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Relationship of annual flow with Hydrochemical analysis of the Tigris river and Evualation of Water for Drinking and Irrigation Uses

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ABSTRACT

The Tigris River represents one of the main sources of water with the Euphrates River in Iraq. Iraq is plagued by a water shortage as well as water resource management issues and these can be impact on the water quality. For these reason, the study area included the water of the Tigris River to show effect of the shortage of the annual flow on the water quality. The length of the Tigris River in Iraq is 1900 km^2 and includes (534) km^2 into the study area, Six stations along the Tigris River starting from Mosul station (North part) to the Al-Azizziyah station (Middle part) of Iraq. All samples were analyzed for physiochemical parameters such as water temperature, pH, EC, TDS, TH, major ions (Ca^{2+}, Mg^{2+}, Na^+, K^+, SO_4^{2-}, Cl^-, CO_3 and HCO_3), and nutrients (NO_3). Also, using the available historical climate data includes (Rainfall and Temperature) and Annual flow of the Tigris River for the period (1990-2020). Suitability of water for Irrigation uses was evaluated depending on the criteria or standards of acceptable quality for that use. In addition to the statistical correlation coefficient method was applied also. Water of the Tigris River were classified as $CaHCO_3$- water type at ST.1 and ST.2, While, from ST.3 to ST.6 classified as NaSO4-water type. Suitability of water for drinking purpose is evaluated depending on the criteria or standards of acceptable quality for that use (WHO and Iraqi Standard). All surface water stations of the Tigris River are unsuitable for drinking and not within the standard quality criteria for most of physiochemical parameters. Additionally, ST.1 and ST.2 fell within Excellent class, while, from ST.3 to ST.6 fell within the Permissible class based on the suggested limits of EC value (Ayers and Westcot, 1985) for irrigation. According to the Don (1995) classification of the irrigation water depend on sodium hazard based on SAR values, ST.1 and ST.2 stations of the Tigris River were classified as Good class but from ST.3 to ST.6 which classified as Doubtful class.

Key words: *Tigris River, Water quality, Discharge, Climate change, TDS, Iraq.*

Introduction

The Tigris River represents one of the main sources of water with the Euphrates River in Iraq. Iraq is plagued by a water shortage as well as water resource management issues. Iraq is at particular risk for being unable to pr2ovide clean drinking water and adequate sanitation systems for citizens, ensure sustainable irrigation, use hydropower to produce electricity, and maintain diverse ecosystems. Iraq is therefore in a situation where it must plan for several different future scenarios, mostly negative if climate change results in increased temperatures and decreased precipitation levels. Even in the absence

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of any negative effects of climate change, Iraq is dealing with steady growth in population, increased urbanization, and neighbor's countries which they built a dams on the main rivers of Iraq. In the last few years, however, water levels in Iraq's rivers have rapidly decreased to less than a third of their normal capacity. Water levels may fall further in the coming years due to declining precipitation, gradual desertification, and upstream water use and damming (Al-Ansari, 2013). The average annual flow of the Tigris River at Mosul city prior to 1984 was 701 m^3/ sec and dropped to 596 m^3/sec' afterward after 2002. The decrease of flow is accompanied by deterioration of the water quality due to the increase in salinity and other pollutants (Al-Ansari *et al.,* 2011).

The study area starting from Mosul city which it located in the north part of Iraq. The Tigris River flow in this city and continue to the south of Mosul, Further south, the Lesser Zab tributary joins the Tigris at Fatha. This tributary drains an area of 21,476 km^2 (25% in Iran) with a mean annual flow of 227 m^3/s whiles the mean annual flow of downstream of this confluence. South of Al-Fatha city , the Adhaim tributary joins the Tigris . This tributary drains an area of 13,000 km ^{2} and lies totally in Iraq (Al-Ansari *et al.,* 1986). The mean annual flow of this river reaches 25.5 km^3. This tributary runs dry between June and November each year. The last major tributary, the Diyala River joins the Tigris at the south of Baghdad at (Al-Karaghoulia station). The Diyala basin is 31,846 km^2 of which about 20% lie in Iran. The mean daily flow of this tributary is 182 m^3/s. No major tributary joins the River Tigris south of Baghdad (Al-Ansari *et al.,* 1986b and 1987). The Tigris River is a dynamic system with a state of continuous change in their quality and quantity, It needs successive studies to notice the changes through time due to decrease of the annual flow of it with time due to the increase of agricultural activities , building of dams in Turkey as well as climate change (Abdulhadi, 2015). The decrease of flow is accompanied by deterioration of the water quality due to the increase in salinity and other pollutants. Moreover, the main goal of this study is to investigate the dimension of climate change on the Tigris River for the period (2005- 2020).

Materials and Methods

Study Area

The study area is extending from Mosul city which is instead in the north part of Iraq to the south of: Baghdad (Al- Azizziyah city), at 120 km north of'Baghdad, Central Iraq, within the following geographical coordinates ranges : (36°34'89"- 32.911836° N) and (43°15'77"- 45.061348°E) (Figure 1). The length of the Tigris River along Iraq is (1900) km^2, while in this research it's (534) km^2. Where the Tigris River passes through this path, which contains many industrial projects.

The geological components of the Tigris River are different from one place to another depends on the effecting force of the Albanian- Banian Movement. When the Tigris river entre to the Iraqi land , its practice cutting off the Mosul sediments which represented by Muqdadiya, Injana, Fatha Formations, and continues as well until meeting the upper- Zab river in the south of Mosul (Jassim and Goff, 2006). The Tigris River continues to move through the quaternary deposits which appear along the river bed in Qayaraa city and effluent of lesser Zab at Tigris River, and appearing of Al-Fatha and Injana Formations in Baeje city then continue within the quaternary deposits until south of Baghdad city (Al Bayati, 1980).

Study Method

Historical Climatological data (Rainfall and Temperature) were taken from Iraqi Meteorological Organization for the period (1990-2020). Six gauging stations were chosen on the stretch of Tigris River . Discharge of the Tigris River data were collected from a historical data for the period (2005-2020), (The National Centre for Water Resources Management, 2021).

The Tigris River water were analyzed for physiochemical parameters such as (TDS, EC, pH, T.H), Major cations (Na^+, Ca_2^+, Mg^{2+} and K^+), Major anions ($Cl^>$, SO_4^2, $HCO_3^>$), and Minor elements nutrient (NO_2) for the period (2005- 2020) in laboratory of The National Centre for Water Resources Management. To get a full idea about the discharge effect on the water quality of the Tigris River are investigated and correlated with the discharge values and the total dissolved solids and water quality of the present study were compared with the other studies .

