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Hydrochemical study and Water quality of Tigris Channel at Al- Taji area, Northern Baghdad

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Abstract

The water quality of the Tigris Channel at Al-Taji area were studied in both periods (August, and March, 2022). Eight samples were collected from Tigris channels to investigate water quality and parameters such as electrical conductivity (EC), total dissolved solids (TDS), Temperature (T), hydrogen number (pH), Total Hardness (T.H), as well as significant cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}), significant anions (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}) and Heavy metals (Cd, Pb, Fe, Zn, Ni and Cr). The results show that the maximum value of EC is 1182 (µS/cm) in Ch3 in the dry period, while the lowest value of EC is1105 (µS/cm) in Ch1 in the wet period. The hydrochemical formula of water samples in both periods is CaCl. In this study, the dominating cation is Ca^{2+}, followed by Na^{+}, Mg^{2+}, and K^{+}, whereas the dominant anion is Cl^{-}, followed by SO_4^{2-}, HCO_3^{-}, and CO_3^{-}. According to Piper's illustration, all water samples that fall in class (e) are arranged together for both periods (wet and dry) "Earth alkaline water with a higher percentage of alkali and a sulfate and chloride predominance." Finally, the WQI is rated excellent for the wet Tigris channel and good water for the dry Tigris channel.

Keywords: Tigris Channel, water quality, Hydrochemistry, uses of water

دراسة هيدروكيميائية ومؤشر نوعية المياه لذراع دجلة شمال بغداد، العراق

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الخلاصه

تم دراسة نوعية المياه السطحية في ذراع دجلة في منطقة التاجي خلال موسمي الزيادة المائية والنقصان المائي (آذار ،أب ٢٠٢٢). في هذه لدراسة تم جمع ثمانية عينات مائية لدراسة نوعية المياه في محطات مختارة على ذراع دجلة في منطقة التاجي والمتمثلة بالتوصيلة الكهربائية EC،كمية المواد الصلبة الذائبة TDS،درجةالحرارة T،رقم الهيدروجين pH، والعسرة الكلية T.Hوالايونات الموجبة والايونات السالبة فضلا عن العناصر الثقيلة (Cd, Pb ,Fe, Zn, Ni , Cr). أشارت النتائج إلى أن أعلى قيم للتوصيلية الكهربائية كانت ١١٨٢ مايكروسيمنز /سم 2 في المحطة Ch3 خلال موسم النقصان المائي بينما كانت اقل قيمة للتوصيلية الكهربائية ١١٠٥ مايكروسيمنز/سم2 في المحطةCh1 في موسم الزيادة المائية . الصيغة الكيميائية لمياه منطقة الدراسة كانت CaCl مع سيادة ايون Ca للايونات الموجبة يليها K^{+},Mg

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Na^{+},$^{2+}$وسيادة ايون Cl للايونات السالبة يليها SO_4^{2-}, HCO_3^{-} و CO_3^{-} . اعتمادا على مخطط بايبر فان جميع العينات تقع ضمن الصنف e والذي يدل على مياه قلوية مع ارتفاع النسب الكبريتات والكلوريدات. اخيرا فأن مؤشر نوعية المياه في منطقة الدراسة تشير الى انها مياه ممتازة في الموسم الرطب وجيدة في الموسم الجاف.

1. Introduction

Water has become a more scarce resource in several arid and semi-arid nations in recent years, pushing planners to investigate any sources of water that could be used cheaply and effectively to support further development.

Water quality has become a critical necessity in recent years, owing to the increasing strain on water resources induced by rapid population growth and climate change [1]. Water quality is primarily assessed by hydrochemical analysis [2]. River water is the main source of drinking water, irrigation, and other purposes in Iraq, and the quality is controlled by various essential elements, including basin lithology, atmospheric inputs, climatic conditions, and anthropogenic inputs[3,4]. Anthropogenic factors (urban, industrial, and agricultural activities and increased water resource consumption) degrade surface waters and render them unfit for drinking, industrial, agricultural, recreational, or other uses [5,6,7]. In the study area, Few studies have been done to evaluate water quality for different uses [2] studied the Hydrochemical characteristics and environmental evaluation of surface and groundwater quality at Al-Tarmiyah Area and concluded that most surface water of the studied area was suitable for all purposes, this research aims to determine the hydrochemistry of the Tigris channel in the Al-Tajii district and their uses, in addition to assessing the water quality Index of the water channel.

1.1 Study area

The study area is located in the north of Baghdad city, with heights from 31 to 42m above sea level. It is situated between latitudes 33° 30′ to 33° 28′ N and longitudes 44°10′to44°17′E Figure1. This channel plays a very important role in irrigation, flood control across the region and will serve as the main water source of the nearby Baghdad city.

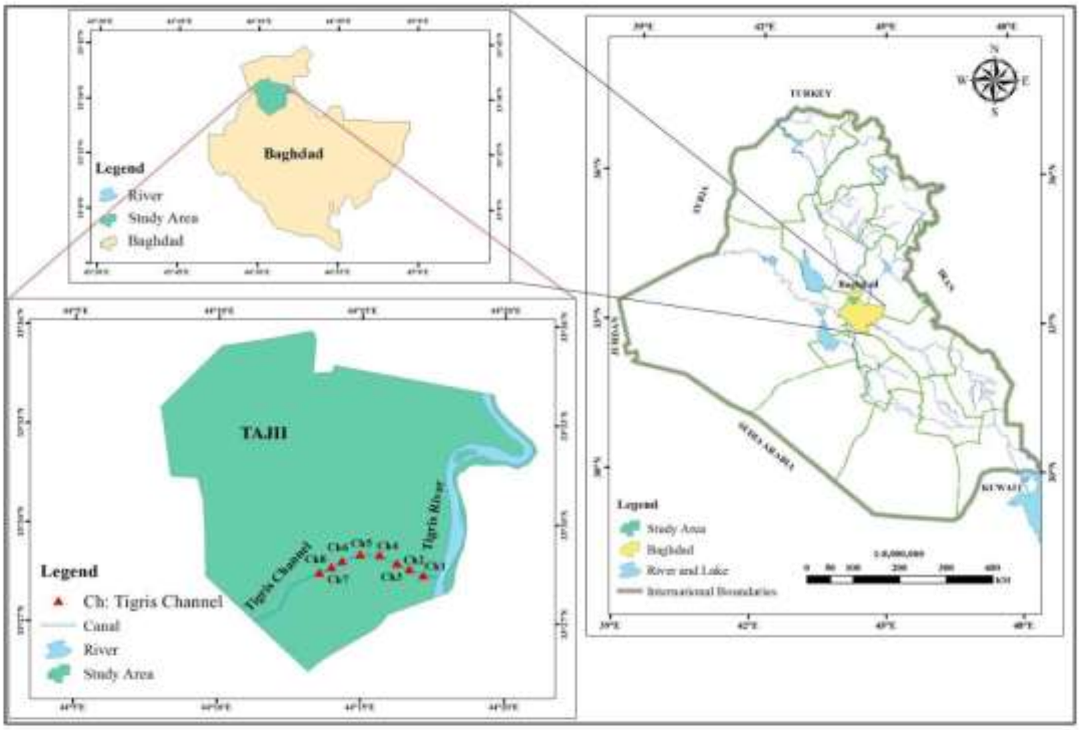


Figure 1: Map showing the study area of the Tigris channel.

Geologically, the study region is primarily covered by Holocene deposits and is represented mainly by Quaternary deposits (Pleistocene) [8]. The hydrogeological sitting in the study area, an excellent sand aquifer, has been discovered underground at 8–20 m deep [9].

