2 and 3488.5 mg.L^{-1}), as for Al-Faw, it recorded the lowest rate during the spring season, which is (2796.3 mg.L^{-1}), as for the seasonal changes, the lowest rate of magnesium was recorded during the winter season at the station (154.0 mg.L^{-1}), and the highest rate was recorded in the autumn and summer seasons (3488.5 and 3255.9 mg.L^{-1}), these values are consistent with previous studies on sodium values in Shatt Al-Arab waters (Lateef *et al.*, 2020; Al-Hejuje, 2014). The results of the statistical analysis showed that there were significant differences (P<0.05) between the studied stations, as well as the presence of significant differences between the seasons.

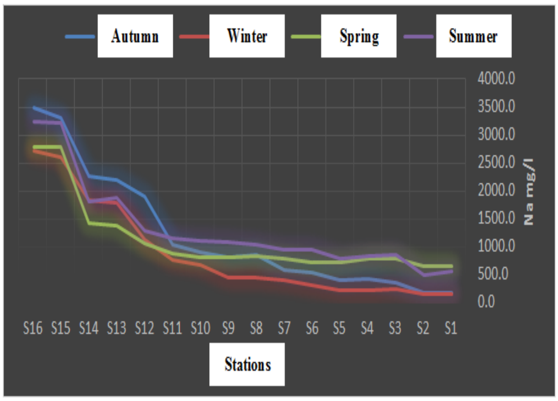

Figure (5): Sodium concentrations at the different stations during the four seasons along Shatt Al-Arab.

Potassium (K):

Figure (6) shows potassium levels in plants during four seasons, the lowest recorded average of potassium was in the first station (Al-Qurna) and the second (Paper Mill) during the four seasons (autumn, winter, spring and summer). The first station (Al-Qurna) recorded the lowest rate, which is (4.9, 7.5, 3.7 and 5.3 mg.L^{-1}) in the four seasons, followed by the second station (The Paper Mill) (recording rates) (9.3, 9.6, 4.6 and 7.6 mg.L^{-1}), as for the seasonal changes, the lowest rate recorded was in the winter season in the first station (Al-Qurna), and the rate of potassium was (3.7 mg.L^{-1}). The highest rate is in the last station (Al-Naqaa), which recorded (291.1 mg.L^{-1}). Potassium values were gradual from the north towards the south of the river. The highest values were recorded in the last stations and during the summer season (Al

Asadi *et al*., 2020) due to the saline effect of the waters of the Arabian Gulf, sewage and waste thrown out by factories, stations and agricultural operations, as well as high temperatures and increased evaporation.

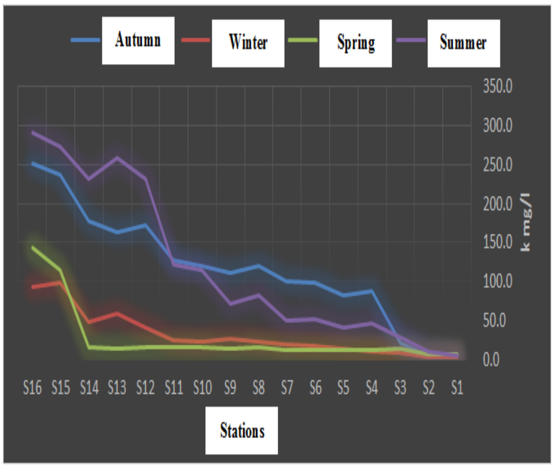

Figure (6): Potassium concentrations at different stations during the four seasons along Shatt Al-Arab.

Chloride (Cl)

Figure (7) shows the local and seasonal changes in chloride levels for stations taken along the Shatt Al-Arab. The chloride levels ranged between the lowest recorded in the first and second stations, and gradually increased as we moved towards Al-Faw and Al-Naqaa, as it was (6376.2 and 444.30 mg.L^{-1}) during the autumn season and (4153.8 and 369.6 mg.L^{-1} during the winter), and it ranged between (995 and 910.1 mg.L^{-1}) during the spring, in the summer, it ranged between (7861 and 824.9 mg.L^{-1}), as for the seasonal changes, they ranged from the lowest rate during the winter season to the highest rate during the summer season (7861 and 369 mg.L^{-1}). The reason for this is attributed to the low discharge of water from the Tigris and Euphrates and the high temperature, especially during the summer season, which increases the concentrations of dissolved salts in the water towards the south of the Shatt Al-Arab, the chloride ion is present in high concentrations in wastewater compared to raw water, because sodium chloride is a staple in the diet, its use in purification operations, in addition to the connection of the Shatt al-Arab to the secondary channels laden with sewage water and agricultural and industrial waste. Previous studies have shown high concentrations of chloride, which exceed Iraqi and international standards, as Al-Ashar recorded a concentration of up to (3360 mg.L^{-1}), while the lowest concentration was in Al-Uzair (330 mg.L^{-1}) during the winter of 2018, which exceeded the standards of the World Health Organization (250 mg.L^{-1}) (Lateef *et al.*, 2020). The results of the statistical analysis showed significant differences between the stations selected in the study, as well as significant differences between the seasons (P>0.05).

