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Evaluation of the Quality of Some Water Stations on the Tigris River Using the Iraqi Water Quality Index (Iraq WQI)

Rawaa Nader Al-Saedy[1*], Jinan S. Al-Hassany[2], and Fouad K.Mashee Al-Ramahi[3]

[1,2]Department of Biology, College of Science for Women, University of Baghdad, Baghdad, Iraq
[3]Remote Sensing Unit, College of Sciences, College of Science, University of Baghdad, Baghdad, Iraq
*Corresponding Author.

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Abstract

Water quality assessment is important for water resource management. The current study focuses on the analysis of monitoring water quality data of the Tigris River in Iraq by applying the Iraqi Water Quality Index (WQI). Twenty-one parameters Quality standards were taken along the river for three governorates and for eight stations, starting from Salah al-Din, north of Baghdad, with one station (Samarra), and Baghdad represented by three stations (Al-Mutha Bridge, Atifia, Jadriya) and south of Baghdad represented by Kut Governorate (Aziziyah, Zubaydah, Numaniyah, Al-Muftah), and included Quality standards nine standards were used for the purposes of living organisms, including (pH, T.w., PO_4, NO_3, Cl, NO_2, TDS, Tur, DO) and eight standards for the purpose of fresh water maintenance (NO_3, Cl, TDS, Tur., DO, BOD_5, pH, PO_4). The result showed that the application the Iraqi WQI decrease in the quality of the river water and its suitability for the neighborhoods living towards the north of Baghdad (Samarra), it reached (71.38 poor) in the dry season. While the highest value was (175.21, unsuitable) in southern Baghdad (Numaniyah) during the dry season, the water quality index for the purpose of maintaining fresh water recorded a decrease in station2 (Al-Muthanna Bridge) for the wet season, while the index value increased in station7 (Numaniyah). for the dry season. The results of the two seasons (wet and dry) coincided for the purposes of living creatures, while the index differed for the two seasons for the purposes of fresh water conservation; this is due to the increase pollution in the river as a result of human activities. Therefore, the guide used in this study could be applied to all rivers in Iraq based on the reliability of the quality index. The water in Iraq no longer requires the use of indicators designed for water in other countries.

Keywords: Iraqi water quality index, Tigris River, Iraq.

1.Introduction

All life depends on fresh water, which is the most valuable natural resource on the planet (1). Understanding the cycles of river variations in physical and chemical concentrations, including nutrients, is important since their quality depends on typical processes (soil weathering, erosion, precipitation, etc.) in rivers (2, 3). An important factor in affecting water quality is also human activity, including industrial, urban, and agricultural operations. Due to their inherent vulnerability to discharges from industry, household life, and agriculture, rivers are highly fragile bodies that are impacted by pollution (4, 5). The Tigris River is the second-largest in Iraq. The basin has a high population density because of its fertile soils and plentiful water supply (6). River water is utilized as a receiver and for industrial, household, and irrigation uses. The quality of river water and industrial and municipal wastewater has decreased as a result during the past several decades (7). Predictions and future availability and quality projections for water resources are significantly impacted by global climate change (8, 9). As the world's population grows, more activities that need a lot of water are being undertaken. The majority of these methods cause significant pollution and go beyond what is sustainable in terms of how water resources are used (10-12) state that the Tigris and Euphrates rivers, many lakes and wetlands, and the lack of water, pollution, and salinity all have an impact on Iraq's water supply (13). Water quality (WQ) refers to undesired or poor water quality conditions and is a broad word for water pollution (14). For the purpose of condensing several lengthy water analysis reports into a single number or word file, water quality indicators are crucial. The fundamental objective of water quality indicators is to follow changes in water quality at the source as a function of time and other influencing variables. This, in turn, is simple to grasp and helpful for comparing water quality in various sources and for tracking changes in water quality at the source as a function of time(15, 16). The WQI can be formulated in one of two ways: (1) scales with ascending indices, where the index numbers (values) rise with the level of pollution (WPI Water Pollution Indicators), and (ii) scales with descending indices, where the index numbers (values) fall as compared to the level of contamination (Water Quality Indicators) (17, 18). One disadvantage of traditional methods for assessing water quality, which rely on comparing experimentally proven parameter values with current standards (19), is that they are challenging to apply to large samples with concentrations of several parameters. Numerous national and local research studies have been conducted on the topic of water quality (20). In 1970 (21), he subsequently created a generic water quality index. The Great Lakes ecosystem's environmental quality index was used (22). The Canadian Water Quality Index was first introduced in 1995 (23). National Foundation for Sanitation and Water Quality in the US. The index, the Oregon Water Quality Index, and the British Columbia Water Quality Index are often used. A lot of studies examined the water quality in Iraq. Bodies, as (24) examined the Hammar Marsh's surface water quality using several water quality standards. Moreover, he studied (25). the Tigris River's water quality for drinking inside the city of Baghdad utilizing a variety of environmental characteristics (including turbidity, TH, pH, TS, and Talk). The Iraqi WQI (26) was created by a team of Iraqi academics to evaluate the river's acceptability for drinking. In order to build a thorough index of water quality for Iraqis, this is the first stage. This manual was created by (27). The study's goal is to create an index of water quality that is appropriate for Iraqi water systems and accurately reflects the environmental conditions in Iraqi waters. The user can select any of them from a list of parameters provided in the sheet based on the data available and can override any parameter that is present in the sheet but cannot add other parameters.