2. Methodology

2.1 Fieldwork

In each period (August and March 2022), water samples from the Tigris channel north of Baghdad were were taken. During this period, we established monitoring locations along the Tigris channel and collected surface water samples at eight locations. Field parameters determinations (pH, EC, and T) were measured with hand-held electrical conductivity and pH meter. For hydrochemical analysis, Electrical Conductivity (EC), Hydrogen Number (pH) Total Dissolved Solids (TDS), Total Hardness (T.H), major cation (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}), with significant anion concentrations (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}). In addition to Heavy metals (Pb, Cd, Fe, Zn, Cr, and Ni). All samples were collected in duplicate and stored in one-litre polyethene bottles at 4°C before being covered with two covers and stored in a cool box. Samples collection, labelling, preservation, and laboratory transport were done before sampling. Water samples were carried out at the Research Center Laboratories in the Ministry of Science and Technology for hydrochemistry analysis. Standard methods were used to examine the parameters [10] (Table 1).

Table 1: Summary of chemical analysis techniques.

Parameter	Method of analysis
T.H, Ca^{2+}, Mg^{2+}	Titration against EDTA
Cl^{-}	Titration against $AgNO_3$
Na^{+} and K^{+}	A Flame photometer
SO_4	Spectrophotometer
CO_3 and HCO_3	Titrating
TDS, EC	Meter instrument

For accuracy, duplicate analyses were tested as follows:
The method that was used in this present study is a relative difference (R.D) has been calculated using the flowing relationship [11]:

$$R.D\% = \frac{(\sum Cation - \sum Anion)}{(\sum Cation + \sum Anion)} *100 \quad \ldots\ldots (1)$$

When the (R.D) is less than 5%, the result may be considered acceptable for interpretation. If (R.D) is less than 10%, the result is acceptable with considerable risk, and if (R.D) is greater than 10% result is uncertain. In the present study, all stations have values less than 5% (accepted). The results of accuracy as shown in Table 2.

Table 2: Accuracy of chemical analysis of the water samples.

Sample No	R.D wet period	Decision	R.D dry period	Decision
Ch1	2.82	Acceptable	2.78	Acceptable
Ch2	1.047	Acceptable	1.068	Acceptable
Ch3	0.74	Acceptable	0.77	Acceptable
Ch4	0.32	Acceptable	0.44	Acceptable
Ch5	0.27	Acceptable	0.33	Acceptable
Ch6	0.038	Acceptable	0.22	Acceptable
Ch7	0.62	Acceptable	0.55	Acceptable
Ch8	1.25	Acceptable	1.33	Acceptable

3. Results and Discussion

The physio-chemical characteristics of water samples in the Tigris Channel are shown in Tables 3 and 4.

Table 3: Surface water analysis data (Tigris channel) in the studied area in March and August 2022.

	Wet period March 2022					Dry period August 2022				
Station No.	T°C	pH	EC (μ S/cm)	TDS (ppm)	T.H ppm	T°C	pH	EC (μ S/cm)	TDS (ppm)	T.H ppm
Ch1	24	7.6	1105	850	480	25.5	7.9	1170	901	507
Ch2	24	7.7	1117	859	478	26	8.1	1182	910	506
Ch3	24.5	7.7	1118	859	485	25.5	8.1	1182	911	512
Ch4	24	7.7	1100	846	482	26	8.1	1164	896	509
Ch5	24.5	7.7	1101	847	480	26	8.1	1165	898	507
Ch6	24.5	7.8	1100	846	448	25.5	8.2	1164	897	475
Ch7	24	7.8	1113	856	465	25.5	8.2	1178	908	492
Ch8	24.5	7.8	1100	846	468	26	8.2	1164	897	495
Min	24	7.6	1105	846	448	25.5	7.9	1164	896	475
Max	24.5	7.8	1118	859	485	26	8.2	1182	911	512
Mean	24.7	7.72	1106.7	851.1	473.2	25.7	8.1	1171.1	902.2	500.3
[6]	----	6.5-8.5	500	1000	500	----	6.5-8.5	500	1000	500
[7]	----	6.5-8.5	500	1000	500	----	6.5-8.5	500	1000	500

Table 4: Cation and Anion concentration of (Tigris channel) in the studied area in March and August 2022.

	Wet period March 2022								Dry period August 2022							
Station No.	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	SO_4^{2-} ppm	Cl^{-} ppm	CO_3^{-} ppm	HCO_3^{-} ppm	Ca^{2+} ppm	Mg^{2+} ppm	Na^{+} ppm	K^{+} ppm	SO_4^{2-} ppm	Cl^{-} ppm	CO_3^{-} ppm	HCO_3^{-} ppm
Ch1	123	42	103	3.1	112	213	2.1	174	129	45	110	3.2	118	226	2.2	184
Ch2	119	44	101	3.7	123	210	2.2	179	125	47	108	3.9	129	223	2.3	190
Ch3	120	45	101	4	130	212	2.2	177	126	48	108	4.2	136	225	2.3	188
Ch4	117	46	100	3.9	131	211	2	173	123	49	107	4.1	137	224	2.1	183
Ch5	118	45	100	3.7	129	212	2.0	175	124	48	107	3.9	135	225	2.1	186
Ch6	110	42	100	5.1	110	214	2	177	116	45	107	5.4	116	227	2.1	187
Ch7	117	42	100	4	114	216	1.9	176	123	45	107	4.2	120	230	2	187
Ch8	118	42	103	4	128	212	1.1	168	124	45	110	4.2	134	225	1.2	178
Min	110	42	100	3.1	110	210	1.1	168	116	45	107	3.2	116	223	1.2	178
Max	123	46	103	5.1	131	216	2.2	179	129	49	110	5.4	137	230	2.3	190
Mean	117.7	43.5	101	3.93	122.12	212.5	1.937	174.87	123.75	46.5	108	4.13	128.12	225.6	2.03	185.37
[6]	150	100	200	------	400	350		450	150	100	200	-------	400	350		450
[7]	150	125	200	12	250	250		250	150	125	200	12	250	250		250

During the wet period, the range of temperature, pH, EC, TDS and T.H in water samples of Tigris channel were (24-24.5°C), (7.6-7.8), (1105-1118) μ S/cm, (846-859) ppm and (448-485) ppm with an average of (25.7°C), (7.72), (1106.7) μ S/cm, (851.1) ppm and (473.2) ppm, respectively.

During the dry period, the range of temperature, pH, EC, TDS and T.H in water samples of Tigris channel were (25.5-26°C), (7.9-8.2), (1164-1182) μ S/cm, (896-911) ppm and (475-512) ppm, with an average of (24.7 °C), (8.1), (1171.1) μ S/cm, (902.2) ppm and (500.3) ppm, respectively. Due to climate conditions and discharge effects, the physiochemical values of the Tigris channel are highest during the dry period (designated in this study as August) and lowest during the wet period (March). Figure 2 show the distribution of temperature values in the study area in both periods.