Results and Discussion

Climate data Impact on Tigris River

Iraqi Meteorological Organization Climate data for

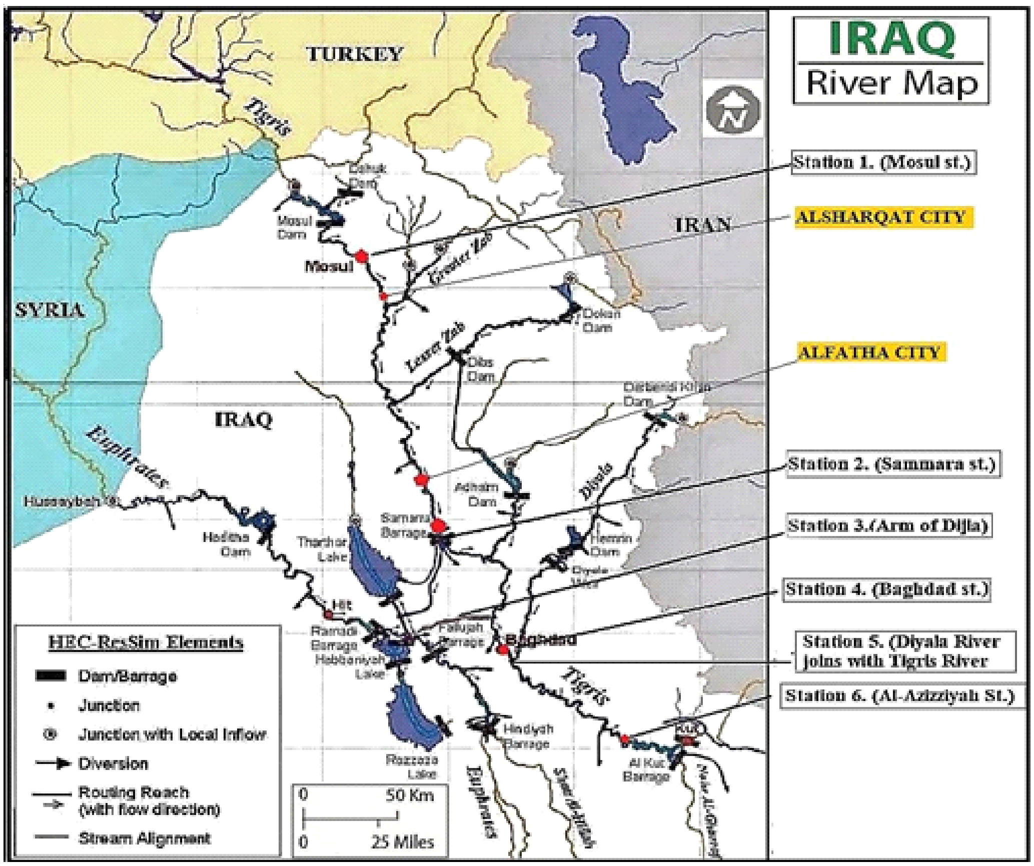

Fig. 1. Location map of Iraq the study area (NCWRM, 2020).

the period (1990-2020) that show the Monthly Mean Air Temperature values of: ST.1 station were in the range between (18.3-24.9C°) (Figure 2A), While in ST.2 station range between (28.0-33.5C°) (Figure 2B). In ST.4 station ranged between (28.8-33.0 C°) (Figure 2C), While in ST.6 station range between (30.4-41.1C°), (Figure 2D). Also, Iraqi Meteorological Organization Climate data of Rainfall data for the period (1990-2020) shows that the values of ST.1 station are range between (146.9-639.9) mm (Figure 3A). In ST.2 Station, ranged range between (65-247.3) mm (Figure 2B). While, in ST.4 and ST.6 stations varies between (58.5-162.3) and (1.1-228) mm respectively (Figure 2C&D).

Annual flow of the Tigris River

The average annual flow of the Tigris River in ST.1 station for the period (1990-2020) ranges between (193-906) m^3/sec and for ST.2 station ranges between (339-977) m^3/sec (Figure 4A&B). ST.3 (Canal of Dijla) joins the Tigris River in the north part of Baghdad which have a discharge ranges between (5-217) m^3/sec (Figure 4C). After that, the Tigris River inter to ST.4 station (Baghdad city) with annual flow ranges between (392-1173) m^3/sec and continue his flow to south of Baghdad city and Diyala River joins at (Al-Karaghoulia city-ST.5 station) with discharge ranges between (22.8-193) m^3/sec (Figure 4D&E). Finally the Tigris River reach to ST.6 station at (Al-Azizziyah city) with discharge ranges between (134-430) m^3/sec (Figure 4F).

Water Quality of the Tigris River

Physico - chemical parameters

Physiochemical parameters result of the Tigris River compared with Iraqi and WHO Standards (2009 and 2008) as shown in Table 1.

The mean pH values for surface water of the Tigris River were (7.3-8.1) & (7.5-8.2) for ST.1 and ST.2 stations respectively. While, for ST.3 ,ST.4, ST.5, and ST.6 stations were varies between (7.5-8.2), (7.02-8.3), (7.3-8) and (7.1-8.03) respectively Table 1. pH of surface water for (2005-2020) are within the

Table 1. Mean and Range of Physio - chemical Parameters Concentrations along Tigris River for the Period (2005-2020), (NCWRM, 2021).