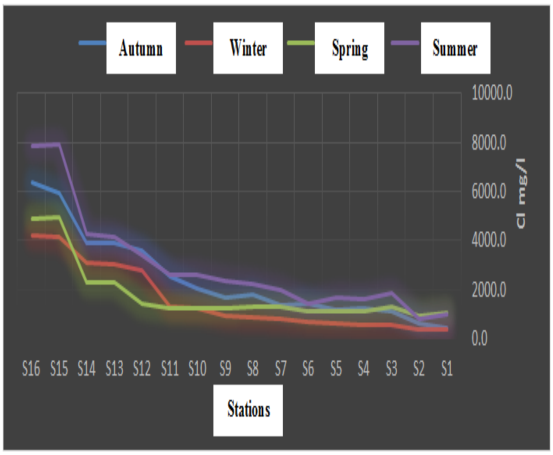

Figure (7): Chloride concentrations at different stations during the four seasons along Shatt Al-Arab.

Sulfates (SO4):

The Figure (8) show the rate of sulfate in the Shatt Al-Arab water according to the four seasons of the stations selected for the study, as the rates between the lowest and the highest rate varied between the stations and increased as we advanced towards the mouth of the river. Autumn season, (717.1 and 136.3 mg.L^{-1}) during winter, (1127.2 and 657.2 mg.L^{-1}) during spring, and (2535.2 and 757.6 mg.L^{-1}) during summer. These values were consistent with Abbas *et al*. (2014) in a study to assess the water quality of the northern part of the Shatt al-Arab, in three stations, as the lowest value recorded for sulfate was (158 mg.L^{-1}) in the first station (Al-Hartha) in January, while it was The highest recorded value is in the third station, which was (536 mg.L^{-1}) in the month of September), the reason is attributed to the proximity of these stations to populated areas, and thus the increase in waste disposal and accumulation whenever we go south of the river, and also the agreement with Lateef *et al*. (2020) in a study to determine the water quality of the Shatt Al-Arab in eleven stations, as the sulphate values ranged in her study and for four seasons (1602 and 149 mg.L^{-1} from Winter 2018 to the autumn of 2019), attributed the reason for the rise in sulfate concentrations to a number of reasons, including the presence of electric power stations and agricultural activities, in addition to what is thrown out of sewage water.

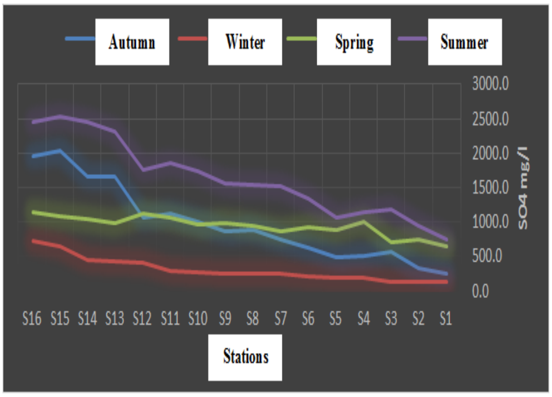

Figure (8): Sulfate concentrations at different stations during the four seasons along Shatt Al-Arab.

Carbonates and bicarbonates (CO_3+HCO_3):

The values of bicarbonate shown in Figure (9) were variable according to stations and seasons, as were the rest of the ions that preceded it. The rates ranged between 405.9 and 154.0 mg.L^{-1} during the autumn, (335.3 and 79.6 mg.L^{-1}) during the winter, (209.3 and 57.3 mg.L^{-1}) during the spring, and (148.0 and 113.3 mg. L^{-1}) during the summer, as for the seasonal changes in the levels of bicarbonate, it ranged between the lowest value in the spring and the highest value during the autumn season, it was between (05.9-57.3 mg.L^{-1}), the reason for that is due to the difference in the pollutants expelled during the seasons.

