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Evaluating the Water Quality of the Tigris River Between Al-Qurna and Al-Azayer Cities in Southeastern Iraq

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ABSTRACT

The water quality index (WQI) is a unified measure that summarizes many water test characteristics to provide a single value indication of water quality. The Tigris River is a vital water source in southeastern Iraq. Monthly water samples were collected from August 2022 to July 2023. Eighteen parameters were analyzed. The principal component analysis (PCA) was applied to analyze the environmental variables. First, it helped us choose significant water quality limits and determine their comparative weights. Second, we constructed excellence curves for the selected parameters to estimate the WQI conclusion based on water quality values. Six variables were selected to be included in the guide based on their significant influence on water quality which involved total dissolved solids (TDS), total hardness (TH), dissolved oxygen (DO), total coliform (TC), chemical oxygen demand (COD) and chlorides (Cl^-), aiming to capture the specific features of the Iraqi waters. In this analysis, an eigenvalue of 8.325 was observed, signifying a substantial value given by the initial fifteen factors examined. The cumulative effect of the three components, namely F1, F2, and F3, amounted to 46.2٥, 69.4٦, and 79.878%, respectively. The results of the Iraq water quality index (WQI) for the Tigris River in southeast Iraq revealed acceptability, with scores of 65.32, 53.03, and 57.15 during winter, spring, and autumn, while the summer season exhibited poor water quality with a score of 23.45. On an annual average basis, the water quality of the Tigris River was found to be poor, with a mean of 49.74± 18.256. These results suggest that the water in the entire river is unsuitable for potable water.

INTRODUCTION

Surface water plays a vital role as a fundamental natural resource for both human survival and development-related activities. Consequently, it becomes imperative to preserve and uphold high-quality surface water to ensure sustainable development and protect human health **(Parween *et al.*, 2022)**. Examining the quality of water comprises evaluating the conditions of natural water and its expediency for potable, agricultural use, domestic, industrial, and irrigation processes **(Egbueri *et al.*,2023)**. In recent decades, we have observed an ongoing decline in surface water quality, primarily due to its vulnerability to contamination from both natural and human-induced sources, including industrial sewage, domestic waste disposal, and irrigation drainage **(Rahman *et al.*, 2021)**.

The water quality of rivers is of an utmost importance as these water resources are widely utilized for numerous purposes, such as drinking domestic and residential water supplies, agriculture for irrigation purposes, generating hydroelectric power, transportation and infrastructure, tourism, and recreation **(Venkatramanan *et al.*, 2014)**.

The water quality in the river was affected by various interrelated variables, which exhibited local and temporal differences. These environments are interrelated by some influences, containing the flow of water rate, which differs during the seasons **(Mandal *et al.*, 2010)**. The quality of water catalogs to four main groups. First, evaluate general water quality such as the NSFWQI **(Dash & Kalamdhad, 2021)**. Second, the study categorizes usage indices for purposes of water like potable and ecological protection, as shown by the OWQI **(Keraga *et al*., 2017)**. The third indices encompass that assignment as tools for arranging and conclusion action in water quality organization plans **(Adom & Simatele, 2022)**. The fourth group includes an arithmetical technique-based guide and doesn't consolidate particular conceptions. These catalogs rely on the application of water at that estimation **(Ticehurst *et al.*, 2022)**. There have been several global studies directed at the quality of water. For example, **Chebet *et al.* (2020)** assessed the quality of water in the Molo River system, which is an important source of drinking water and industries in Nakuru and Baringo counties in the Kenyan Rift Valley. Moreover, **Aydin *et al.* (2021)** examined the quality of water variations in seven important rivers, and the analysis of results was classified according to the World Health Organization potable water limit values. An instant response to water contamination was developed with the application of multivariate statistical methods to assist in water quality monitoring **(Chu *et al.*, 2018)**. One multivariate statistical methodology that is widely utilized in scientific research is the principal component analysis (PCA). This method helps decrease data set dimensionality while preserving the features of the variables that are primarily responsible for this variance **(Zeinalzadeh & Rezaei, 2017)**. The Tigris River stands as the second longest river in Southeast Asia, stretching across a length of 1800km and encompassing a basin that spans 221000km2 and intersects four riparian countries; Turkey (24.5%), Syria (0.4%), Iran (19%), and Iraq (56.1%); it undergoes a transformative journey as reported by **UN-ESCWA (2013)**. The Tigris River encounters human and natural issues such as water scarcity, plant growth, and mud accumulation. Many studies have evaluated the water quality in inland water bodies of Iraq; **Abdullah *et al.* (2019)** studied the quality of water in southern Iraq at the Euphrates River, the purpose of the research was to assess the quality of the river water to diverse uses, contenting potable water, agriculture, and irrigation. **Ewaid *et al.* (2019)** established the quality of water to evaluate the convenience of potable water. **Chabuk *et al.* (2020)** revealed a calculation of the quality of water in the Tigris River, the researchers used the WQI method to evaluate the overall water quality based on the twelve parameters. **Al-Barwary (2021)** studied and assessed the water quality in Iraq, specifically in the city of Zakho at Kurdistan Region. Eleven physiochemical factors were tested on the water during the research to evaluate its potability. Ten quality water variables were used to assess the water in the Euphrates River for potable purposes **(Khaleefa & Kamel, 2021)**.