This study published the application of chemical and physical factors as an indicator for evaluating water quality for three governorates of eight locations along the Tigris River, represented by Salah al-Din (Samarra), Baghdad (Al-Muthanna Bridge, Al-Atifiyah, Al-Jadriya), and Kut (Azizia, Zubaydah, Numaniyah, Al-Muftah) through the application of the Iraqi Water Quality Index. This includes using it for two main purposes, which is for living creatures and for freshwater.

2. Materials and methods

2.1 Description of the study area

Due to its large hydrological environment and its location, the Tigris River was chosen as a study area. The fieldwork in this study was carried out in eight locations representing three governorates in the central part of the country of Iraq. Stations were chosen randomly to collect study samples from the river water, starting from Salah al-Din Governorate (north of Baghdad) in one location in the city of Samarra, passing through the city of Baghdad, and three stations were chosen. As for the stations of Al-Muthanna Bridge, Al-Atifi, and Al-Jadriya in Al-Kut Governorate, four stations (Al-Aziziyah, Al-Zubaydah, Al-Numaniyah, and Al-Muftah) were chosen. **Table 1** represents the determination of the distance between each station and the other and the length of the study area, as shown in **Figure 1.**

Table 1. Distance between each stations from the other and the length of the study area.

Distance (km)	Lentht (m)	Lentht-nam
782685	922812	Al-Kut to Omara boundary
782685	1660210	Samarra to Al-Muthanna Bridge
782685	2035370	Samarra to Karkuk boundary
782685	138869	Al-Muthanna Bridge to Al-Atifia
782685	937161.1	Al-Atifia to Al-Jadria
782685	1794340	Al-Jadria to Al-Azizia
782685	19695.3	Al-Azizia to Al-Zubadia
782685	523673	Al-Zubadia to Al-Numania
782685	638161	Al-Numania to Al- Kut