Parameters		ST.1-Mosul	ST.2-Sammara	ST.3-Canal of Dijla	ST.4-Sarrai-Baghdad	ST.5-Al-Karaghoulia-South of Baghdad	ST.6-Al-Aziziyah	IQS, 2009	WHO, 2008
pH	Mean	7.6	7.9	7.9	7.8	7.6	7.6	6.5-8.5	6.5-8.5
	Range	7.3-8.1	7.5-8.2	7.5-8.2	7.02-8.3	7.3-8	7.1-8.0		
EC	Mean	0.4	0.5	1.7	0.9	2.6	1.3	1530	—
	Range	0.2-0.8	0.4-0.5	1.6-2.24	0.7-1.1	1.8-3.1	0.9-2.9		
TDS	Mean	340.8	319.3	1199.5	572.5	1937.0	937.5	1000	1000
	Range	126.5-634.3	274-v	864.6-1601.8	481-736.3	1706.4-2172.1	602-2112.4		
Ca	Mean	51.3	51.4	135.6	60.5	129.3	85.4	150	100
	Range	53-72.2	44.7-58.1	72.9-163.3	34-104	98.3-144	53.1-133.3		
Mg	Mean	29.4	28.1	61.7	40.0	115.8	56.5	100	125
	Range	14-43.8	22.6-42.1	47.2-71.6	24-50.9	79.2-144	79.2-140		
Na	Mean	29.8	26.1	137.2	71.8	285.9	112.4	200	200
	Range	18.6-45.1	19.4-32.2	81.1-238.5	47.6-93.3	180.6-377	88.4-344		
K	Mean	4.1	3.1	5.0	3.5	10.0	5.7	—	12
	Range	2.9-9.6	2.7-3.8	4.4-5.7	2.7-3.6	5-22.3	2.4-21.0		
Cl	Mean	21.9	23.5	157.8	48.2	252.0	136.8	350	250
	Range	16.2-24	16.3-32	81.3-256.1	54.5-95.9	18.7-382.4	74-382.4		
SO_4	Mean	136.0	127.3	535.3	198.2	642.0	347.0	400	250
	Range	32-271.8	101.8-158.6	446.6-610.7	134.2-293.2	205.6-884.8	220.8-742.8		
CO_3	Mean	4.4	6.0	6.3	7.8	20.6	9.7	—	—
	Range	2.6-7.2	2-9.1	5.7-8	1.7-15.6	1.1-58.2	8.1-16		
HCO_3	Mean	167.4	153.3	107.5	133.5	271.7	183.3	—	—
	Range	134-255	135.5-161.8	87.4-132	66.5-171.7	216.6-342.2	149.5-293.8		
NO_3	Mean	4.8	5.0	4.4	3.4	7.6	8.1	50	50
	Range	1.7-10.9	1.6-14.4	1.5-6.5	2-5.5	44239.0	1-47.02		
T.H	Mean	249.5	229.4	599.7	329.7	772.9	452.2	—	—
	Range	180-367.1	175-241.9	485-686.8	255-440	560-891.7	336-850		

acceptable range of (IQS, 2009 and WHO ,2008), which indicating that the river is healthy (Figure 5).

Electrical conductivity (EC) is an indirect measurement of salinity, and it is temperature dependent. This parameter is a function of the presence of ions and has direct relationship to the total dissolved solids (TDS). The mean EC values for surface water of Tigris River were ranges between (0.2-0.8) and (0.4-0.5) ds/m for ST.1 and ST.2 stations respectively. While, ST.3 station ranges between (1.6-2.2) ds/m. For ST.4, ST.5, and ST.6 stations were varies between (0.7-1.1), (1.8-3.1) and, (0.9-2.9) ds/m respectively (Figure 6).

The TDS Annual average values of: the Tigris River ranges between (126.5-634.3) and (274- 373.6) ppm for ST.1 and ST.2 stations respectively. While, ST.3 station ranges between (864.6-1601.8) ppm. For For ST.4, ST.5, and ST.6 stations were varies between (481-736.3), (1706.4-2172.1), and (602-2112.4) ppm respectively (Figure 7). According to classifications of surface water (Todd, 2007), show that the surface water of Tigris River at ST.1 and ST.2 stations was freshwater and ST.3, ST.4, ST.5 and ST.6 stations is Brackish water.

According to (Figure 7), Baghdad city has high dissolved salinity significantly in study area stations that suffered high levels of TDS and EC contents than others stations because it close to Canal of Dijla and it the big effect on it due to their geological composition of the Canal of Dijla and, for Al-Azizziyah station which also have a high dissolved salinity than other stations due to is due to the land's nature in the feeding areas, especially in agricultural areas and the Tigris river is flowing and dissolved all the salts which are in the river basin in addition to the main reason effect on al-Azizziyah station its Al-Wahda station which is a wastewater treatment station, located in the south of: Baghdad city. It's