Within this context, this study required the development of the Iraqi water quality index by using the authors' previous knowledge and principal components analysis. The index was based on the water quality criteria and designed according to the Iraqi standards. This index was developed to monitor the drinking water quality of the Iraqi rivers and streams, as well as to analyze fluctuations in this quality for the aim of improving the water resource management. To accomplish this target, we used environmental indicators to determine the water quality index with a set of selected environmental standards and measures applicable to the study area.

MATERIALS AND METHODS

Description of area

The study area was meticulously delineated, covering between the geographical coordinates of station one (31.2570 N, 47.43210 E) to station four (31.0210 N, 47.43760 E), covering an expanse of 52km. Four stations were selected in this study to investigate water quality (Table 1 & Fig. 1).

Table 1. A station of sampling and their coordinates on the Tigris River

Station	Name of station	Latitude (N)	Longitude (E)
1	Al-Azayer city	31.2570	47.43210
2	Al-Sakhrija village	31.1651	47.43138
3	Nakhlate village	31.0913	47.42750
4	Al-Qurna city	31.0210	47.43760

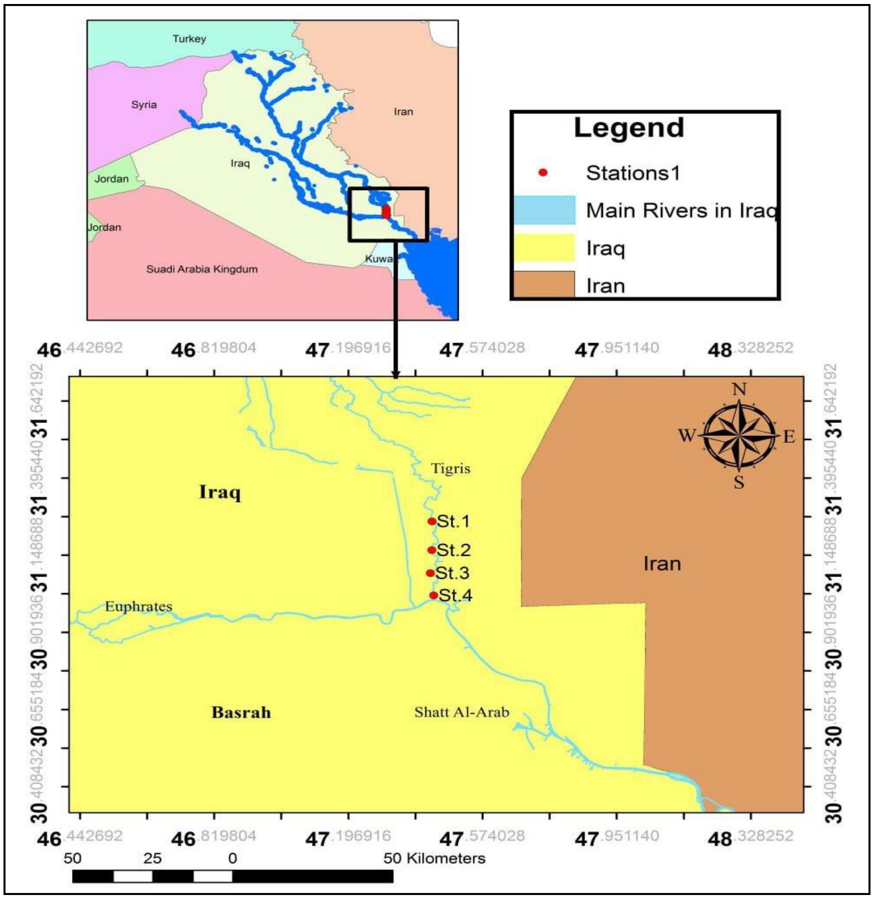

Fig. 1. The map and the sampling stations of the study area

Field sampling and measurements

Each month, water samples were collected from each of the four designated monitoring stations in the Tigris River from August 2022 to July 2023; the statements were classified through seasons into four collections. Monthly values of eighteen water quality parameters were used to derive the index, including air temperature (A. temp.) and water temperature (W. temp.), and the resulting measurement was expressed in ($^{\circ}$C), while potential hydrogen ion concentration (pH), salinity (Sal), total dissolved solids (TDS), and electric conductivity (EC) were meticulously gauged using the YSI 556 MPS model 2005, and the resulting measurement was expressed in milligrams per liter (Mg/ l) and micro Siemens per centimeter (µS/ cm) respectively. In parallel, the water's turbidity was methodically ascertained utilizing a meticulously crafted HANNA HI-93703 turbidity meter of German origin, which was determined in Nephelometric Turbidity Units (NTU). Some of the parameters were measured in the laboratory (Table 2).

Table 2. Measuring quality parameters of water in the laboratory

Variable	Unit	Method
Dissolved oxygen (DO)	mg/l	Welch (1964)
Total hardness (TH)	mg/l	Lind (1979)
Calcium (Ca^{+2})	mg/l	Lind (1979)
Magnesium (Mg^{+2})	mg/l	Lind (1979)
Nitrate (NO_3)	mg/l	Parson *et al.* (1984)
Phosphate (PO_4)	mg/l	Murphy and Riley (1962)