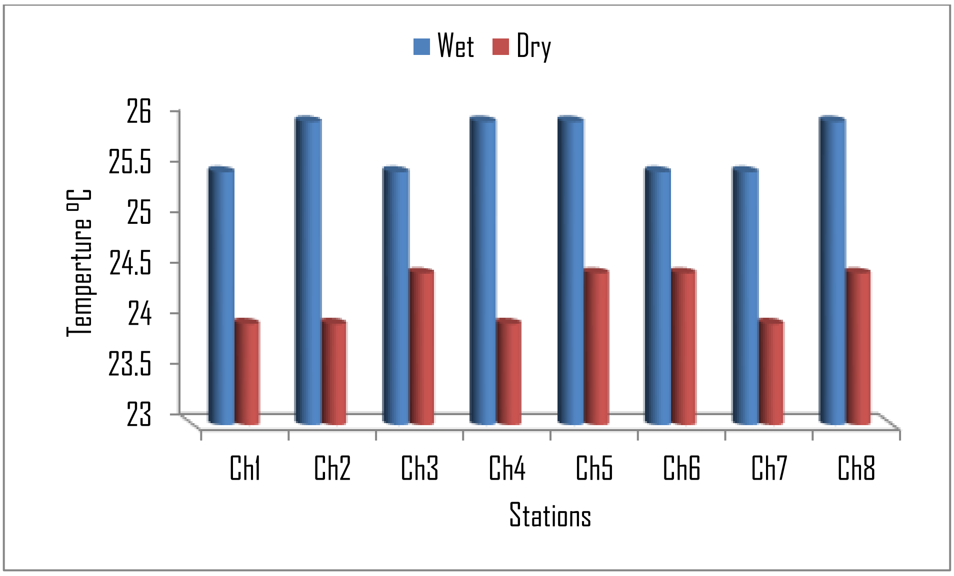


Figure 2: Temperature (˚C) values of the Tigris Channel samples for both periods.

Depending on: pH, TDS and EC, T.H according to [12-17] classification Table 5,6,7 and 8, The Samples were classified as weakly alkaline, fresh water, excessively mineralized water and very hard, respectively.

Table 5: Komatina classified water based on its pH value [12]

pH	<3.5	3.5-5.5	5.5-6.8	6.8-7.2	7.2-8.5	> 8.5
Type	Strongly acid	Acidic	Weakly acidic	Neutral	Weakly alkaline	Alkaline

Table 6: Water classification based on TDS, Altoviski [13], Drever [14], and Todd [15]

Water Class	TDS (ppm) Altoviski [13]	TDS (ppm) Drever [14]	TDS (ppm) Todd [15]
Fresh water	0-1000	<1000	1000
Brackish water	1000-3000	1000-10000	1000-10000
Salty water	3000-10000		
Saline water	10000-100000	35000	10000-100000
Brine water	>100000	<100000	>100000

Table 7: After Detay, the relationship between EC [16].

EC (µS/cm)	Mineralization
<100	Very weakly mineralized water
100 -200	weakly mineralized water
200 -400	Slightly mineralized water
400 -600	Moderately mineralized water
600 -1000	Highly mineralized water
>1000	Excessively mineralized water

Table 8: Classification of water according to total hardness [17].

Classification	T.H ppm
Soft	0 - 75
Moderate Hard	75 - 150
Hard	150 – 300
Very hard	>300

For cations analysis, during the wet period, the range of Ca^{2+} concentration in the Tigris channel was (110-123)ppm with an average of (117.75)ppm, range of Mg^{2+} concentration in the Tigris channel was (42-46)ppm with an average of (43.5)ppm, Figure 3. the rang of Na^{+}

concentration in Tigris channel were (100-103)ppm with an average of (101)ppm, the rang of K^+ concentration in Tigris channel were (3.1-5.1)ppm with an average of (3.937) ppm, Figure 4, the range of SO_4^{2-}concentration in Tigris channel was (110-131)ppm with an average of (122.12)ppm, the range of Cl^- concentration in Tigris channel was (210-216) ppm with an average of (212.5)ppm. The range of CO_3^- concentration in the Tigris channel was (1.1-2.2) ppm with an average of (1.937) ppm. The range of HCO_3^- concentration in the Tigris channel was (168-179) ppm with an average of (174.875)ppm. Figure5.

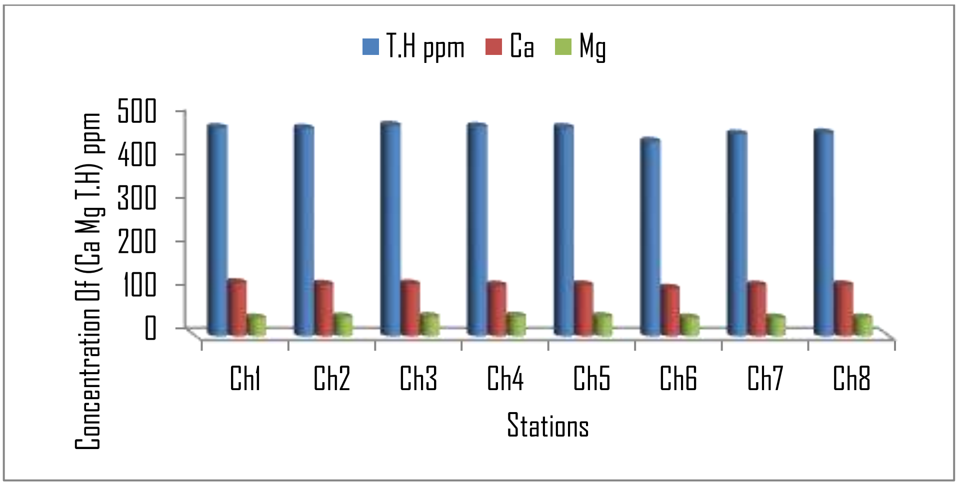


Figure 3: Concentrations of Ca, Mg, T.H of the Tigris Channel samples for,wet period (March 2022).

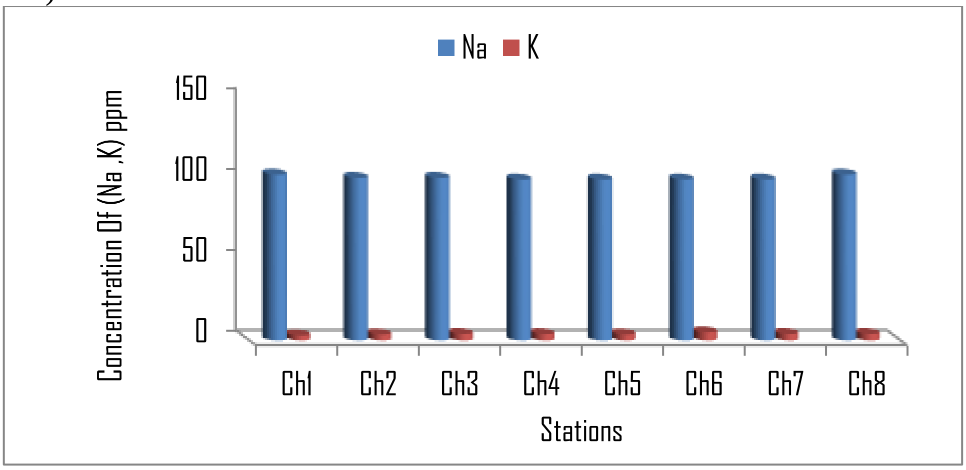


Figure 4: Concentrations of Na, K of the Tigris Channel samples for the wet period (March 2022).

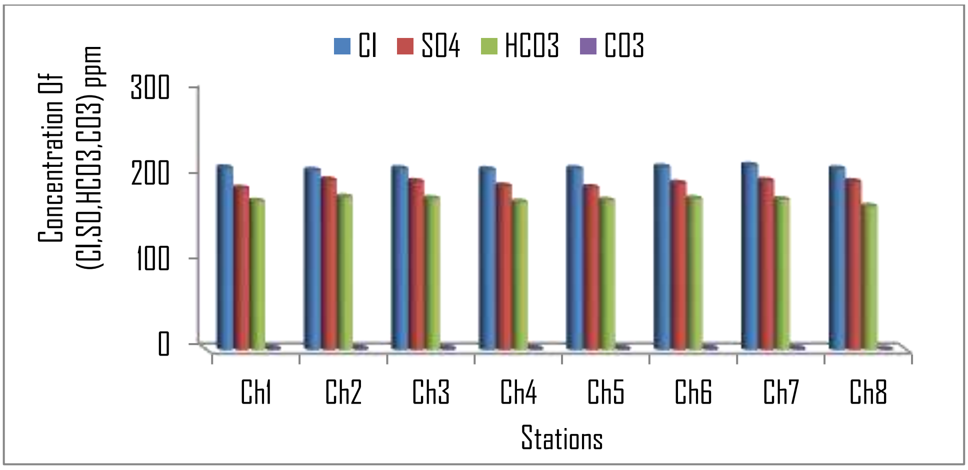


Figure 5: Anions Concentrations of the Tigris Channel samples for,wet period (March 2022).