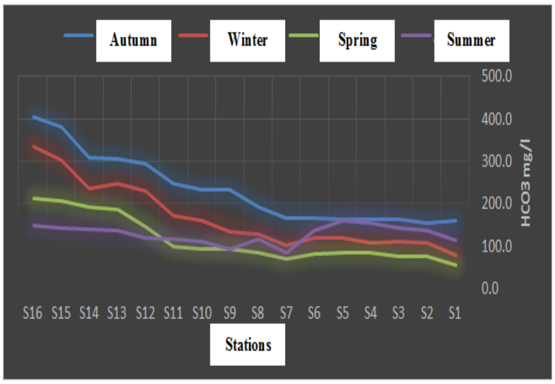

Figure (9): Sulfate concentrations at different stations during the four seasons along Shatt Al-Arab.

Piper diagram's:

The results of the chemical analyzes are plotted on a Piper's diagram, shows water analyzes and their interactions, this diagram has been developed to show the origin of this water and the source of the dissolved salts, an illustration of the various processes that affect the properties of water, indicating the nature of the mixing of this water from different sources and the paths of its development through the diagram. The diamond is represented in the Piper diagram by seven categories of water, as shown by Langguth, (1966), whose details are shown in Table (1):

Table (1): Sections of the Piper chart according to the Langguth method (1966).

Class	Secondary title	Primary title
A	With prevailing bicarbonate	Normal earth alkaline water
B	With prevailing bicarbonate and sulphate or chloride	
C	With prevailing sulphate or chloride	
D	With prevailing bicarbonate	Earth alkaline water with increase portion of alkali
E	With prevailing sulphate or chloride	
F	With prevailing bicarbonate	Alkaline water
G	With prevailing sulphate or chloride	

Autumn season:

The Piper method was used to classify the waters of the Shatt al-Arab into four seasons and sixteen stations along the Shatt al-Arab river and divide the water quality according to Langguth (1966) into seven types (A, B, C, D, E, F, G) as shown in

Figure (10), which also shows the main positive ions (Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}) and the main negative ions (Hco_3^{-1}, SO_4^{-2}, Cl^{-1}) in the autumn season, after projecting the percentages of positive and negative ions on the chart and interrupting them at one point, as the point consists of two longitudinal lines and a contact diagram, according to the directions used, and according to what is found in Figure (10), it was found that the majority of Shatt al-Arab waters are within type (G) and some of them are within type (E), which represented the stations (Al-Qurna, Paper Mill, Al-Hartha, Al-Najibiya and Al-Ashar), most of the stations are of ground alkaline water quality with an increase in the levels of sulfates or chlorides (Table 1), as for the rest of the aforementioned stations, their water quality was of an alkaline nature and contained high levels of calcium and magnesium ions, and a mixture of sodium and potassium, sulfate ions or chlorides were dominant, it was clear from the classification results the effect of the original rocks of the region on the water quality. The concentrations of chloride during this season ranged between (6376.2 and 444.3 $mg.L^{-1}$), sulfate between (2029.4 and 262.2 $mg.L^{-1}$), and sodium (3488.5 and 183.1 $mg.L^{-1}$), these concentrations exceeded the Iraqi standards, which were set (200 $mg.L^{-1}$) for chloride and sulfate in the system for protecting rivers from pollution in 1967, except for the two stations of Al-Qurna and the paper mill, and the Ayers and Westcot (1985) system, determined the concentration of chlorine (149 $mg.L^{-1}$) 9 $meq.L^{-1/2}$ (SAR), meaning that it is polluted water and not suitable for irrigation in most stations.

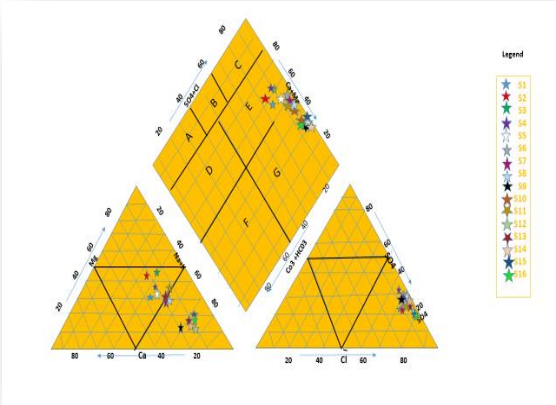

Figure (10): Water quality according to Piper's classification for the autumn season.