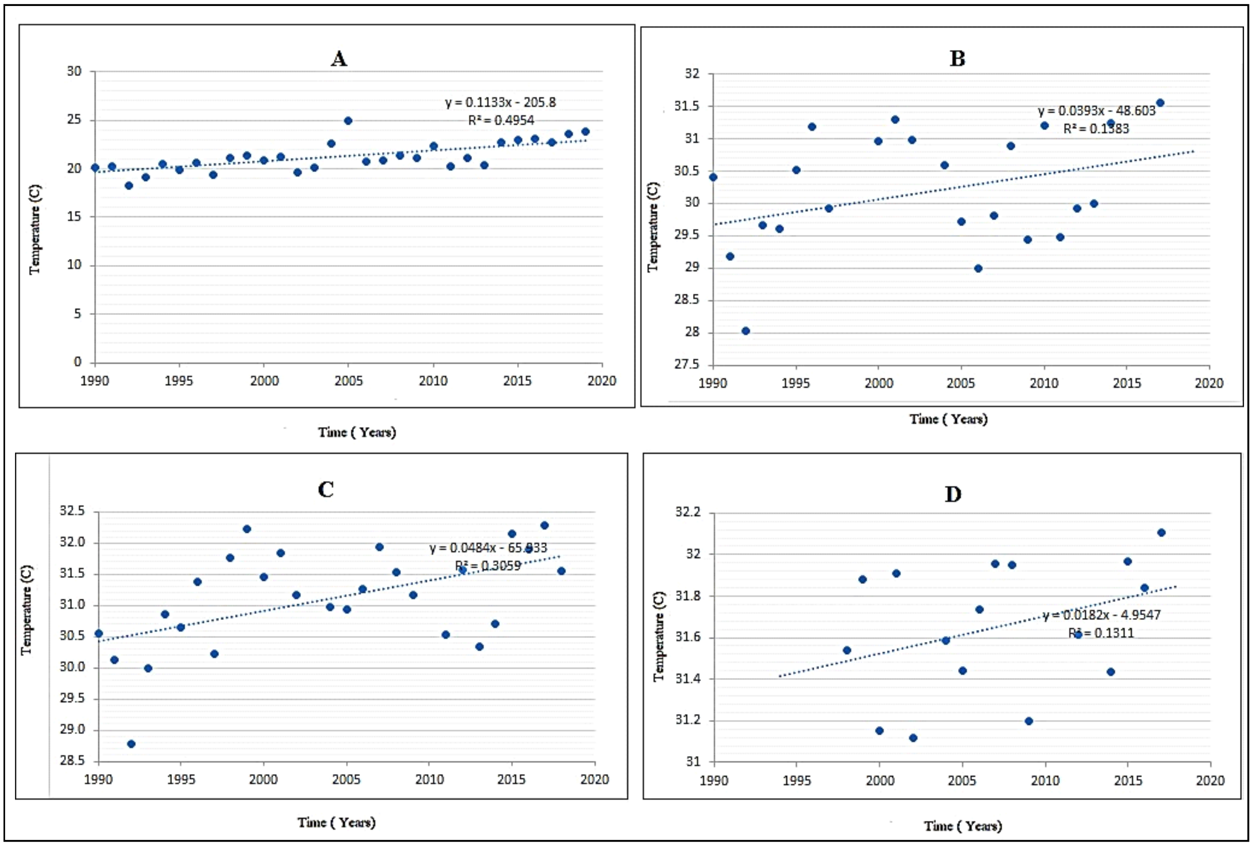

Fig. 2. Annual average values of Temperature (C°) for the period (1990-2020) in (A): ST.1 station,(B): ST.2 Station, (C): ST.4 station and, (D): ST.6 Station, (Iraqi Meteorological Organization, 2021).

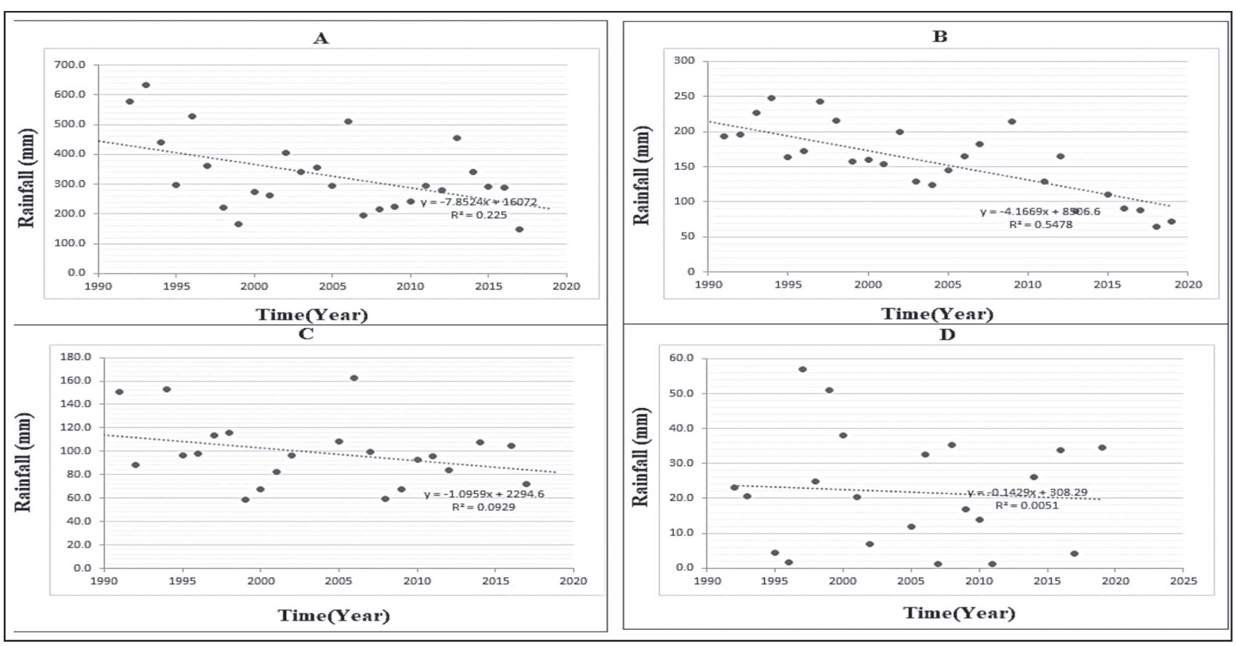

Fig. 3. Annual average values of Rainfall for the period (1990-2020) in (A) : ST.1 station,(B): ST.2 Station, (C): ST.4 station and, (D): ST.6 Station, (Iraqi Meteorological Organization, 2021).