During the dry period, the range of Ca^{2+} concentration in the Tigris channel was (116-129)ppm with an average of (123.75)ppm. The range of Mg^{2+} concentration in the Tigris channel was (45-49) ppm with an average of (46.5) ppm, Figure 6. The range of Na^{+} concentration in the Tigris channel was (107-110) ppm with an average of (108) ppm. The range of K^{+} concentration in the Tigris channel was (3.2-5.4) ppm with an average of (4.137) ppm, Figure 7. The range of SO_4^{2-}concentration in the Tigris channel was (116-137)ppm with an average of (128.12)ppm, and the range of Cl^{-} concentration in the Tigris channel was (223-230)ppm with an average of (225.625)ppm. The range of CO_3^{-} concentration in the Tigris channel was (1.2-2.3)ppm with an average of (2.0375)ppm, and the range of HCO_3^{-} concentration in the Tigris channel was (178-190) ppm with an average of (185.375) ppm (Figure 8).

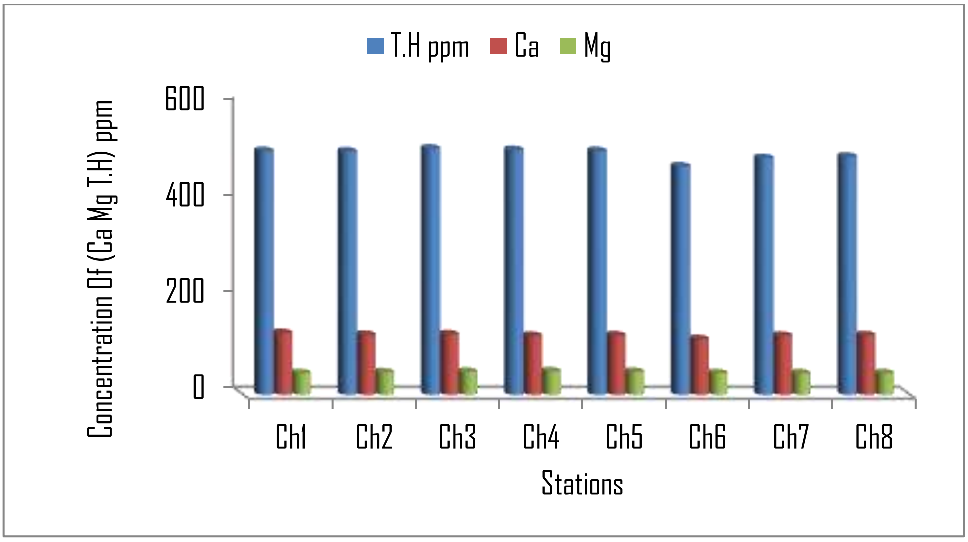


Figure6: Concentrations of Ca, Mg, T.H of the Tigris Channel samples for, dry period (August 2022).

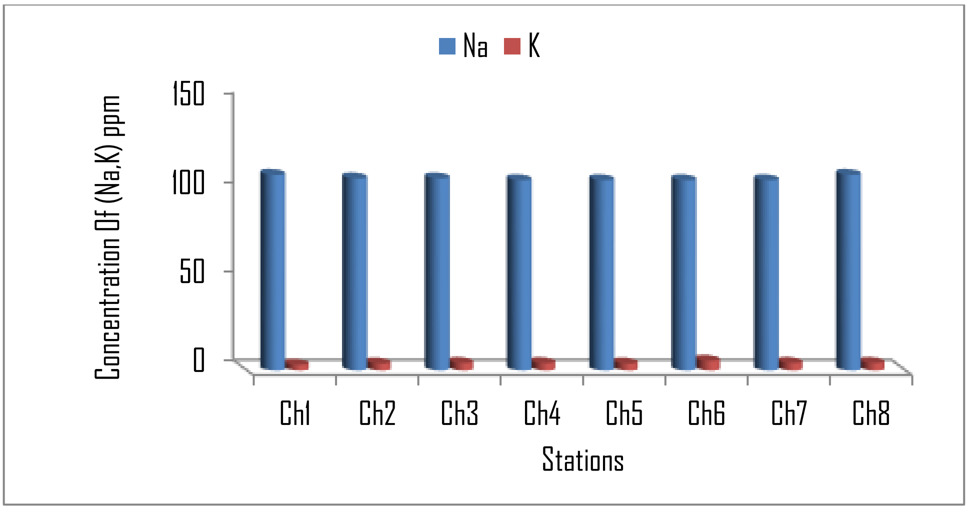


Figure 7: Concentrations of Na, K of the Tigris Channel samples for, dry period (August, 2022).

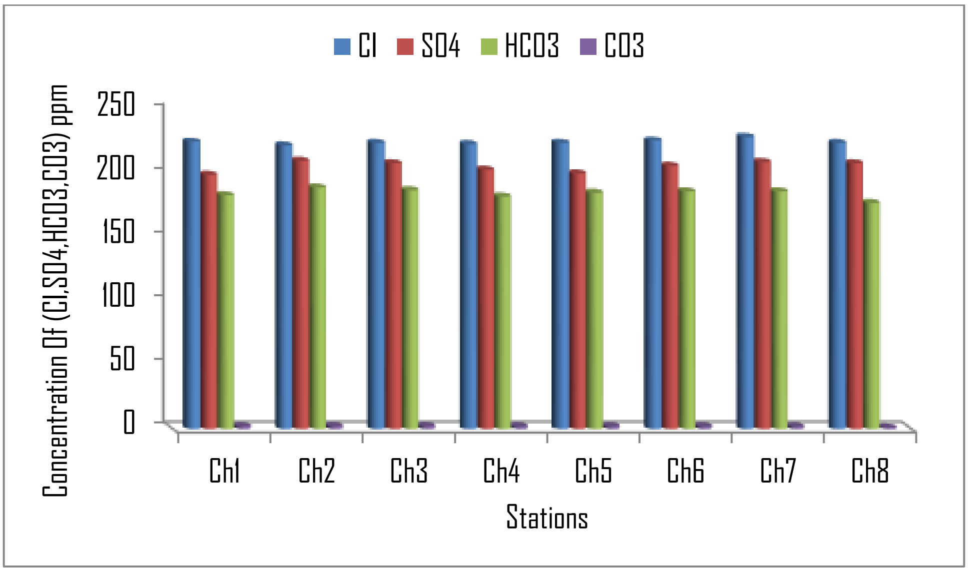


Figure 8: Anions Concentrations of the Tigris Channel samples for,dry period (August 2022).

The results reveal the Ca^{2+}, Na^{+} ions predominant cations, while Cl^{-} is the most common anion in surface water. This reflects the existence of halite and limestone deposits [18]. Ca^{2+} concentrations in the dry period are higher than in the wet period because increased evaporation reduces water supply during the summer period [2]; Mg^{2+} increase may be ascribed primarily to wastewater discharge in urban and agricultural lands, concentrations of Na^{+} for surface higher throughout the dry period than in the wet period, presumably as a result of excessive water dilution brought on by high rainfall during the wet period, which also increases evaporation. The increased concentrations above standards undoubtedly cause the release increases in the amounts of Na^{+} for both periods due to the direct discharge of untreated wastewater from various human sources into rivers. Applying chemical fertilizers results in an increase in K^{+} concentration in surface water over the allowable limits due to the high levels of K^{+} in the water [2] and relatively high levels of Cl^{-} over the dry and wet period, partly as a result of increasing river discharge and anthropogenic.