Winter season:

This chapter represents the months (December, January and February), the results of the study, shown in Figure (11), showed the main positive ions (Ca+2, Mg^{+2}, Na^{+1}, K^{+1}), the main negative ions (Hco_3^{-1}, SO_4^{-2}, Cl^{-1}), by projecting the percentages of the ions positive and negative on the diagram and intersect them at one point, it was found that the quality of the Shatt al-Arab water in most of the stations was within type (G) and some of them were within type (E), which was represented by the stations (Al-Qurna, Al-Najibiya and Ports), the majority of stations are characterized as alkaline water with an increase in the levels of sulfates or chlorides (Table 1), as the concentrations of chloride during this season ranged between (4153.8 and 369.6 $mg.L^{-1}$), sulfate between (717.1and 136.3 $mg.L^{-1}$), sodium (2725.2 and 154.0 $mg.L^{-1}$), as for the rest of the stations, as is evident from the classification results, the effect of the original rocks of the region on the water quality, which is (water of an alkaline-terrestrial nature) containing high levels of calcium and magnesium ions, and a mixture of sodium and potassium, and the sulfate or chloride ions were dominant, these concentrations have exceeded the Iraqi standards, which set (200 $mg.L^{-1}$) for chloride and sulfate in the system for protecting rivers from pollution in 1967, except for some stations (Al-Qurna, Al-Najibiyah and Ports) and the Ayers and Westcot (1985) system, which determined the concentration of chlorine (149 $mg.L^{-1}$) and 9 $meq.L^{-1/2}$ (SAR), meaning that it was polluted water and was not suitable for irrigation in most stations.

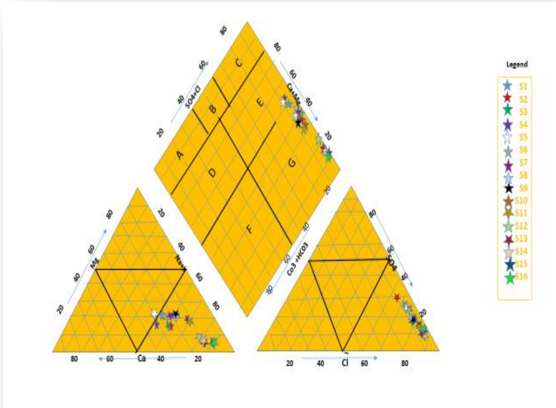

Figure (11): Water quality according to Piper classification for the winter season.

Spring season:

This chapter was represented by the months (March-April-May), results of the study shown in Figure (12) showed the main positive ions (Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}), the main negative ions (HCO_3^{-1}, SO_4^{-2}, Cl^{-1}), by projecting the percentages of positive and negative ions on the chart and interrupting them at one point, it was found that the quality of Shatt Al-Arab water in all stations was within type (G), meaning that most of the stations are alkaline water with an increase in the levels of sulphates or chlorides (Table 1), as the rates of chloride during this season ranged between (4995.4 and 910.1 $mg.L^{-1}$) and sulfates (1127.2 and 657.2 $mg.L^{-1}$), these concentrations exceeded the Iraqi standards (200 mg.L^{-1}). Regarding chloride and sulfate in the system for protecting rivers from pollution in 1967 and the of Ayers and Westcot (1985) system, which determined the concentration of chlorine (149 mg.L^{-1}) and its suitability for irrigation, that is, it is polluted water.

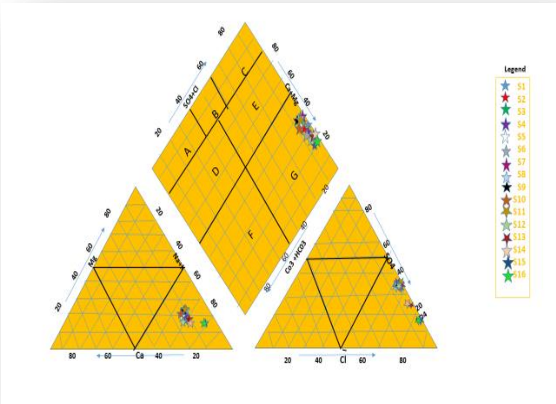

Figure (12): Water quality according to Piper's classification for the spring season.