Biological oxygen demand (BOD_5)	mg/l	APHA (2005)
Alkalinity	mg/l	APHA (2005)
Chloride (Cl^{-1})	mg/l	APHA (2005)
Chemical oxygen demand (COD)	mg/l	Baird *et al.* (2017)
Total coliform (TC)	mg/l	Baird *et al.* (2017)

Application of WQI

The water quality index (WQI) wa used in the current study as recognized by **Tyagi *et al.* (2013)** and **Ewaid *et al.* (2020).** The study was analyzed and the process comprised reduplicating each water variable with a scaling factor and collecting them through a plaint calculation average, then the indicators with the least variance were excluded, and a PCA for those factors was conducted for the remaining factors **(Chu *et al.*, 2018)**. This method involved four disconnected proceedings:

Weight assignment of parameters selected

Table (3) explains the weights of the variables dispensed by a professional commission, reflecting the authors' expertise and the significance of these factors in the assignment quality of water in Iraq inland water, which included total dissolved solids (TDS), total hardness (TH), dissolved oxygen (DO), total coliform (TC), chemical oxygen demand (COD) and chlorides (Cl^-). Moreover, data presents the value of various water quality that is categorized by the water quality of Iraq index (WQI), associated with both the Iraqi standards and the World Health Organization for potable water **(Iraqi Standard Water, 2009; WHO, 2011)**.

Table 3. The quality of water categories for water quality index (WQI), calculated equations for curves, and assigned weights for six parameters

Variable	Very good 90-100	Good 70-90	Acceptable 50-70	Bad 20-50	Very bad 0-20	Equation	R2	Weight
TDS	**50-100**	**200-300**	**500-1000**	**2000-3000**	**3500-4000**	**Y= -0.0438X + 91.85**	**0.9223**	**0.2**
TH	**50-200**	**300-400**	**500-600**	**650-700**	**750-800**	**Y=-0.3098X +249.03**	**0.9261**	**0.15**
DO	**10- 9**	**8-7**	**6-5**	**4-3**	**2-1**	**Y=71.984X -526.09**	**0.9368**	**0.2**
TC	**0-1000**	**2000-2500**	**3000-5000**	**6000-8000**	**12,000-15,000**	**Y=-0.0979X +107.28**	**0.9748**	**0.2**
COD	**0- 0.5**	**1-2**	**4-6**	**8-10**	**12-14**	**Y=-10.453X +109.56**	**0.9423**	**0.1**
Cl^-	**50-150**	**200-300**	**400-500**	**550-650**	**700-800**	**Y=-0.1163X +112.57**	**0.9682**	**0.15**

Principal component analysis

In this study, we applied multivariate analysis, specifically, PCA using XLSTAT-Premium 2018.1 to unveil the relationships between the diverse abiotic environmental features. Subsequently, we conducted the PCA, which is a recognized multivariate investigation method enabling the discovery of patterns within a dataset and presenting them in a way that highlights similarities and differences, and effectively reducing dimensionality without significant loss of information.