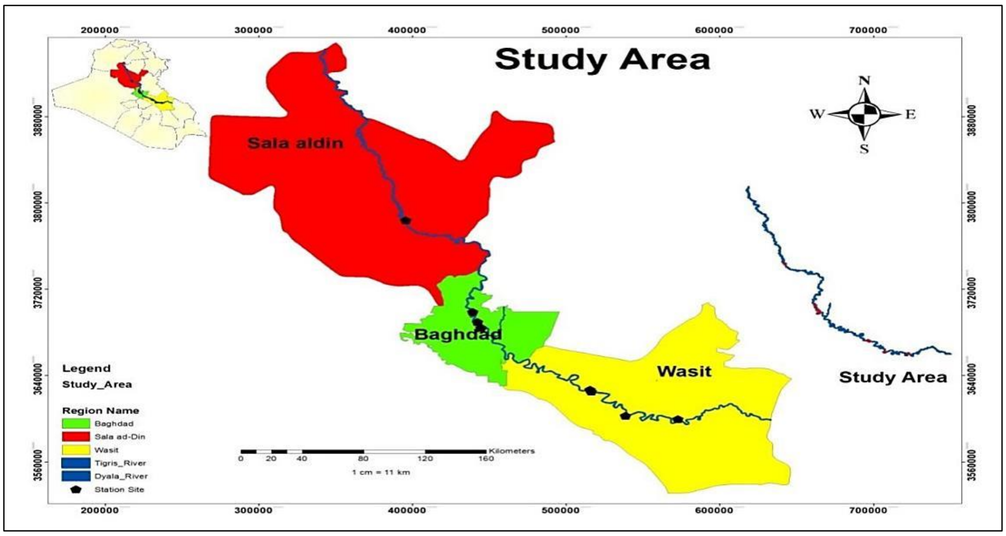

Figure 1. Study area map of Tigris river pass throw three governorates in Iraq country.

The first station is the Wasit Governorate, located at latitude 31.474° and longitude E 46.54244°. The distance from the Baghdad Governorate (to the south of Baghdad) is roughly 180 kilometers. The 2022 census shows that there are 1,303,100 people living there. The Republic of Iraq's capital, Baghdad, occupies a total area of 17,275 square kilometers and is located at latitude N 33.748 32.831 and longitude E 43.771 44.912. In 2022, it will cover an area of 5,221 km² and have an estimated population of 8,780,422 million. The third location is the Salah al-Din Governorate. Latitude N 35.653 33.625 and longitude E 42.445 44.851 are the coordinates for the city. The city is located 111.9 kilometers north of Baghdad, with an annual population of approximately 1,509,200 million. The typical climate of the area is hot and semi-arid, lasting for about eight months, with a brief, harsh winter lasting for about three months. High levels of humidity and drought in the subtropical areas are impacting the climate of Iraq (28, 29). The region heavily relies on chemical fertilizers, is primarily agricultural to the north and south of the study area, and is densely populated along the Tigris River. It is dotted with a few companies, labs, commercial enterprises, hospitals, as well as housing complexes for people and pets and leisure facilities that dump their trash into the Tigris River (30).

2.2. Physicochemical Parameters

Water samples were collected over two seasons (dry and wet) from February 2022 to January 2023. Some field and laboratory measurements of physical and chemical parameters were included, twenty-one parameters according to the standard methods described in (31). field measurements including air and water temperature by mercuric thermometer (°C), current water (current meter (M)), light penetration (Secchi Disc (CM)), PH (pH meter), EC (electrical conductivity meter (µs/cm)), Turbidity (Turbidity meter (NTU)), and D S (total dissolved solid meter (CM)). While laboratory measurements include TSS (dry with temperature (mg/L)), salinity (calculation method) (‰), total alkalinity, Total hardness, Ca^{+2} (titration (mg/L)), Mg^{+2} (calculation method (mg/L)), DO (Wink Azid Modification (mg/L)), BOD_5 Incubator (mg/L)), TDS (oven (mg/L)), PO_4^{-3} (Spectrophotometer UV-1200 (mg/L), NO_3, NO_2 (UV spectrophotometer (mg/L)), Cl titration (mg/L)), Sio_3 (complex, molybdate silicate spectrophotometer (mg/L)). The parameters were determined in accordance with the goals of the water users. For two reasons. The first is to compare the results of IWQI with the Canadian model by using real creatures and fresh water. A mathematical method known as the CCMEWQI is used to evaluate surface water for various applications in accordance with predetermined standards (32). If we present the parameter and retrieve the final value of the index using the formulas below, we will get the following output:

$final\ Wi = \sum t\ W \sum tW$ (1)

$Qi = Ci- Cideal\ si-Cideal \times 100$ for pH and DO (2)

$Qi = Ci\ si \times 100$ for other parameters (3)

SIi= the sub index of the ith parameter

Qi= quality rating based on concentration of the ith parameter

Ci= is the observed value of the nth parameter

Si= is the standard value of the nth parameter

Cideal for DO= 14.6

Cideal for pH=7

Wi= final wight

$IraqiWQI = \sum SIi\ /Wi$ (4)

Then the extracted value of the index is compared with **Table 2** which is the best classification for the computational water quality index. These categories include (Excellent, Good, Poor, Very Poor, and Unsuitable) according to (33).

Table 2. Classification of water quality according to the water quality index.

Water Quality Rating		
WQI value	**Rating**	
0-25	Excellent	Blue
26-50	Good	Green
51-75	Poor	Yellow
76-100	Vary poor	Orang
Above 100	Unsutabil	Red

3. Results

We relied on the Iraqi model to measure the water quality index according to (27). Based on the purpose of water use, we selected the parameters for two purposes. Firstly, for the livelihood of the living, we used eight physical and chemical parameters. Secondly, for the maintenance of fresh water, we used a guide that included eight factors for the IWQI. These parameters are shown in **Table 3** presents descriptive statistics for the nine water quality parameters in this study, all expressed in mg/L except for T.W. (°C), Tur. (NTU), and pH. Twenty-one parameters were analyzed to develop the water quality index in Iraq. From 11 parameters, they were removed experimentally because they do not cause problems in Iraqi waters rivers (3, 7, 34) according **Table 4.**

Table 3. Descriptive statistics for water quality parameters in dry season

Parameters	Mean	Std. Deviation	Minimum	Maximum	Iraqi Standard
Cl	201.250	20.561	160.000	222.500	250
Sali	0.384	0.026	0.350	0.420	-
EC	694.031	66.499	600.000	766.250	1000
TDS	325.219	33.397	268.500	360.250	1000
pH	6.656	0.241	6.300	7.100	6.5-8.5
TSS	14.043	4.303	7.920	21.250	-
SiO_3	8.000	0.955	7.340	9.610	-
TH	635.000	63.552	501.250	688.750	-
Ca^{+2}	92.507	7.910	76.870	105.800	-
Mg^{+2}	36.457	3.404	30.420	40.370	-
Turb	12.531	2.339	7.750	15.250	-
Alkaline	231.438	17.734	201.250	252.500	-
W.T.	13.719	1.863	11.500	17.500	-
Air T.	19.406	2.310	16.750	24.000	-
Cu	1.019	0.088	0.900	1.150	-
Light	81.531	22.025	50.250	110.000	-
Do	7.513	1.371	5.000	9.250	-
BOD_5	6.131	1.106	5.050	8.500	Less 5
PO_4	0.191	0.060	0.120	0.280	0.40
NO_3	4.756	0.531	4.240	5.590	1.00
NO_2	0.050	0.035	0.007	0.105	-

Table 4. Descriptive statistics for water quality parameters in wet season.

Parameters	Mean	Std. Deviation	Minimum	Maximum	Iraqi Standard
Cl	369.700	62.480	243.600	432.000	250
Sali	0.519	0.380	0.260	1.440	-
EC	643.300	101.964	524.000	831.000	1000
TDS	298.325	50.641	231.400	387.600	1000
pH	7.100	0.141	6.900	7.300	6.5-8.5
TSS	26.875	6.359	16.200	33.400	-
Sio_3	10.604	0.422	9.680	11.030	-
TH	657.750	43.390	608.000	708.000	-
Ca^{+2}	87.854	4.440	82.320	95.600	-
Mg^{+2}	34.587	3.572	30.000	41.800	-
Turb	13.125	2.717	8.600	16.200	-
Alkaline	246.300	16.525	216.000	266.000	-
W.T.	25.075	0.894	23.600	26.800	-
Air T.	32.475	4.814	24.200	38.000	-
Cu	0.963	0.192	0.700	1.360	-
Light	85.250	14.399	64.200	108.000	-
Do	7.013	1.928	4.200	10.000	-
BoD_5	9.524	1.155	8.000	11.500	Less 5
PO_4	0.269	0.164	0.020	0.560	0.40
NO_3	0.323	0.086	0.190	0.410	1.00
NO_2	0.155	0.099	0.020	0.300	-