3.1 TDS - EC Relationship for surface water

Measuring a solution's electrical conductivity (EC) can also provide a relative indicator of the amount of dissolved salts. According to [19], it is possible to relate the TDS value to EC, which is typically measured in (μs/cm) units

$$TDS\ (mg\ L^{-1}) = k\ .EC\ (\ \mu S\ cm^{-1}) \qquad \text{............ (2).}$$

Where:
TDS: total dissolved Solid
EC: electrical conductivity $\mu S\ cm^{-1}$
k: constant

The correlation factor, k, can be calculated for each field inquiry and is normally between 0.5 and 0.8.using the data and applying a statistical program for the best-fit line, a strong linear relationship between EC and TDS exist (Figures 9and10), whereas R^{2} (correlation coefficient) value is close to (1).

Mathematical approximation of TDS (ppm) = 1.2901x + 7.1111 (μs/cm) in the dry period and TDS (ppm) = 1.3446x - 37.642 (μs/cm) in the wet period. This relation may be used to evaluate the TDS value by knowing EC values for the study area.

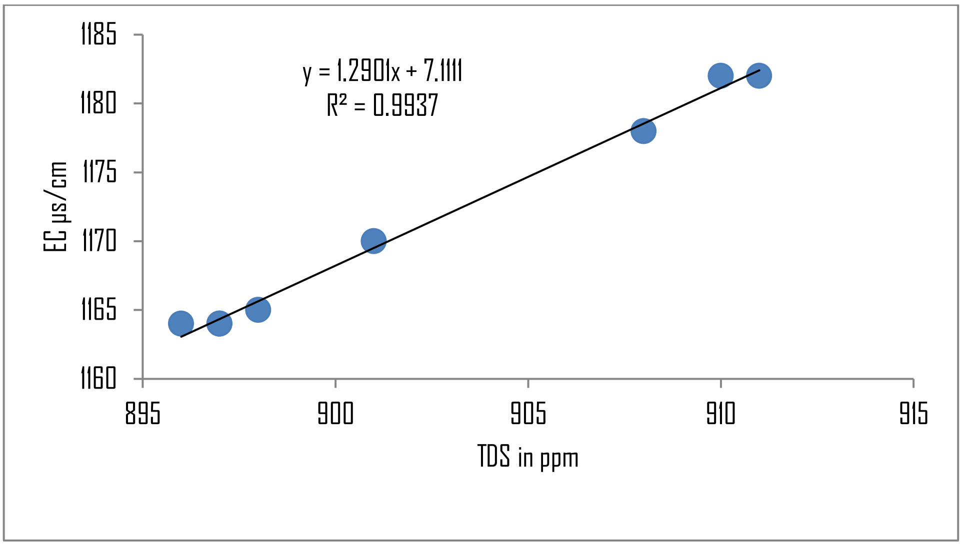


Figure 9: Relationship between EC & TDS for Tigris channel in the dry period (August 2022).

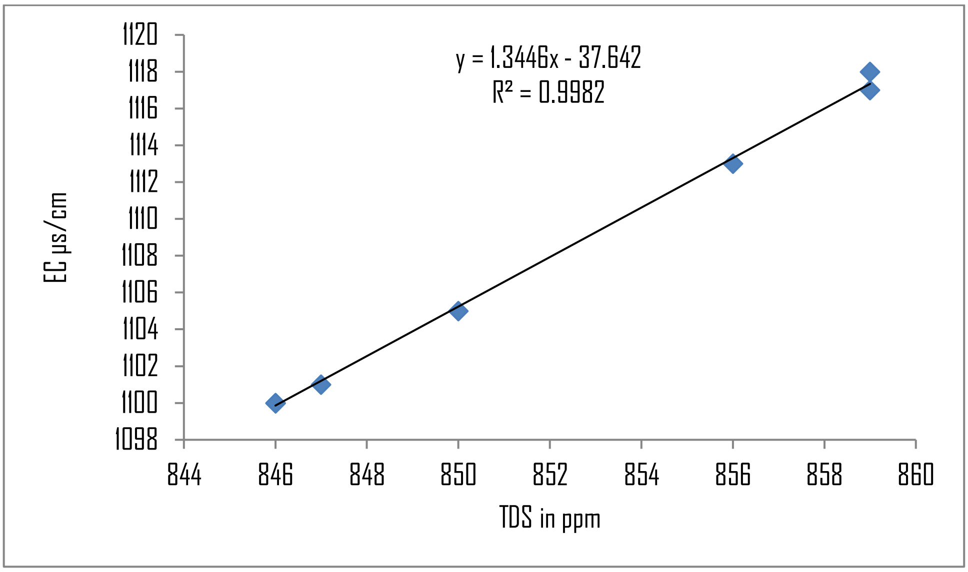


Figure 10: Relationship between EC & TDS for Tigris channel in wet period (March 2022).

For heavy metals in the studied area, the range of Fe, Zn, Ni and Cr concentrations in Tigris channel was (0.032-0.047)ppm, (0.013-0.021)ppm, (0.015-0.023)ppm, and (0.023-0.03) ppm, with an average of (0.0413), (0.0173),(0.0187) and (0.0265) ppm in the dry period, while in the wet period, the range of Fe, Zn, Ni and Cr concentrations in Tigris channel were (0.03-0.044) ppm, (0.011-0.018)ppm,(0.011-0.022) ppm, and (0.015-0.022)ppm, with an average of (0.0377) ppm,(0.0145),(0.0162)and (0.0185)ppm respectively. The concentration of Cd and Pb was recorded below the detection level (0.010) in both periods Table 9, Figures 11 and 12.

Table 9: Concentrations of Heavy metals (ppm) of the Tigris channel for two periods (August 2022 and March 2022).

Stations	Dry period 2022						Wet period 2022					
	Fe ppm	Cd ppm	Pb ppm	Zn ppm	Ni ppm	Cr ppm	Fe ppm	Cd ppm	Pb ppm	Zn ppm	Ni ppm	Cr ppm
Ch1	0.032	BDL	BDL	0.013	0.016	0.023	0.031	BDL	BDL	0.012	0.013	0.022
Ch2	0.043	BDL	BDL	0.015	0.017	0.024	0.042	BDL	BDL	0.013	0.016	0.021

Ch3	0.041	BDL	BDL	0.016	0.015	0.025	0.038	BDL	BDL	0.015	0.017	0.020
Ch4	0.045	BDL	BDL	0.017	0.018	0.026	0.044	BDL	BDL	0.014	0.014	0.019
Ch5	0.046	BDL	BDL	0.018	0.019	0.027	0.037	BDL	BDL	0.011	0.011	0.018
Ch6	0.033	BDL	BDL	0.019	0.02	0.028	0.03	BDL	BDL	0.016	0.018	0.016
Ch7	0.045	BDL	BDL	0.020	0.022	0.029	0.040	BDL	BDL	0.017	0.019	0.015
Ch8	0.047	BDL	BDL	0.021	0.023	0.030	0.039	BDL	BDL	0.018	0.022	0.017
Max	0.047	BDL	BDL	0.021	0.023	0.03	0.044	BDL	BDL	0.018	0.022	0.022
Min	0.032	BDL	BDL	0.013	0.015	0.023	0.03	BDL	BDL	0.011	0.011	0.015
Mean	0.0413	BDL	BDL	0.0173	0.0187	0.0265	0.0377	BDL	BDL	0.0145	0.0162	0.0185