Creating the sub-indices

The sum index of the weighted method was used, which suggested groups of value for varied rating quality of water, and was visualized as curves of the water quality. A sequence of mean curves, one of each variable, was formed to describe the variations in water quality consisting of a diverse mensuration to every specific factor. These curves ranged from 0 to 100 on the vertical lines, with the variables differing levels plotted length away from the horizontal axis **(Ewaid *et al.*, 2020)**.

Aggregating the sub-indices

Each one of the parameter's scores was averaged to assess its influence on a unified single scale. To realize this, we employed the average of weighted accumulating objectives, as suggested by **Sun *et al.* (2016)** and **Tian *et al*. (2019)**.

$$\mathrm{WQI} = \sum_{i=1}^{n} \mathrm{Wi} \times \mathrm{Qi}$$

WQI = the water quality index for Iraq, the range between 0 and 100.

Qi = the quality of the itch variables, the value between 0 and 100.

Wi = the weight unit of the factor, a number between 0 and 100

$$\sum_{i=1}^{n} \mathrm{Wi} = 1$$

n = a number of parameters.

RESULTS

Environmental properties

The results of physiochemical variation were summarized, as shown in Table (4). Table (4) exhibits the expressive indicators, contenting lowest, highest, average, standard deviation, and values of variance for 18 parameters of water quality. It was shown that three variables (Salinity, pH, and BOD_5) recorded minimum variance. The values of the important factors used in analyzing the water quality were as follows: The minimum air temperature was 21.37°C and the highest was 39.12°C with a mean of 29.35± 5.9°C; water temperature differed from 19 to 33.87°C with an average of 26.39± 5°C; dissolved oxygen (DO) varied from 6.97 to 8.52mg/ l with an average of 7.85± 0.46mg/ l; the pH values ranged between 7.2 & 8.15 with a mean of 7.71± 0.07; the minimum value of turbidity was 53 NTU, and the highest was 92.37 NTU with an average of 67.57± 12.49; the total hardness (TH) ranged between 621 and 816.25mg CaCO3/ l with a mean of 711.71± 66.33mg CaCO3/ l, whereas the minimum value of the total dissolved solids (TDS) was 747.75mg/ l and the highest was 1668.5mg/ l with an average of 1162.46± 345.08mg /l. On the other hand, the salinity varied from 0.96 to 1.15g/ l with a mean of 1.03± 0.07g/ l; EC differed from 1462.5 to 1795µS/ cm with an average of 1606.46± 102.73µS/ cm; Ca^{+2} ranged from 150.5 to 178.5mg CaCO3/ l with a mean of 164.77± 8.79mg/ l; the values of Mg^{+2} varied from 55.55 to 90.45mg/ l with an average of 73.01± 13.22mg/ l. In addition, the minimum of NO_3 was 4.87mg/ l and the highest was 31.58mg/ l with an average of 12.64± 8.48mg/ l; PO_4 values differed from 1.24 to 5.84 mg/ l with a mean of 3.21± 1.39mg/ l; the BOD_5 ranged from 0.7 to 1.63mg/ l with an average of 1.14± 0,34mg/ l; alkalinity values varied from 85.5mg CaCO3/ l to 152mg/ l with a mean of 111.42± 24.17mg/ l; the values of chloride (Cl^{-1}) ranged between 162.5 & 210.75mg/ l with a mean of 187.81± 13.48mg/ l; the chemical oxygen demand (COD) differed from 2.23 to 9.65mg/ l with a rate of 5.67± 2.43mg/ l, and the minimum value of total coliform (TC) was 101.96mg/ l and the highest was 945.1mg/ l with a mean of 512.39± 281.87mg/ l.

Table 4. Results of the 18 parameters of water quality of the monitoring stations in the Tigris River from August 2022 to July 2023

Variable	Minimum	Maximum	Mean	SD	Variance
A. temp.	21.37	39.12	29.35	5.9	34.91
W. temp.	19	33.87	26.39	5	25.02
DO	6.97	8.52	7.85	0.47	0.22
pH	7.2	8.15	7.71	0.27	0.07
Tur.	53	92.37	67.57	12.49	155.97
TH	621	816.25	711.71	66.33	4399.32
TDS	747.75	1668.5	1162.46	345.08	119083.2
Salinity	0.96	1.15	1.03	0.07	0
EC	1462.5	1795	1606.46	102.73	10552.79
Ca^{+2}	150.5	178.5	164.77	8.79	77.24
Mg^{+2}	55.55	90.45	73.01	13.22	174.77
NO_3	4.87	31.58	12.64	8.45	71.33
PO_4	1.24	5.84	3.21	1.39	1.93
BOD_5	0.7	1.63	1.14	0.34	0.12
Alk.	85.5	152	111.42	24.17	584.42
Cl^{-1}	162.5	210.75	187.81	13.48	181.73
COD	2.23	9.65	5.67	1.83	5.94
TC	101.96	945.1	512.39	89.87	79451.35