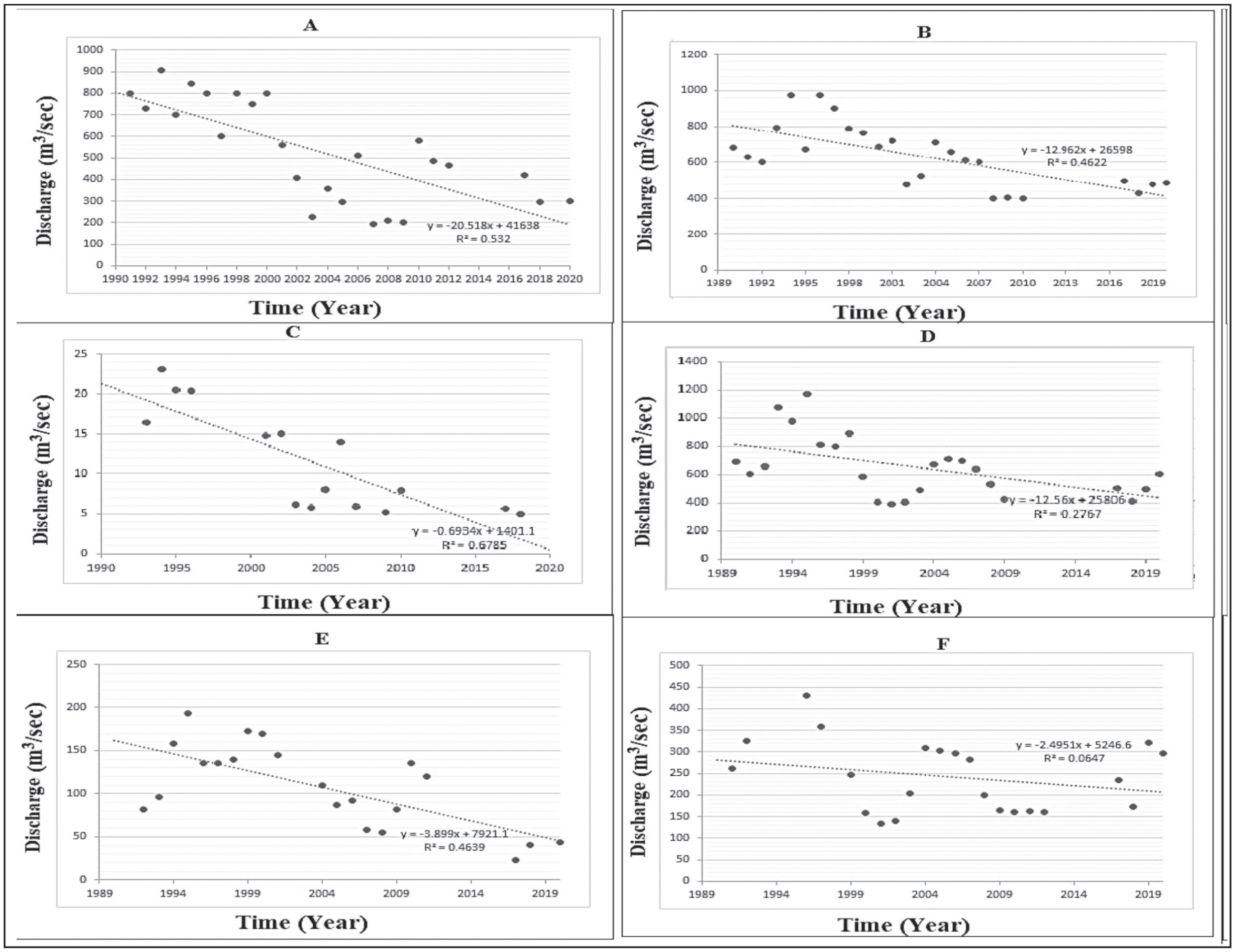

Fig. 4. Discharge (m^3/sec) of the Tigris River for the period (1990-2020), (A): ST.1 station,(B): ST.2 station,(C): ST.3 station (D): ST.4 station, (E): ST.5 station, and (F): ST.6 station (NCWRM, 2021).

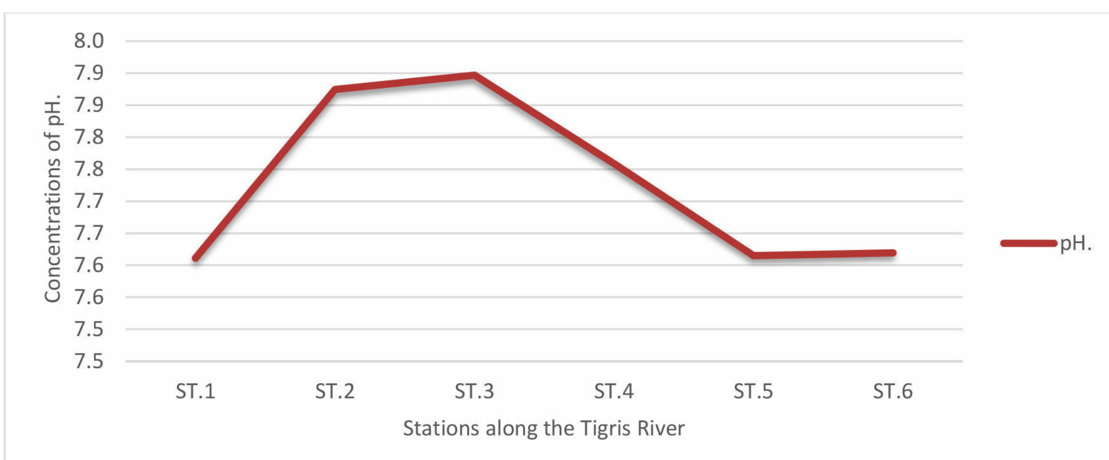

Fig 5. pH Annual average values ppm: along the Tigris River from ST.1 to ST.6 stations for the period (2005-2020), (NCWRM, 2020)

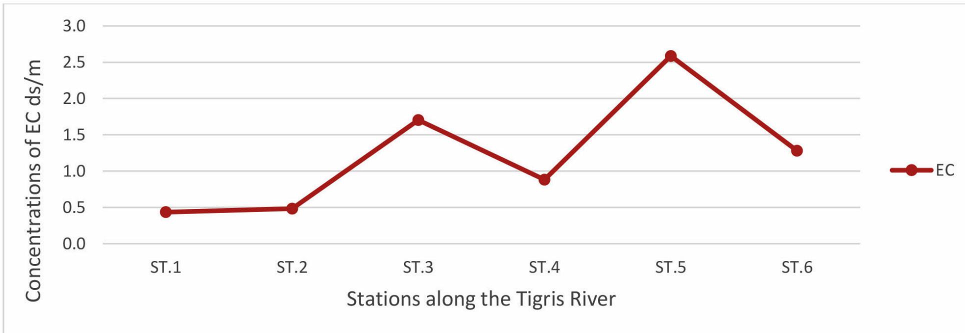

Fig. 6. EC Annual average values (ds/m) along the Tigris River from ST.1 to ST.6 stations for the period (2005- 2020), (NCWRM, 2021).

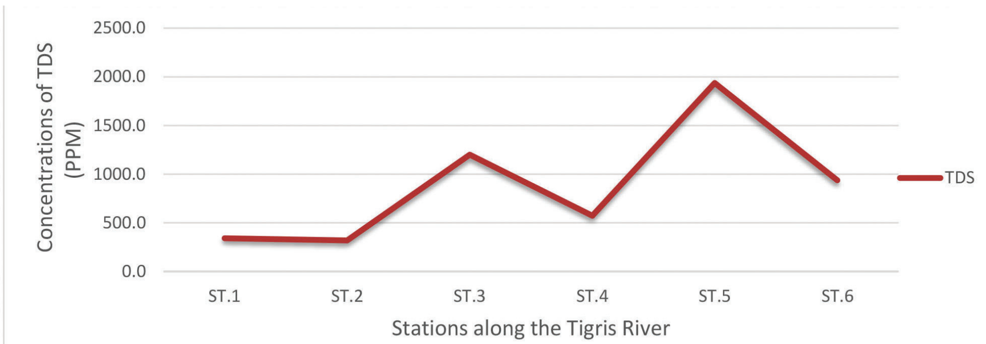

Fig. 7. TDS Annual average values ppm along the Tigris River from ST.1 to ST.6 stations for the period (2005- 2020), (NCWRM, 2020).

throwing the wastewater directly into the Tigris River without any treatment because of that notes that Diyala River has a high concentrations of salinity.