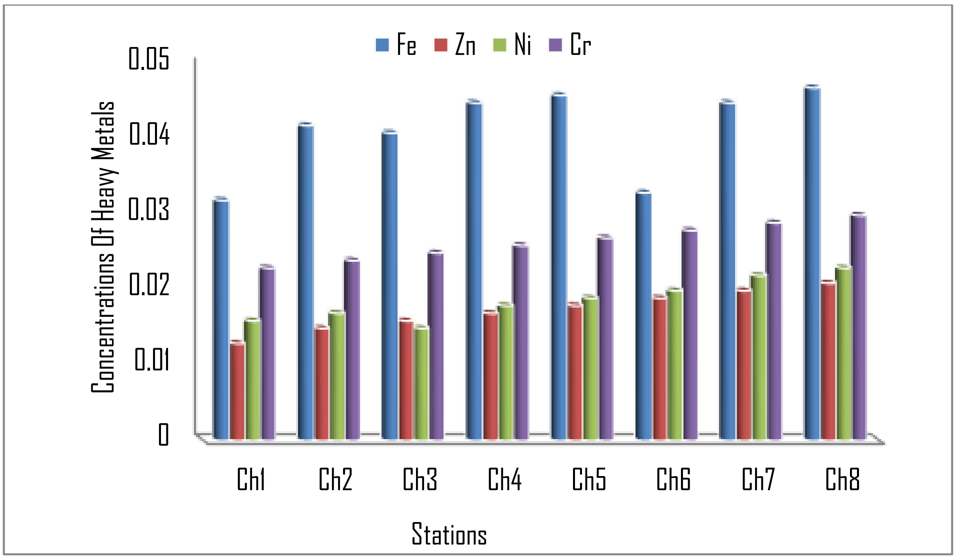
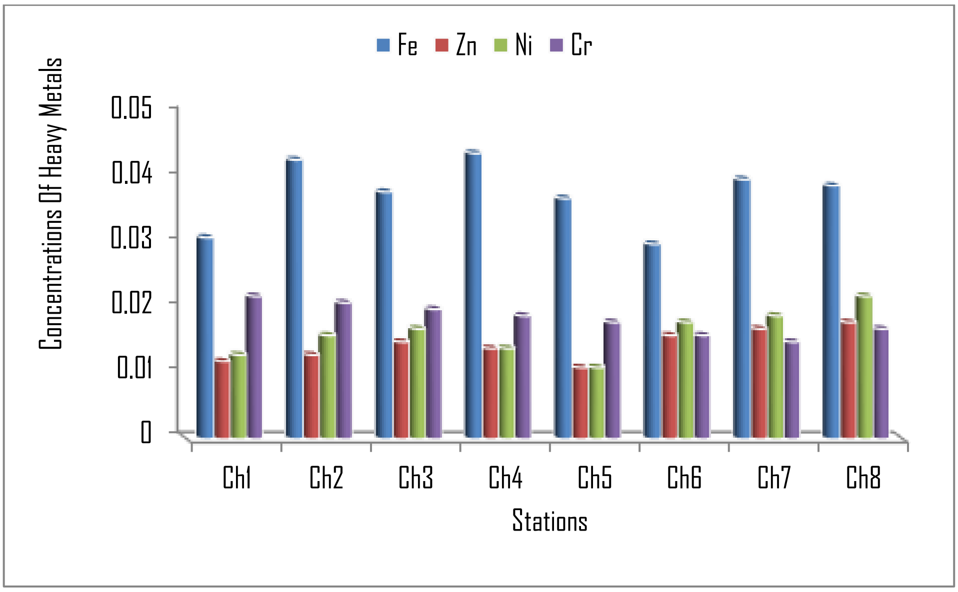


Figure11: Concentrations of Heavy metals in ppm of Tigris channel for dry period (August, 2022).



Figures12: Concentrations of Heavy metals in ppm of Tigris channel for the wet period (March 2022).

3.2 Pollution indicators

The HPI (heavy metal pollution index) and MI (metal pollution index). The Heavy Metal Index (HPI) is calculated as follows:

$$HPI= \sum_{i\ 1}(\mathbf{Qi\ Wi}) / \sum_{\mathbf{i\ 1}} \mathbf{Wi} \qquad \ldots\ldots\ldots\ldots 3$$

Where: Q_i is the sub-index of the parameter, and Wi is the unit weightage.

$$Wi = k / Si \qquad \ldots\ldots\ldots\ldots\ldots\ 4$$

Where Wi is the unit weightage, Si is the recommended standard, and k is the constant of proportionality =1

$$Qi = 100\ Vi / Si \qquad \ldots\ldots\ldots\ldots\ldots\ 5$$

MI is (metal pollution index) is calculated as follows:

$$MI = \sum [C_i / (MAC)_i] \qquad \ldots\ldots\ldots\ldots\ldots 6$$

MAC is the maximum allowable concentration and Ci is the mean concentration of each metal. The HPI and Mi values of samples in the study area are listed in Tables 10 and 11

Table 10: Mean HPI, MI of water samples in the wet period

Heavy metal	mean mg/l	Standard mg/l[6]	Unit weightage (W_i)	Subindex Q_i	W_i x Q_i	HPI	MI
Fe	0.0377	0.3	3.333	12.56	41.88		
Zn	0.0145	3	0.333	0.48	0.16		
Ni	0.0162	0.02	50	81	4050	65.59397	1.3105
Cr	0.0185	0.05	20	37	740		
			∑ Wi= 73.66667		∑Wix Q_i= 4832.046		

Table 11: Mean HPI,MI of water samples in dry period

Heavy metal	mean mg/l	standard mg/l[6]	Unit weightage (W_i)	Subindex Q_i	W_i x Q_i	HPI	MI
Fe	0.0413	0.3	3.333	13.76	45.884		
Zn	0.0173	3	0.333	0.57	0.192		
Ni	0.0187	0.02	50	93.5	4675		
Cr	0.0265	0.05	20	53	1060	78.47685	1.6084333
			∑ Wi= 73.66667		∑Wix Q_i= 5781.076		

From Tables 10 and 11, the Heavy Metal Pollution Index (HPI) values were 78.47686 in the dry period and 65.59397 in the wet period. According to [20], the HPI of samples in the study area is less than 100, indicating that the water is not polluted. In this study, the ∑MI in the dry period is 1.608433, whereas in the wet period is 1.3105, depending on classification [21-22].

3.3 Water Quality Index

A common water quality index technique was produced by carefully selecting characteristics, creating a standard scale, and allocating weights. TH, pH, TDS, cations, and anions are among the water quality criteria used in the proposed approach for comparing the water quality of various water sources [23]. Weighted Arithmetic Index Method (WQI) was calculated in this study using the calculations below to assess if it is appropriate for human consumption [23]:

$$WQI = \sum QiWi / \sum Wi \quad ......7$$

$$Qi = (V_i - V_0 / Si - V_0) * 100 \quad ..... 8$$

Vi is the (concentration of each parameter in each water sample in mg/l, V_o is the parameter's optimum value in pure water (V_0=0 except for pH =7), and Si is the Iraqi standards for drinking each chemical parameter in mg/l.

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$Wi = K / Si \quad .... 9$$

Where K = proportionality constant and can also be calculated by using the following equation:

$$K = \frac{1}{\Sigma(\frac{1}{Si})} \quad .... 10$$

The WQI of Tigris channel water samples was computed in Tables 12, 13.

Table 12: standard values and weighted arithmetic for parameters according to [6].