Principal component analysis

The PCA results are presented in Table (5) and Fig. (2), revealing the selection of three PCA, with a cumulative variance of 79.878%. We subjected the results of the environmental variables to analysis using the principal component analysis (PCA) technique. This analysis unveiled an eigenvalue of 8.325, signifying a significant value given by the fifteen factors under examination. Moreover, the proportions of the variables' contributions were distributed as 46.25, 23.21, and 10.42% in the first, second, and third components (F1, F2, and F3).

Table 5. Three PCA chosen with a cumulative variance of 79.878%

Variable	F1	F2	F3
A. temp.	0.737		
W. temp.	0.620		
DO	0.809		
Turb.		0.681	
TH	0.294		0.242
TDS	0.364	0.524	
Ca^{+2}	0.611		
EC	0.390	0.288	
Alkal.	0.552	0.407	
NO_3	0.402	0.279	
PO_4		0.582	
Mg^{+2}		0.268	0.337
Cl^{-1}		0.290	0.197
COD	0.781		
TC	0.572	0.235	0.115
Eigenvalue	8.325	4.178	1.875
Variability (%)	46.25	23.21	10.42
Cumulative %	46.25	69.46	79.878

Notably, a cumulative influence of the compositional makeup of the three components F1, F2, and F3 amounted to 46.25, 69.46, and 79.878 %, respectively. These cumulative values collectively underscore the substantial impact of these components in capturing the underlying patterns within the dataset (Fig. 2). The first rotated component, PCs (F1), is strongly positive with PO_4, TDS, total alkalinity, NO_3, Mg^{+2}, and TH, while negative with DO. PCs (F2), accounting for 23.21% of the data sets' total variance. Turbidity, Cl^{-1}, W. temp., EC, A. temp., Ca^{+2}, TC, and COD all appear highly positive, while DO shows a considerable negative correlation with these factors. PCs (F3), explain 10.42% of the overall variance and included TDS, PO_4, Ca^{+2}, EC, Cl^{-1}, TH, and Mg^{+2}. It showed a positive correlation; on the other hand, it exhibited a strong negative correlation with dissolved oxygen.

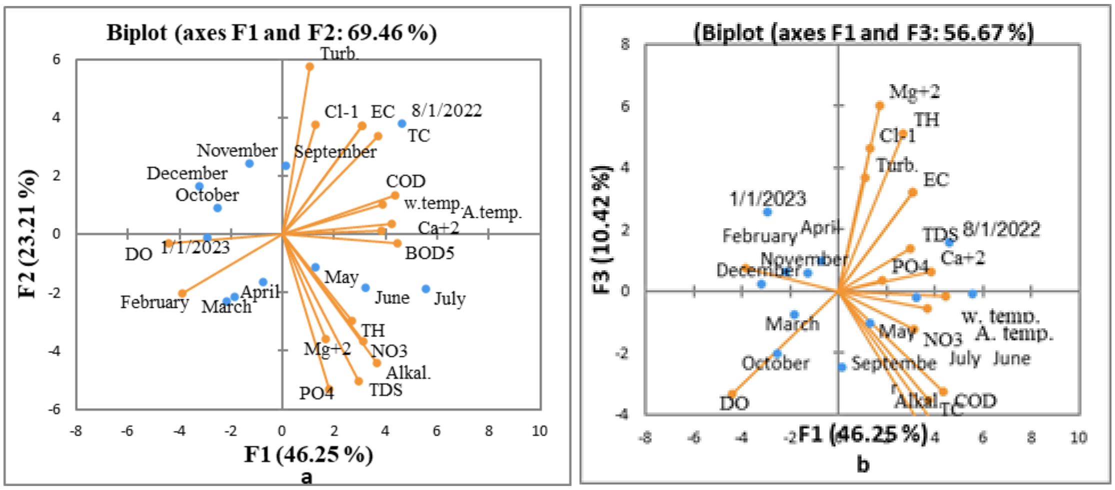

Fig. 2. The effects of current physicochemical variables on the study region throughout time using the principal component analysis (PCA) technique on the study area over the months

Creating the sub-indices

To create the sub-indices, we generated a series of average curves, where each curve illustrates the variations in water quality levels caused by different measurements of its corresponding parameter. These curves are positioned along the vertical axis, covering a range from 0 to 100. Concurrently, we charted various parameter levels over the horizontal axis, as visually represented in Fig. (3).

