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Assessment of water quality of Tigris River by using WQ index in Salah Al-Din province

Khudhur Abbas Allawi and Shaimaa Fatih Ali *

Department of Biology, Coll. of Science, Tikrit University, Iraq.

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Abstract

The management of water resources depends on the evaluation of water quality. In this research, Water Quality Index (WQI) was used to evaluate Tigris River water quality for drinking water purposes and assess significant factors that affect water quality. The physiochemical parameters measurements of water samples taken from four sites along the river within Salah Al-Din province were collected from October 2022 to May 2023, including water temperature, turbidity, Electrical Conductivity (EC), Total dissolved Solids (TDS), pH, Dissolved Oxygen (DO), Biological oxygen demand (BOD_5), Total harness, Calcium, Magnesium, Total Alkaline, Chloride, Sodium, Potassium, Sulfate, Nitrite, and Phosphate. The results of WQI values ranged from 71.28 to 90.78, the water was considered poor to very poor in the study sites, due to the water getting polluted to some extent, so the value of WQI decreases. This indicated the Tigris River in the study area was unsuitable for drinking uses.

Keywords: Water quality; Index; Tigris River; Physiochemical properties

1. Introduction

The Tigris River is one main water sources in Iraq, its used for drinking, domestic, industrial and irrigation purposes. Its profligate use and increased water demand and its pollution puts unsustainability pressure on water availability and quality (Adimalla *et al.,* 2020).

Many rivers have undergone water quality degradation and pollution (Tanjung *et al.,* 2022). The problem of water pollution makes it very difficult to keep the rivers' water quality within the acceptable limits allowed for drinking, industrial and agricultural uses, so determining water quality requires certain conditions for water's physicochemical or biological properties (Radaideh, 2022). This study intends to apply WQ index to determine factors that affect water quality of Tigris River and contribute to pollution.

2. Material and methods

2.1. Study area

The Baiji district is situated in Salah Al-Din province in northern Iraq, between longitude 34°55′47″N and latitude 43°29′35″E. It is situated in the middle of the route leading to Mosul, it is located roughly 210 kilometers north of Baghdad. Its position currently has geographic significance and is distinguished by both an urban and a rural character. The Baiji Refinery, the largest oil refinery in Iraq, is located there. The texture of the soils of the Baiji region varies, they are either mixed sandy soils, mixed clayey soils, or mixed clay-sandy soils. This mismatch was caused by the substantial amount of sand present as well as the various particle sizes, ratios, and forms (Twaisan, 2021).

* Corresponding author: Shaimaa Fatih Ali

Water sampling was taken from four sites along the Tigris River during the period from October 2022 to March 2023 (Figure 1, Table1).