Summer season:

This season is represented by the months (June, July and August), Figure (13) showed the main positive ions (Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}), the main negative ions (HCO_3^{-1}, SO_4^{-2} and Cl^{-1}), by projecting the percentages of positive and negative ions on the chart and interrupting them at one point, the quality of the Shatt Al-Arab water in most of the stations was within type (G) and some of them were within type (E), which was represented by the stations (Al-Bahadriya, Al-Muhaila, Abu Al-Khasib and Seyhan), the majority of stations were characterized by alkaline water with an increase in the levels of sulfates or chlorides (Table 1), as for the rest of the stations, as is evident from the classification results, the effect of the original rocks of the region on the water quality, which was (water of an alkaline-terrestrial nature) containing high levels of calcium and magnesium ions, and a mixture of sodium and potassium, and the sulfate or chloride ions were dominant, as the concentrations of chloride during this season ranged between (7861.9 and 824.9 mg.L^{-1}), sulfate between (757.6 and 2535.2 mg.L^{-1}), and sodium (3255.9 and 502.9 mg.L^{-1}), these concentrations exceeded the Iraqi standards, which set (200 mg.L^{-1}) for chloride and sulphate in the system for protecting rivers from pollution in 1985, and the system of Ayers and Westcot (1985), who determined the concentration of chlorine (149 mg.L^{-1}) and 9 meq.$L^{-1/2}$ (SAR), meaning that it is polluted water and not suitable for irrigation in most stations.

The quality of the water in all the studied stations was alkaline with the predominance of chlorides or sulfates, which are the most common in Shatt Al-Arab water compared to other compounds and in almost all seasons. Some stations have the nature of the water in it (water of an alkaline-earth nature) containing high levels of calcium and magnesium ions, and a mixture of sodium and potassium, and the sulfate or chloride ions predominated. The reason for this is that the Shatt al-Arab has recently suffered from large quantities of salinity seeping into the river compared to previous years, due to the lack of fresh water imports that used to feed the river (Hamdan *et al*., 2020), in addition to what is thrown out by homes, industrial wastewater, waste of agricultural operations, fertilizer residues, the lack of feeding the river with fresh water to reduce the impact of these factors, and the absence of stations to treat these wastes before throwing them into the river, led to the deterioration of the water quality in it and it became unsuitable for domestic and recreational uses, and even for irrigation, unless purification and treatment processes were carried out before using it (Gatea, 2018).

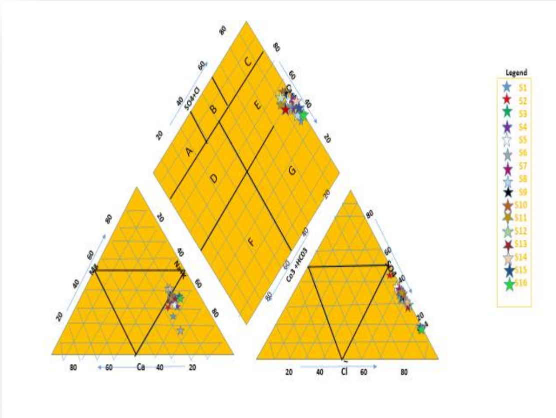

Figure (13): Water quality according to Piper classification for the summer season.

Conclusion

Compared to previous years, and these negative effects are gradual, whether environmental, industrial, demographic and agricultural factors, as we head towards the south of the river. The piper diagram showed that the most common ions in the water of the stations along the Shatt Al-Arab stream were chlorides or sulfates, and that the water quality in most of the stations is alkaline water. The data for the chemical composition of Shatt Al-Arab water indicated that the cations took the following order:
($Na^{+} > Mg^{+2} > Ca^{+2} > K^{+}$), while the order of the anions was ($Cl^{-} > SO_4^{-2} > HCO_3^{-}$).

Recommendations

The Piper chart can be adopted to determine the water quality of any area and to determine the extent of its use in irrigation. The high concentrations of salt in the water of the studied stations to high levels, requires all responsible authorities to take a serious stance to solve this problem and put in place laws and regulations that prevent waste of all kinds from being thrown into water sources without treatment, as its effects will be disastrous for everyone. The course of the river, as well as requiring factories and laboratories to have treatment units and closing factories that do not have wastewater treatment units, or the presence of treatment units, but they are not effective. Due to the dangerous pollutants received by these laboratories. The need for the government in Iraq to conclude water agreements with upstream countries such as Turkey and Iran that require increasing water releases and restoring some tributaries such as the Karun and Karkheh to increase water supply and reduce salt concentrations in the river. Paying attention to scientific research regarding water, its management and financing, and predicting its future conditions. Work to set Iraqi standards for Iraqi water that are compatible with the conditions of the region. Building a dam to prevent the return of salty water from the Arabian Gulf, especially during the period of recession.

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