Calculation of WQI

Consequently, the concluding formula for the Iraqi water quality index was as follows:

Iraq WQI = [(-0.0438 TDS + 91.85) × 0.2] + [(-0.3098 TH + 249.03) × 0.15] + [(71.984 DO - 526.09) × 0.2] + [(-0.0979 TC + 107. 28) × 0.2] + [(-10.453 COD + 109.56) × 0.1] + [(-0.1163 Cl + 112.57) × 0.15].

We determined the quality of the water index from the river by employing specified arithmetic index equations. Over the course of our study, we conducted evaluations and inspections of various sources of drinking water. Six variables were selected, namely total dissolved solids, total hardness, dissolved oxygen, total coliform, chemical oxygen demand, and chlorides; based on expert panel advice and PCA testing, these variables were deemed to significantly influence surface water quality.

To classify water quality, five categories were created: excellent, good, suitable, poor, and very poor. These categories were determined by creating ratings based on specific parameters. A detailed presentation of the proposed criteria for water quality classification, including category and indicator assignments is shown in Table (3).

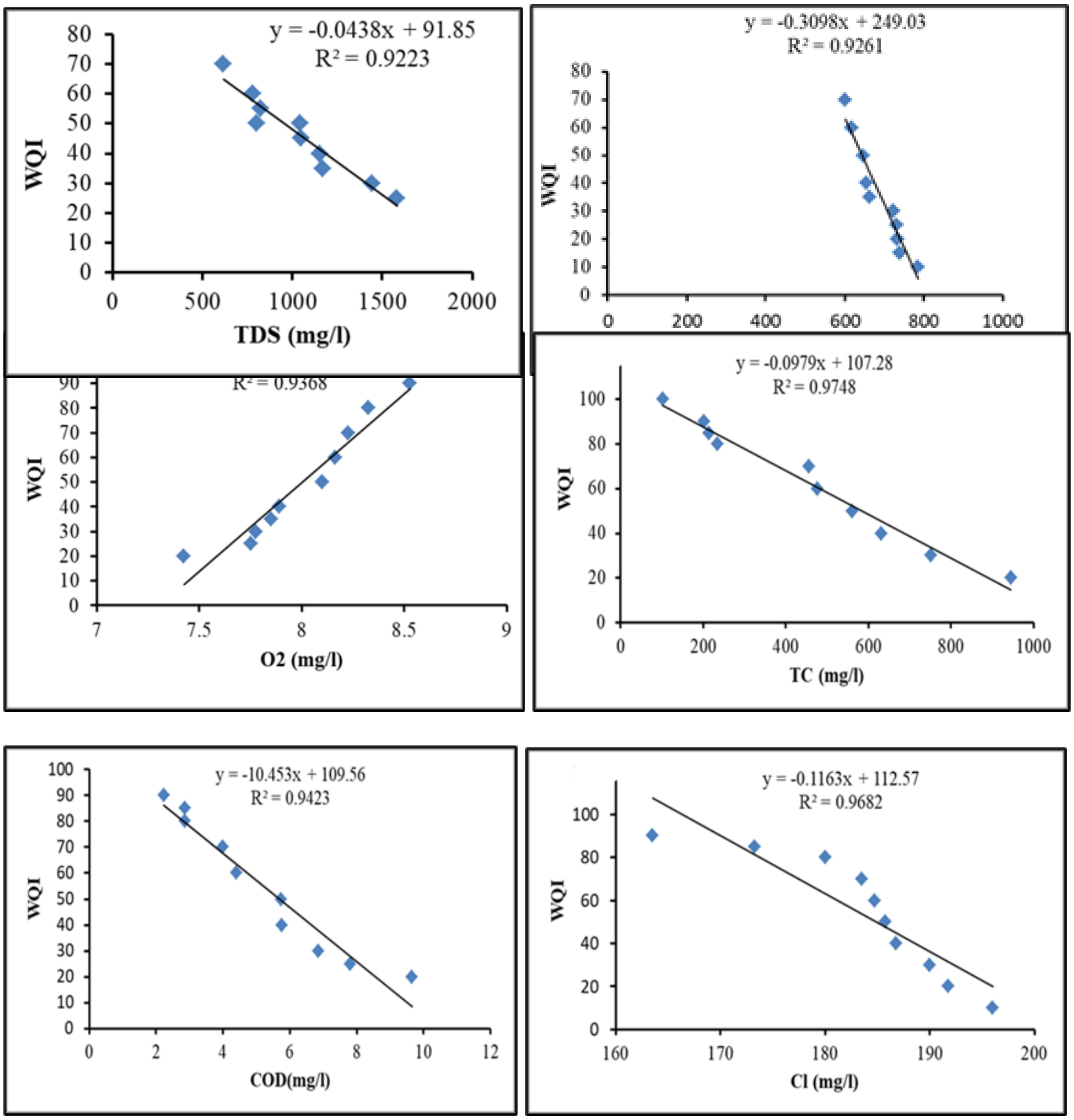

Fig. 3. The curves representing the water quality for six parameters

The results of Iraq's water quality index (WQI) in the Tigris River in southeast Iraq indicated acceptability (scores of 65.32, 53.03, and 57.15) in winter, spring, and autumn, and bad quality in summer (23.450). The average annual of quality water for the Tigris River was found to be poor or bad (49.74± 18.256), as presented in Table (6).

Table 6. Utilization of the proposed index for assessing seasonal parameter values at the Tigris River in southeast Iraq during four different seasons

Season	TDS	TH	DO	TC	COD	Cl^{-1}	WQI
Winter	1017.2	715.33	8.2475	257.47	2.6567	186.08	65.32
Spring	1396.5	708.42	7.875	303.86	5.6767	183.42	53.03
Summer	1565.6	783.42	7.1925	897.8	8.9	194.4	23.45
Autumn	779.58	645.67	8.0792	648.58	5.8467	189.25	57.15
Average ± SD	1162.5	711.71	7.8485	512.4	5.6792	187.81	49.47± 18.25

DISCUSSION

Environmental properties