The Iraqi standards (39) and the World Health Organization (40) for water quality specify different uses. The nine parameters included total dissolved solids (TDS), dissolved oxygen (DO), chlorides (Cl^-), pH, T.w, PO_4, NO_3, NO_2, Tur, this parameter was used for living organisms, while the above criteria were used by adding the vital requirement for oxygen and removing NO_2 from it for the purpose of fresh water maintenance.

The water quality index according to the IWQI for this study recorded mixed results according to the sampling stations, as it was poor in the dry season for the purposes of living in the first stations by (71.3) and very poor in the second stations (98.2), and unsuitable in the rest of the stations if it was recorded between (110.86). -123.9) as a maximum and minimum limit for unfit water in these stations. While the value of the indicator ranged between poor in the first three stations, as it ranged between (65.07-74.15) and very poor in the other stations, so its percentages were (69.43-96.89) for the same season. While the wet season recorded a variation in the water quality index according to the stations and the purpose of using the index, as it was poor for stations 1 (74.4) and very poor for stations 2, 3, 4, and 5, respectively, as it ranged (91.4-98), while the rest of the stations recorded water quality (not suitable) for the living of the living. The value of the water quality index for the purposes of fresh water conservation for the same season ranged from being (good) in stations 1, 2, and 5, respectively, reaching (49.26-50.54), while it was poor in stations (3, 4, 6, 7, 8) as the value of the indicator ranged from (53.13-69.51) according **Tables (5, 6)**.

Table 5. The IraqWQI values of all stations study of the Tigris River during the dry season.

Parameters	Sit.1	Sit.2	Sit.3	Sit.4	Sit.5	Sit.6	Sit.7	Sit.8
Cl	243.6	345	340	357	406	410	424	432
TDS	231.4	320.2	275.8	244.8	325.4	322	279.4	387.6
pH	7.1	6.9	7.1	7.2	6.9	7.1	7.3	7.2
Turb	8.6	9.8	12	14	14.6	14.6	15.2	16.2
W.T.	26.8	25.2	24.6	24.8	23.6	25.2	25	25.4
Do	8	7.8	9	10	5.5	6.6	4.2	5.6
BoD_5	10.5	9	9.37	10.16	8.33	8	11.5	9.33
PO_4	0.02	0.2	0.56	0.35	0.12	0.28	0.36	0.26
NO_3	0.37	0.22	0.19	0.27	0.4	0.39	0.33	0.41
NO_2	0.02	0.08	0.12	0.08	0.15	0.26	0.3	0.23
IWQI (Q.L)	71.3	98.2	133.1	11o.86	123.9	149.3	175.2	153.1
RWQ	p	V. p.	Un.	Un.	Un.	Un.	Un.	Un.
IWQI (FW)	65.07	67.94	74.15	69.43	77.74	85.94	96.89	93.6
RWQ	P	P	P	V.p.	V.p.	V.p.	V.p.	V.p.

Table 6. The IraqWQI values of all stations study of the Tigris River during the wet season.