Total Hardness (T.H)

T.H concentration varies (180-367.1) and (175-241.9) ppm for the Tigris River ST.1 and ST.2 stations respectively. While, ST.3 station ranges between (485-686.8) ppm. For ST.4, ST.5, and ST.6 stations were varies between (255- 440), (560-891.7) and, (336-850) ppm respectively (Figure 8).

Major ions of surface water of the Tigris River

The chemistry of water is depended mainly on major ion concentrations. All water samples were analyzed for major cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}), major anions (SO_4-2, Cl^- and HCO_3^-), and minor anions (NO_3^-). The results of the major and minor ions of water samples are displayed in the Table (1) and (Figures 9, 10, 11).

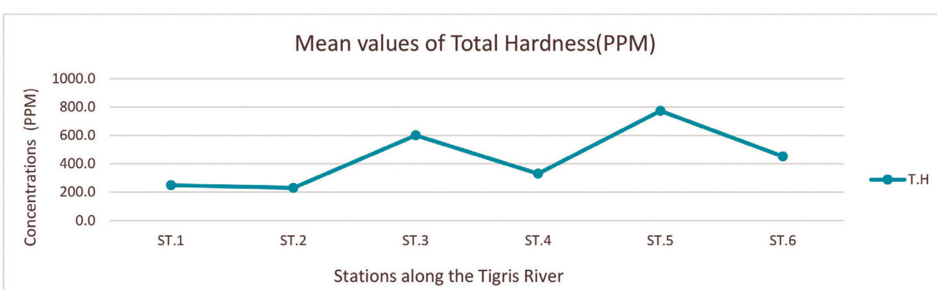

Fig. 8. T.H Annual average values ppm along the Tigris River: from ST.1 to ST.6 stations for the period (2005-2020), (NCWRM, 2021).

Calcium (Ca^{2+})

Evaporates rocks containing gypsum and anhydrite are among the most important sources of calcium soluble in water (Hem, 1985). Calcium Annual average values of the Tigris River ranges between (53-72.2) and (44.7-58.1) ppm for ST.1 and ST.2 stations respectively. While, ST.3 stations ranges between (72.9-163.3) ppm. For ST.4, ST.5, and ST.6 stations ranges (34-104), (98-144) and (53.1-133.3) ppm respectively (Figure 9). Ca^{2+} concentrations were higher in ST.3 and ST.5 stations than others, this may be attributed to increase evaporation and, decrease water supply passes the years and may indicate the land's geological composition of ST.3 station.

Magnesium (Mg^{2+})

Magnesium is an essential nutrient for living organisms and it is typically considered as the major constituent of the dark- colored ferromagnesian minerals and carbonate rocks such as limestone, dolomite, magnesite and hydro magnesite (Todd, 2005). Mg^{2+} concentration varies from (14-43.8) and (22.6-42.1) ppm of the Tigris River at ST.1 and ST.2 stations respectively. While, ST.3 station varies between (47.2-71.6) ppm. For ST.4, ST.5, and ST.6 stations varies (24-50.9), (79.2-140) and, (37-120.8) ppm respectively. Figure (9), shown the Mg^{2+} concentration along the Tigris River of the study area and it's increased in ST.6 station and , this increase can be attributed mainly to the effluent of wastewater from urban and agricultural areas.

Sodium (Na^{+})

Na+ concentration varies (18.6-45.1) and (19.4-32.2) ppm of the Tigris River at ST.1 and ST.2 stations respectively. While, ST.3 station values were (81.1-

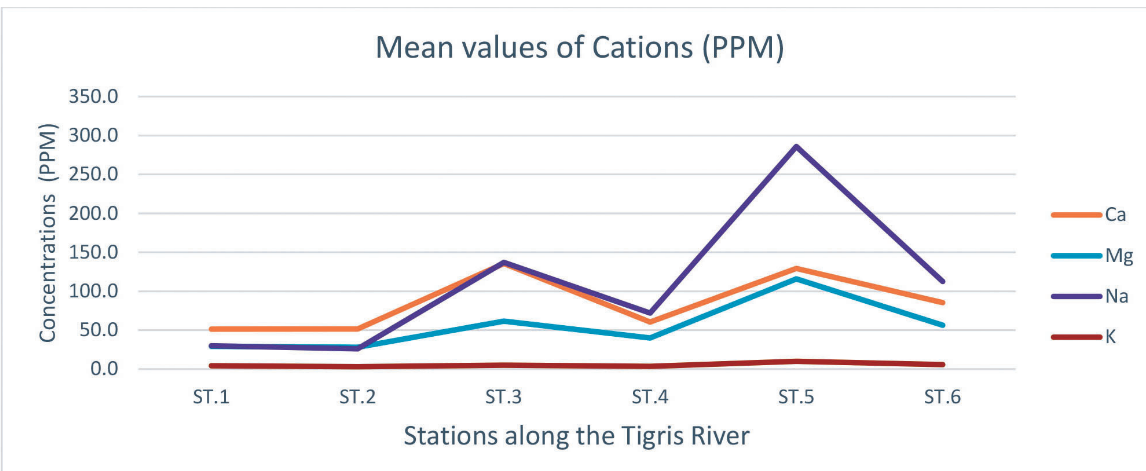

Fig. 9. Cations Annual average values ppm along the Tigris River from ST.1 to ST.6 stations station for the perio (2005-2020), (NCWRM, 2021).