Chemical parameter (mg/l)	*Si* (Iraqi standard) [6]	1/Si	K	Relative weight (*wi*)
pH	6.5-8.5	0.1176		0.410
TDS	1000	0.001		0.003
TH	500	0.002		0.006
Ca^{2+}	75	0.013		0.046
Mg^{2+}	50	0.02		0.069
Na^+	200	0.005		0.017
k^+	10	0.1		0.3489
Cl^-	250	0.004		0.013
SO_4^{2-}	250	0.004	3.4891	0.013
NO_3^-	50	0.02		0.069
Total		0.2866		∑ = 0.994

Table 13: Water quality index in Two period wet March,2022 and dry August,2022

Parameters	**Wet period**			**Dry period**		
	Tigris channel mean mg/l Vi	**Wi**	**Qi**	**Tigris channel mean mg/l Vi**	**Wi**	**Qi**
pH	7.72	0.41	48	8.1	0.41	73.33
TDS	851.1	0.003	851.1	902.2	0.003	902.2
TH	473.2	0.006	473.2	500.3	0.006	500.3
Ca^{2+}	117.7	0.046	117.7	123.75	0.046	123.75
Mg^{2+}	43.5	0.069	43.5	46.5	0.069	46.5
Na^+	101	0.017	101	108	0.017	108
k^+	3.93	0.3489	3.93	4.13	0.3489	4.13
Cl^-	212.5	0.013	212.5	225.6	0.013	225.6
SO_4^{2-}	122.12	0.013	122.12	128.12	0.013	128.12
NO_3^-	2.61	0.069	2.61	2.79	0.069	2.79
		∑ = 0.994	1975.66		∑ = 0.994	2114.72
	WQI= 41.35			WQI= 53.06		

According to [24], results show that WQI is classified as "excellent water" in the wet period, while good water is in the dry period Table 14.

Table 14: Water quality classification based on WQI value [24].

Water value	Class	Water quality classification	Stations
>50	I	Excellent	wet Tigris channel
50-100	II	Good water	dry Tigris channel
100-200	III	poor water	
200-300	IV	vary poor water	
>300	V	Unsuitable water	

3.4 Water classification using Piper Diagram:

Piper proposed a trilinear diagram for water classification [25]. Piper diagrams allow both cation (Mg2+,Ca2+, Na+, K+) and anions ($SO_4^{=}$, HCO_3^-, Cl^-, $CO_3^{=}$) compositions to be displayed on a single graph. These diagrams are handy for visually expressing changes in the chemistry of important ions in water flow systems [26]. When the cation and anion values of the water samples for two periods are compared with the hydrochemical classification diagram [27], the bulk of surface samples fall into class (e), indicating that the kind of water in most studied samples for wet periods and dry periods earth alkaline water with a higher percentage of alkali and a sulfate and chloride predominance, the hydrochemical formula is (CaCl).

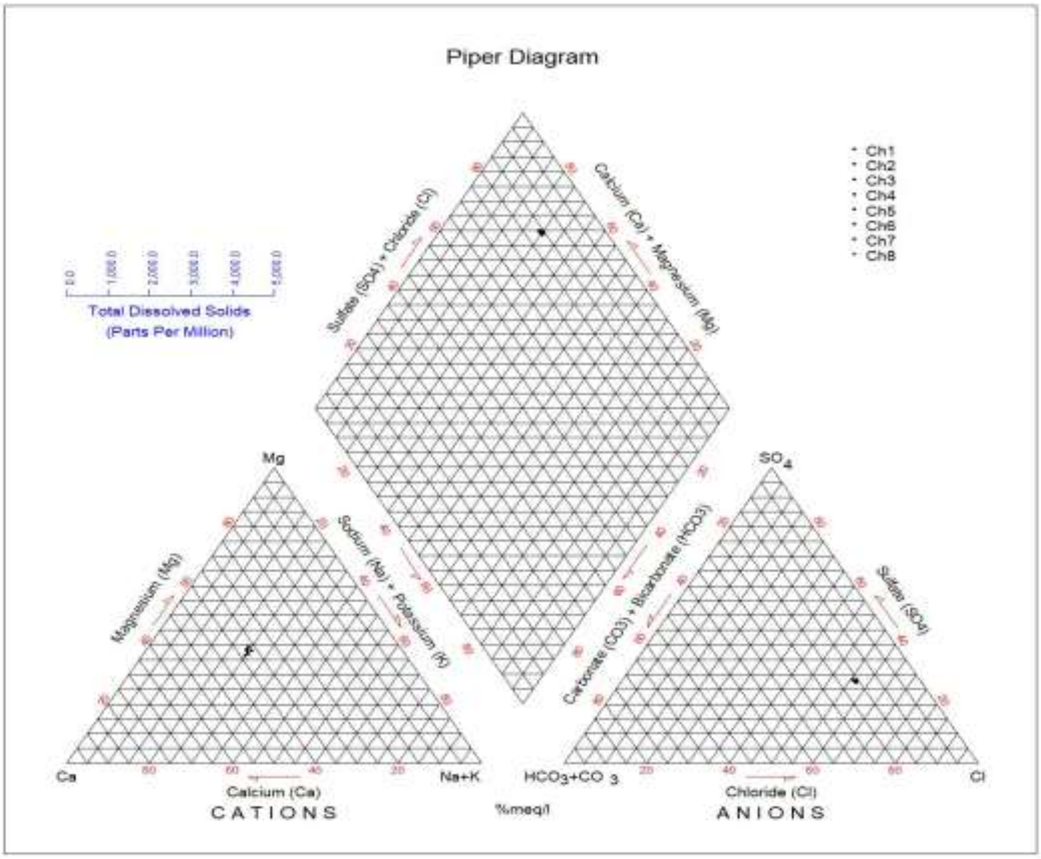


Figure 13: Piper diagram in March, 2022 of studied samples.

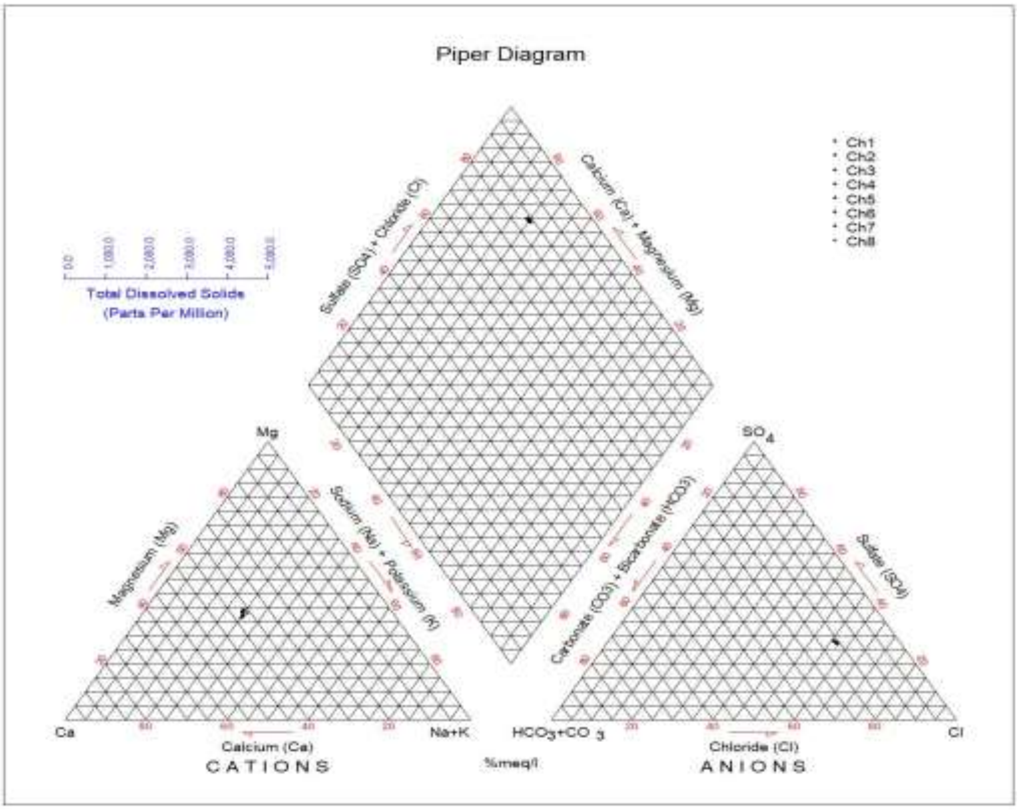


Figure 14: Piper diagram in August 2022 of studied samples.