Parameters	Sit.1	Sit.2	Sit.3	Sit.4	Sit.5	Sit.6	Sit.7	Sit.8
Cl	160	188.75	192.5	202.5	210	215	222.5	218.75
TDS	288	317	318.75	268.5	343.25	353.25	352.75	360.25
pH	6.7	6.3	6.7	7.1	6.4	6.7	6.6	6.7
Turb	7.75	13	15	15.25	12.25	12.25	13.25	11.5
W.T.	12.25	12.5	13.25	13.75	11.5	14.5	14.5	17.5
Do	6	8	7.7	8.75	8	5	6.25	7.1
BoD_5	8.5	5.9	5.05	5.25	5.82	6.5	5.425	6.6
po_4	0.18	0.26	0.14	0.12	0.13	0.21	0.28	0.21
No_3	4.31	4.24	4.38	5.1	4.47	4.55	5.41	5.59
No_2	0.008	0.007	0.03	0.05	0.052	0.05	0.09	0.105
IWQI (Q.L)	74.4	93.9	96.26	98.0	91.4	112.4	119.8	109.3
RWQ	P	V.p.	V.p.	V.p.	V.p.	Un.	Un.	Un.
IWQI (FW)	50.54	49.26	53.33	56.11	49.34	69.51	63.65	62.69
RWQ	G	G	P	P	G	P	P	P

4. Discussion

In general, the IWQI classified the water quality of the Tigris River for all study stations, as well as for living and maintaining fresh water, into four categories: good, poor, very poor, and unsuitable. The Tigris River failed to receive an excellent rating for any purpose, station, or season during the study. The rise in pollution in the Tigris River stems from the release of liquid wastewater from various uncontrollable sources, including industrial, domestic, and agricultural activities. This observation aligns with the findings of (27), who utilized the Iraqi water index in Baghdad to assess the river's suitability for drinking purposes. This index features a static parameter, preventing the inclusion of a new one. Additionally, the index excludes toxic items and materials. This was also confirmed by different researchers, such as the study of (41), where he found an increase in salinity in the Tigris River, the water in the city of Mosul, comparable to the past forty years, and in the study (42) on the Tigris River south of Baghdad, which observed an increase in nutrient concentration with a decrease in dissolved oxygen. It was applied the heavy metals quality index in two locations on the Tigris River in the city of Baghdad and found that cadmium, lead, and chromium are slightly affected, which strongly affects the health of the river. It also studied the water quality in several Iraqi rivers (Diyala, Euphrates, Diwaniyah, Al-Gharraf, Shatt Al-Arab) (43). Data for these sampling stations are from a publication in the literature. The Water Quality Index (WQI) values for the Diyala River, Euphrates River, and Diwaniyah River in Iraq are 69.52, 60.9, and 66.75, respectively, indicating their respective water quality. Rivers in the studied location fall into the category of “acceptable,” and river water needs conventional water purification treatment (sedimentation, filtration, and disinfection). This is the case of the Al-Gharf River, where the index is 71.83, and the quality is relatively better under the category of “good.” In the case of the Shatt al-Arab WQI value for Iraq, it is 33.36; the corresponding quality grade is "bad," and this water needs more than conventional purification treatment (reverse osmosis) before any use (35-37). Therefore, continuous river water quality control is required to assess water quality for various uses.

5. Conclusions

The Tigris River's water is characterized by being well-aerated, hard, and alkaline during the study period. y. We used twenty-one criteria as water quality indicators to evaluate the water situation in the Tigris River across all study stations and observed variations in the WQI results due to various variables. We used the most important criteria, including nine for the maintenance of fresh water, to assess the quality of surface water resources for living purposes. The study encompassed both the physical and chemical characteristics of water. The two seasons, wet and dry, yielded consistent results for living conditions, ranging from poor to very poor to unsuitable. However, the indicators for fresh water maintenance varied between the two seasons, with the dry season recording a poor to very poor indicator and the wet season recording a good to poor indicator. This is attributed to the increase in pollution in the river as a result of human and industrial activities, wastewater, and the increase in the water level in the wet season, which in turn reduces the severity of pollutants in the river water.

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Conflict of Interest

According to the researchers, this effort does not interfere with other people's interests.

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Ethical Clearance

This study did not involve human participants or animals, and therefore did not require ethical approval.

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