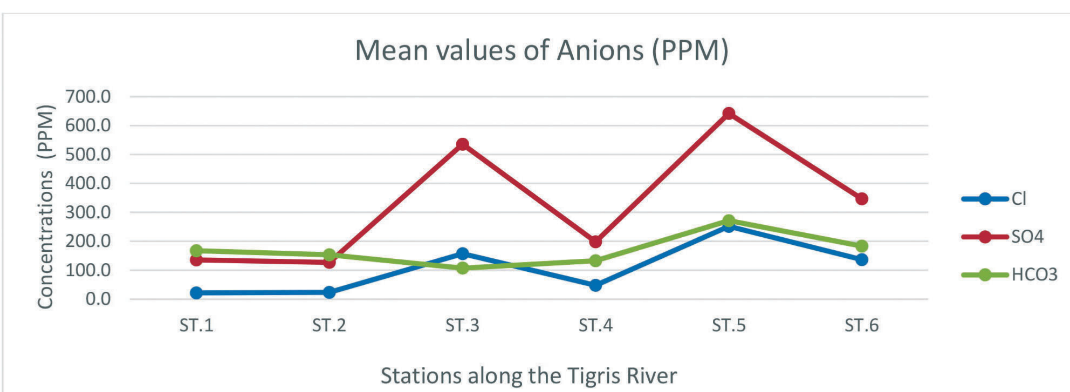

Fig. 10. Anions Annual average values ppm along the Tigris River from ST.1 to ST.6 stations for the period (2005- 2020), (NCWRM, 2021).

238.5) ppm. For ST.4, ST.5, and ST.6 stations were values ranges (47.6-93.3), (180.6-377) and, (88.4-344) ppm respectively (Figure 9). Results shown significantly high sodium during the study period, which it responsible for the deterioration of water quality in general, the result of the increase in the presence of sodium salts in the feeding areas through agricultural areas, evaporation process, and the releasing of: untreated wastewater from different anthropogenic sources directly into the river.

Potassium (K^+)

K+ concentration varies between (2.9-9.6) and (2.7-3.8) ppm for the Tigris River at ST.1 and ST.2 stations respectively. While, ST.3 station ranges between (4.4-5.7) ppm. For ST.4, ST.5, and ST.6 stations ranges between (2.7-3.6), (5-22.3) and, (2.4-21) ppm respectively (Figure 9). The increase of K^+ concentration at ST.5, and ST.6 stations is due to applying of chemical fertilizers in agriculture lands which lead to increase its concentration.

Carbonate (CO_3)

CO_3- concentration varies (2.6-7.2) and (2-9.1) ppm for the Tigris River at ST.1 and ST.2 stations respectively. While, for ST.3 station ranges between (5.7-8) ppm. For ST.4, ST.5, and ST.6 stations range between (1.7-15.6), (1.1- 58.2) and, (8.1-16) ppm respectively (Figure 11).

Nitrate (NO_3^-)

NO_3- concentration varies (1.7-10.9) ppm and (1.6-14.4) ppm for the Tigris River at ST.1 and ST.2 stations respectively. While, for ST.3 station ranges between (1.5-6.5) ppm. For ST.4, ST.5, and ST.6 stations were ranges between (2-5.5) ppm, (2-12) and, (1-47) ppm respectively (Figure 11).

The hydrochemical parameters of this research for the period (2005-2020) were compared with many previous studies Table. A previously studied includes (Al-Bayati, 1980, Al-Sanawi, 1985, and Al-Ansari, 2016). The researchers indicated that the water quality of the Tigris River is affected by climate change and that its headwaters have average salinity of 226-333 ppm at the Iraqi – Turkey border, and the salinity rises along the Tigris river course southward. The deterioration of water quality and the heavy pollution from many sources are becoming serious threats to the river course (Al-Ansari *et al.,* 2019). TDS analysis showed an inverse correlation with discharge from ST.1 to ST.6 stations for years (2005- 2020), (Figure 12).

Hydrochemical formula

Hydrochemical formula of surface in the study area is determined according to Kurlolov's formula . This formula depends on the ratio of the main ions (cations and anions) expressed by equivalents per million %, that are arranged in descending order which have more than (15%) ratio of availability (Ivanov, 1968). The descending arrangement of ions in the formula is utilized to recognize the basic water type. Applying Kurlolov's formula for the study period (2005-20202) shows that the Tigris river have (Ca^{+2}-Na+-Mg^{+2}-HCO_3^--$SO4^{-2}$) at ST.1 and ST.2 and classified as $CaHCO_3$- water type, While, have (Na^+-Ca^{+2}-Mg^{+2}-SO_4^{-2}-Cl) from ST.3 to ST.6 and classified as $NaSO_4$-water type.

Suitability of water for different uses Evaluation of water quality for drinking

Drinking water standards of (WHO, 2008) and Iraqi Standard (2009) are used as a basis for the water quality evaluation of the present study samples for drinking use. All surface water stations of the Tigris River are unsuitable for drinking and not within the

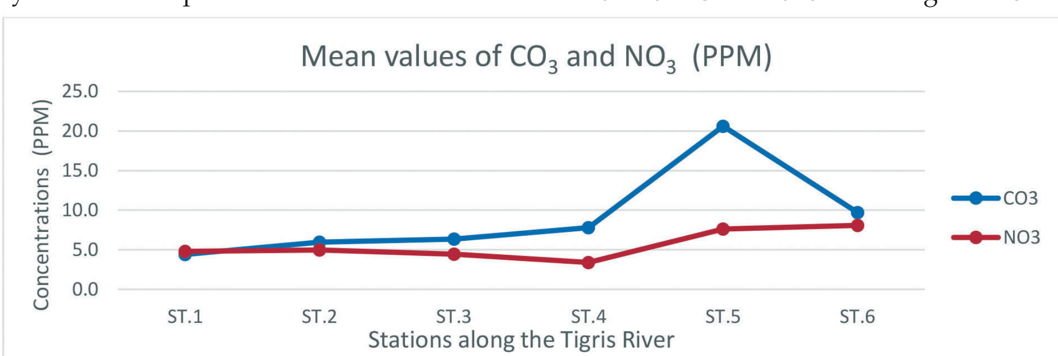

Fig. 11. CO_3 and NO_3 Annual average values ppm along the Tigris River from ST.1 to ST.6 stations for the period (2005-2020), (NCWRM, 2021).