For the ecological factors influence, the water quality in river habitats are a critical aspect of human well-being and sustainable development **(Leitao *et al*., 2018)**. The temperature variations during months, in conjunction with dissolved oxygen and salinity, may strongly contribute to the composition, and prevailing differences in the environment of rivers **(Abdullah *et al.*, 2022)**. The results of the present study of DO and pH fall within the range of the **Iraqi drinking water standard (2009)**. According to the **World Health Organization (2011)**, the river reached its maximum turbidity due to an accumulation of human waste, increased rainfall, and rising water levels. Both inorganic and organic dissolved substances in water, such as minerals, salts, metals, and various compounds, have the highest values of total hardness (TH), TDS, salinity, EC, Ca^{+2}, and Mg^{+2} **(Lind, 1979)**. Nitrate, phosphate, alkalinity, and chloride concentrations in untreated water usually meet or exceed both the Iraqi and World Health Organization guidelines. Due to human-caused pollution and the impact of changing seasons on temperature, the BOD, COD, and TC levels rose **(Ewaid *et al.*, 2020)**.

Principal component analysis

The initial eighteen quality parameters were analyzed for the Iraq water quality index (WQI). Using the experience-based method, we eliminated three 'non-critical' parameters, as they were found not to present issues in the Iraqi river waters **(Rabee *et al.*, 2011; Ewaid *et al.*, 2020)**. The objective of PCA is to transform the initial variables, or factors in this study, into a set of new and uncorrelated variables known as principal components (PCs). This is achieved by forming linear combinations of the original variables, as described by **Shrestha and Kazama (2007)**.

As illustrated in Fig. (٢), the first rotated component, PCs (F1), accounts for 46.25% of the total variance in the datasets. It exhibits strong positive loadings on PO_4, TDS, total alkalinity, NO_3, Mg^{+2}, and TH, while displaying a negative loading on DO. This component is associated with the mineral composition of the river water. The parameters of this component indicate fluctuations in water flow, a decrease in water quality, and an increase in soluble salts in the Tigris River, as discussed by **Oleiwi and Al-Dabbas (2022)**.