According to Piper diagrams, Figures 13 and 14 show a resemblance in the chemical makeup of most of the water in the channel [28].

3.4 Uses of water

3.4.1 Evaluation of water quality for drinking

In the current study, the water quality assessment of samples for drinking use is based on the drinking water standards of the WHO [7] and the Iraqi Standard [6] Table 15. All water samples taken during dry and wet seasons are fit for human consumption and meet the requirements for most physiochemical parameters and trace constituents.

Table 15: Comparison of water samples analysis with the standards according to WHO [7], IQS[6].

Parameters	WHO,[7] ppm	IQS, [6] ppm	Present Study wet period	Present Study dry period
pH	6.5-8.5	6.5-8.5	7.72	8.1
TDS	1000	1000	851.1	902.2
T.H	500	500	473.2	500
Ca^{2+}	150	150	117.7	123.75
Mg^{2+}	125	100	43.5	46.5
Na^{+}	200	200	101	108
K^{+}	12	-	3.93	4.13
Cl^{1-}	250	350	212.5	225.6
SO_4^{2-}	250	400	122.12	128.12
Zn	3	3	0.0145	0.0173
Fe	0.3	0.3	0.0377	0.0413
Ni	0.07	0.02	0.0162	0.0187
Cr	0.05	0.05	0.0185	0.0265

3.4.2 Use for Irrigation purpose

To determine the amount of water necessary for irrigation. SAR is the most important water feature or quality for irrigation applications [29]. The water is suitable for Irrigation purposes.

3.4.2.1 Sodium Hazard

The sodium adsorption ratio (SAR) shows sodium concentration in water relative to Ca^{2+} and Mg^{2+} [29]. SAR can be calculated using the following equation:

$$SAR = \frac{Na}{\sqrt{\frac{(Ca+Mg)}{2}}} \quad \ldots\ldots\ldots.11$$

Where: SAR stands for Sodium Adsorption Ratio, Na^{+}: Sodium concentration in epm, Ca^{2+}: Calcium concentration in epm, Mg^{2+}: Magnesium concentration in epm.
According to sodium hazard based on SAR values [29], all water samples for dry and wet seasons excellent water type cause SAR <10, Table 16 and 17.

Table 16: Sodium Adsorption Ratio for two periods.

Samples No.	**SAR** in the wet period	**SAR** in the dry period
Ch1	2.356	2.465
Ch2	2.338	2.435
Ch3	2.335	2.421
Ch4	2.3211	2.417
Ch5	2.317	2.415
Ch6	2.442	2.501
Ch7	2.337	2.435
Ch8	2.401	2.497

Table 17: Classification of irrigation water based on SAR values according to [29].

SAR	Water Class	Present Study SAR
<10	Excellent	2.356,2.448 for wet and dry period
10-18	Good	
18-26	Fair	
>26	Poor	

3.4.3 Use of water for livestock

Criteria for livestock suitability usually consider the type of livestock, daily water requirements of each species, and information on the toxicity of specific substances to the different species. Depending on [13], all water samples in the study area are safe for livestock Table 18.

Table 18: Standard water for livestock depends on [13].

Ions	**Unite**	**Range of ions**	**WHO,[7] ppm**	**IQS, [6] ppm**	**Present Study Wet period**	**Present Study Dry period**
Ca^{2+}	ppm	350-1000	150	150	110-123	116-129
Mg^{2+}	ppm	150-700	125	100	42-46	45-49
Na^{+1}	ppm	800-4000	200	200	100-103	107-110
Cl^{1-}	ppm	900-6000	250	350	210-216	223-230
$SO_4^{\ 2-}$	ppm	600-1000	250	400	110-131	116-137
TDS	ppm	3000-15000	1000	1000	846-859	896-911

3.4.4 Use of water for building purposes

According to Altoviski [13], categorization is used to identify the acceptability of water samples for building construction. The water in the study area is suitable for building and construction for both periods, with the permissible limit shown in Table 19.

Table 19: Represent classifications of water for buildings depend on [13].

Parameters ppm	Na^{1+}	Ca^{2+}	Mg^{2+}	Cl^{1-}	SO_4^{2-}	HCO_3^{1-}
Permissible	1160	437	271	2187	1460	350
Present Study wet period	101	117.75	43.5	212.5	194.625	174.845
Present Study dry period	108	123.75	46.5	225.625	206.375	185.375

3.4.5 Use of water for industry

Hem [31] proposed industrial water quality. According to the Hem shows that all samples are unsuitable for industrial uses because Ca^{2+} exceeded the permissible limits.

3.4.6 Use of water for agricultural purposes

Use of water for agriculture purpose according to Todd classification[17], which is based on electrical conductivity for plant tolerance differences, indicates that the water samples in the study area is acceptable for fruit crops only (low salt tolerance crops) because the EC exceeds low (3000µS/cm) in both wet and dry period. (Low salt tolerance) include Limon, Apricot, Orange, Apple, Pear, and Peach.

3.6 Gibbs diagram

According to [32], the Gibbs diagram is commonly used to determine the source of dissolved chemical components such as evaporation, rock dominance, and precipitation. This graph (Fig.15) depicts the relationship between the $Cl^-/(Cl^- + HCO_3^-)$ ratio and TDS. The distribution of sample points in the studied area demonstrates that rock-water interaction affects surface water quality (Table 20).

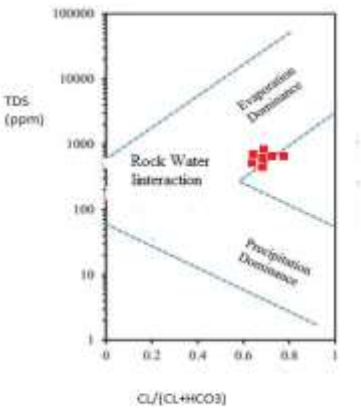


Figure 15: Gibbs Diagram describes the study area.

Table 20: Value of Gibbs diagram for two periods.

Mean of TDS for two periods	Mean of($Cl^-/Cl^-+HCO_3^-$)for two period
875.5	0.681
884.5	0.671
885	0.676
871	0.680
872.5	0.678
871.5	0.678
882	0.681
871.5	0.682

4. Conclusion

This study looked into the physicochemical characteristics of surface water (the Tigris channel) in the Tajii district. Depending on pH, TDS, EC and T.H, the samples were classified is weakly alkaline, Freshwater, excessively mineralized water and very hard, respectively. Dominate cation is Ca^{2+} followed by Na^+, Mg^{2+} then K^+ whereas dominant anion Cl^- followed by SO_4^{2-}, HCO_3^-then CO_3^-. All water samples are grouped together in class (e) in Piper's diagram for the dry and wet periods. Class (e) is "Alkaline water on Earth contains a higher alkali concentration, mostly sulfate and chloride ".The water sample analysis results in the examined area will be used for this purpose and showed suitability for drinking purposes, irrigation and livestock and building purposes in both periods while unsuitable for industry purposes. The WQI in this study is excellent in the wet period and good water in the dry period.

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