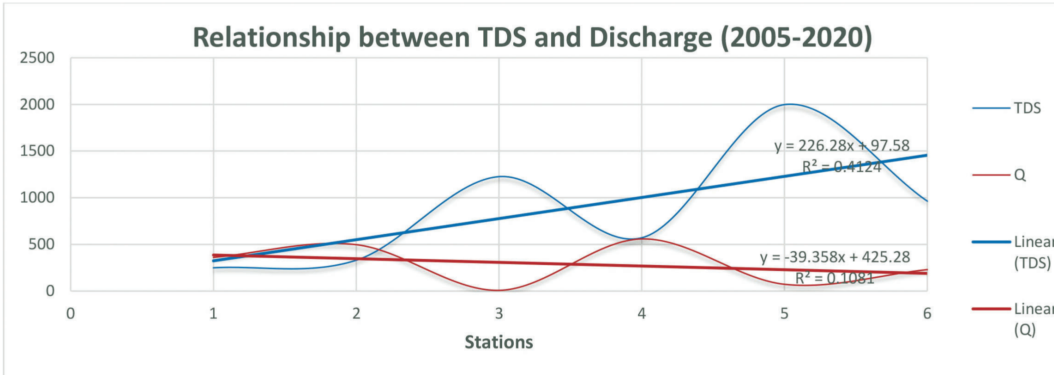

Fig. 12. Relationship between TDS and discharge(m^3/sec) of the Tigris River from: ST.1 to ST.6 stations for the period (2005-2020),(NCWRM, 2021).

Table 2. Comparison of the mean values of Hydrochemical analyses of the Tigris River between current, pervious and recent studies.

Stations	studies	EC	TDS	T.H	Na	Cl	SO4
ST.1-Mosul	Current study(2005-2020)	0.4	340.8	249.5	29.8	21.9	136.0
	Al-Bayati,1980	0.2	193	216	15	20	122
ST.2-Sammara	Current study(2005-2020)	0.5	319.3	229.4	26.1	23.5	127.3
	Al-Bayati,1980		210	164	14.89	12.7	22.33
ST.4-Sarrai- Baghdad	Current study (2005-2020)	0.9	572.5	329.7	71.8	48.2	198.2
	Al-Ansari,2016		470	312.02	70	67.27	198.58
	Al-Bayati,1980	0.3	182	147.64	46	24.46	86.5
ST.5-Al-Karaghoulia-	Current study(2005-2020)	2.6	1937.0	772.9	285.9	252.0	642.0
south of Baghdad	Al-Sanawi,1985	0.5	438	159	213.38	255.6	499.42
ST.6-Al-Azizziyah	Current study(2005-2020)	1.3	937.5	452.2	112.4	136.8	347.0
	Al-Ansari,2016		712.3	251.8	99.8	125.6	209.2

standard quality criteria for most of physiochemical parameters.

Evaluation of water quality for irrigation

Assessment of water for irrigation depends upon many criteria such as Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) (Ayers and Wescot 1985).

Salinity Hazard

The most influential water quality guideline on crop productivity is the salinity hazard as measured by electrical conductivity (EC), water always contain a quantities of dissolve solid origin from rocks and soil, that affect the growth of plants and soil structure. High salinity of the water may reduce water availability to the plants affecting the crop yield (Winner, 2000; Singh *et al.*, 2008). The Tigris River stations (ST.1 and ST.2) were lie within Excellent class based on Suggested limits of EC value for irrigation (Table 3). While, from ST.3 to ST.6 were lie within the Permissible class.

Sodium Hazard

It is used to evaluate the sodium hazard in relation to calcium and magnesium concentrations (Winner, 2000). Sodium Adsorption Ratio (SAR) is an important parameter for determining the suitability of

$$SAR = \frac{rNa}{\sqrt{r(Ca+Mg)/2}}$$

water for irrigation, because it is an indicator of alkali/sodium hazard (Subramani *et al.*, 2005). SAR can be calculated by using the following equation:

According to the Don (1995) classification of the irrigation water depend on sodium hazard based on SAR values , ST.1 and ST.2 stations of the Tigris River were classified as Good class but from ST.3 to ST.6 which classified as Doubtful class.

Table 3. Classification the suitability of water for irrigation according to electrical conductivity, Bauder, (2011)

Classes of water	Electrical Conductivity (dS/m)*
Class 1, Excellent	< 0.25
Class 2, Good	0.25-0.75
Class 3, Permissible[1]	0.76-2.00
Class 4, Doubtful[2]	2.01-3.00
Class 5, Unsuitable[2]	>3.00

*decisiemen/m,(dS/m) at 25°C = millimho/cm, mmho/cm, 1 dS/m = 1000 μS/cm. [1]Leaching needed if used. [2]Good drainage needed and sensitive plants

Conclusion

The Tigris River represents one of the main sources of water with the Euphrates River in Iraq. Iraqi Meteorological Organization Climate data for the period (1990-2020) that show the Monthly Mean Air Temperature values of ST.1 station were range between (18.3-24.9C°) ,While in ST.2 station range between (28.0-33.5C°). In ST.4 station ranged between (28.8-33.0 C°), While in ST.6 station range between (30.4-41.1C°). Also, Iraqi Meteorological Organization Climate data of Rainfall data shows that the values of ST.1 station are range between (146.9-639.9) mm. In ST.2 Station, ranged range between (65-247.3) mm. While, in ST.4 and ST.6 stations varies between (58.5-162.3) and (1.1-228) mm respectively. The average annual flow of the Tigris River in ST.1 station for the period (1990-2020) ranges between (193-906) m^3/sec and for ST.2 station ranges between (339-977) m^3/sec, ST.3 ranges between (5-217) m^3/sec, ranges between (392-1173) m^3/sec, ST.5 station with discharge ranges between (22.8- 193) m^3/sec and ST.6 station ranges between (134-430) m^3/sec.

Applying Kurlolov's formula for the study period (2005-20202), shows that the Tigris river have (Ca^{+2}-Na^{+}-Mg^{+2}-HCO_3^{-}-SO_4^{-2}) at ST.1 and ST.2 and classified as CaHCO3- water type, While, have (Na+-Ca^{+2}-Mg^{+2}-SO_4^{-2}-Cl) from ST.3 to ST.6 and classified as $NaSO_4$- water type. Suitability of water for drinking purpose is evaluated depending on the criteria or standards of acceptable quality for that use (WHO and Iraqi Standard). All surface water stations of the Tigris River are unsuitable for drinking and not within the standard quality criteria for most of physiochemical parameters. Additionally, ST.1 and ST.2 were lie within Excellent class, while, from ST.3 to ST.6 were lie within the Permissible class based on the suggested limits of EC value (Ayers and Westcot, 1985) for irrigation. According to the Don (1995) classification of the irrigation water depend on sodium hazard based on SAR values, ST.1 and ST.2 stations of the Tigris River were classified as Good class but from: ST.3 to ST.6 which classified as Doubtful class.

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Authors Contributions

This work was carried out in collaboration between all authors. Author (2) designed the study and managed the analyses of the study. Author (1) performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Conflict Of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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