PCs (F2) account for 23.21% of the data sets' total variance. Turbidity, WT, EC, A. temp., Ca^{+2}, TC, and COD all appear highly positive, while DO shows a considerable negative correlation. This constituent is typically connected to causes of anthropogenic pollution and the effects of seasonal temperature. According to **Ali *et al.* (2023)**, one significant aspect is the existence of high amounts of dissolved organic substance exhaustion. With a positive total, the third rotated component, PCs (F3), explains 10.42% of the overall variance. This element underscores the importance of human inputs, which are essentially derived from pollution sources, such as air deposition and agricultural runoff, as noted by **Moyle (2014)**.

The **Iraqi Standards (2009)** and the World Health Organization **WHO (2011)** both specify the quality standards for water. Six variables were shown to have a substantial impact on the surface water quality, based on suggestions from an expert panel and a PCA test: total dissolved solids (TDS), total hardness (TH), dissolved oxygen (DO), chemical oxygen demand (COD), chlorides (Cl^-), and total coliform (TC). Those parameters led to the formation of an arrangement structure that classified the quality of water into five collections; very good, good, acceptable, poor, and very poor. Table (3) explains the requests for this quality of water compilation, along with the group distribution and index marks. The subsequent characteristics and variables were considered when selecting these six water quality parameters. Total dissolved solids (TDS) indicate the water's salinity content, which affects its suitability for various uses **(WHO, 2003; Abdul Hameed *et al.*, 2010)**. TH represents the quantity of magnesium and calcium ions **(Lind, 1979)**, which affects the probability of scale increase and the amount of water **(Qasim & Mane, 2013)**.

The dissolved oxygen condensation (DO) is important for defining the health and condition of aquatic life **(Kholikov *et al.*, 2023)**. Oxygen availability is significantly compressed by human efficiency as well as variations in weather situations, such as differences in temperature, rainfall, and speed of wind. The dynamics of biology are affected by this aspect **(Ayala-Torres & Otero, 2023)**. Monitoring water pollution and conditions levels demand for chemical oxygen (COD) is critical **(Prambudy *et al.*, 2019)**. COD provides a universal assessment of the organic content and indicator of the amount of water contamination. The quantity of total coliform (TC) is important for an effective water quality. According to **Marie and Lin (2018)**, microbial contamination causing diseases such as diarrhea, typhoid fever, and bacillary dysentery significantly impacts the human health. The most widely used quality of water point at the moment comprises *Enterococci* of intestinal, fecal coliforms, and *Escherichia coli* **(Hayat & Kurniatillah, 2021)**. High concentrations of chloride (Cl^{-1}) can be caused by either natural processes, including water flowing through salt deposits, or pollution from home or industrial waste and land irrigation **(Awadh & Ahmed, 2013)**.

Calculation of WQI

We determined the water quality index of the river by applying the prescribed subjective arithmetic index equations. The analysis resulted in the calculation of the corresponding water quality index (WQI) scores. Based on the data depicted in Table (3), water quality across the seasons and in the whole river is unsuitable for drinking purposes. Furthermore, the results differ from those of **Ewaid *et al.* (2020)** in their independent investigations related to freshwater quality in the Tigris River within Baghdad City. However, the results coincide with those of **Al-Rekabi *et al.* (2018)**, who conducted their investigations on the Euphrates River. The water quality classification system indicates a lower evaluation during the summer season. At these specific stations, there was a noticeable surge in turbidity, along with an excess of various ions that surpassed both the Iraqi and international standards for safe human consumption. These levels are higher than what is considered to be safe for drinking water. Significantly, an extent of human activities, counting the discharge without processing domestic sewage from the city of Qurna, contributed considerably to the declining quality of water pointers (WQIs). These results agree with the study conceded by **Ameen (2019)**.

During the study period, significant increases in total dissolved solids (TDS) were observed, particularly at the fourth station from February to August. These findings indicate a considerable excess of TDS in the area studied, attributed to increased discharge of domestic wastewater, human activities, and agricultural fertilizers, which degrade water quality. Several variables, including TDS, electrical conductivity (EC), total hardness (TH), and decreased dissolved oxygen (DO) concentrations, contributed to the overall poor water quality observed during the study period **(Lateef *et al.*, 2020)**, assessing a status which is consistent with that of the study conducted on the Euphrates River by **Rabeea *et al.* (2021)**.

CONCLUSION

Based on the environmental factors addressed in this study, it was deduced that the Tigris River water is not fit for human consumption. However, conformist decontamination methods such as sedimentation, filtration, and disinfection must be used together with constant water monitoring to process and enhance water quality. The causes for these discrepancies may be attributed to its downstream station and its confluence with the Shatt al-Arab River in Qurna city. The former is known to consume high amounts of total dissolved solids (TDS) and total hardness (TH).

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