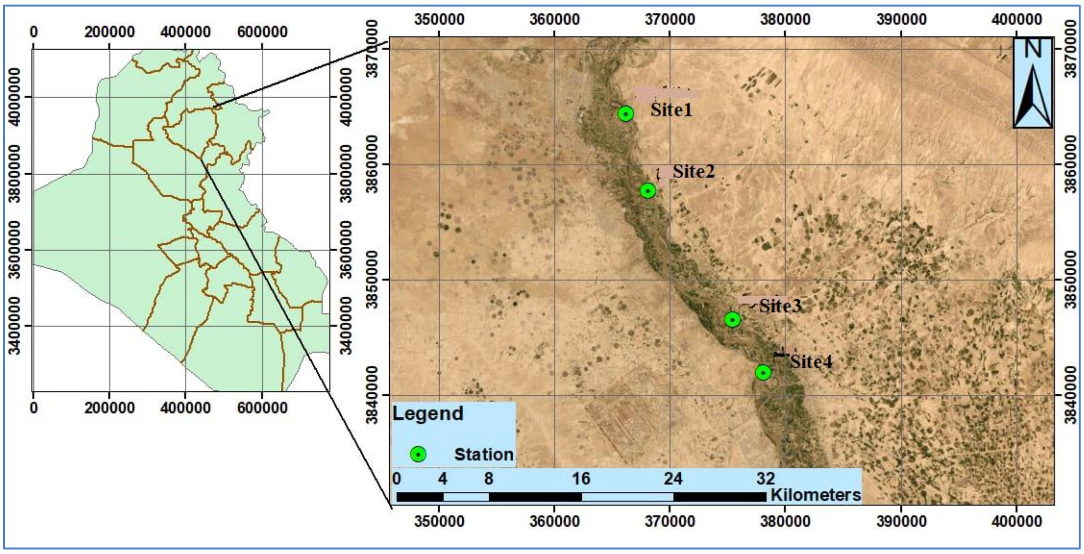

Figure 1 Location of the study area on Tigris River

Table 1 The geographical locations (GPS) of the sample sites

No Site	Site name	Longitude (eastwards)	Latitudes (northward)
1	Al-Baiji	36̊. 6201′	38̊. 64395′
2	Hajaj	36̊.8134′	38̊ .57771′
3	Samra	37̊.5461′	38̊. 46551′
4	Al-Alam	37̊.8134′	38̊. 42030′

The collected samples monthly were analyzed and evaluated for different water quality parameters as detailed in Table 2.

Table 2 The physicochemical parameters and analysis methods

NO.	Parameter	Reference methods
1	Water Temperature (C°)	---
2	Turbidity NTU	APHA (2005)
3	Electrical conductivity EC (µs.cm^{-1})	APHA (2005)
4	Total Dissolved Solids TDS (mg. L^{-1})	APHA (2005)
5	pH	APHA (2005)
6	Dissolved oxygen (DO) (mg. L^{-1})	Marckerath (1963) described in APHA (1999)
7	Biological Oxygen Demand BOD_5 (mg. L^{-1})	APHA (2005)
8	Total Hardness mg $CaCO_3$.L^{-1}	APHA (2005)
11	Total Alkalinity mg$CaCO_3$.L^{-1}	Welch (1948)
12	Chlorides Cl^{-1} (mg. L^{-1})	APHA (2005)

13	Sodium ions mg.L^{-1}	APHA (2005)
14	Potassium ions mg.L^{-1}	APHA (2005)
15	Sulphate SO_4^{-2} (mg. L^{-1})	APHA (2005)
16	Nitrate (NO_3^-) (mg/L)	Strickland and Parsons (1972)
17	Phosphate (PO_4^{-3}) (mg. L^{-1})	Strickland and Parsons (1972)
18	Total coliform bacteria (cell.100ml^{-1})	APHA (2005)

2.2. WQI Calculation

The 18 parameters used to calculate the water quality index for the river were as included: Water temperature, turbidity, EC, TDS, pH, DO, BOD_5, DO, TH, T. Alkalinity, chlorides, Na, K, SO4, NO2, PO_4, Cd, Pb, and Zn for four sampling sites to assess the suitability of Tigris River for drinking purposes. The WQI was calculated by Brown *et al.* (1970) in which water parameters by the following equation.

$$WQI= \sum WiQi / \sum Wi$$

Where:
Qi = The sub-index of the *ith* parameter.
Wi =The unit weightage of the *ith* parameter.
The *Wi* of each parameter was calculated a value inversely proportional to the standard value (STi) of the WHO (2017).

Based on the calculated WQI, the water quality category according to Shweta *et al.* (2013) shown in Table 3.

Table 3 The WQ classification based on WQI value

Range	**Quality**
0–25	Excellent
26–50	Good
51–75	Poor
76–100	Very Poor
>100	Unsuitable for drinking

2.3. Statistical Analysis

In the current study, for the analyses of the results, the SPSS 20.0 program the Mean and Standard Error are the two approaches used.

3. Results and discussion

River water quality for drinking purposes was assessed by calculating the water quality index (WQI) for each sample that indicated the influence of physicochemical parameters on the overall water quality.

The results of the physicochemical values of water sample at the study sites from October 2022 to March 2023 as present in Table 4.

Water temperature is one of the environmental factors that affect the physical and chemical reactions as well as the qualitative properties of water (Falowo *et al*, 2017). It's ranged from 11 ℃ to 24℃, was within the permissible limits of WHO standards (Table 3).

Table 4 Physiochemical values of the study area (mean and Error Stand.)

Parameters	Sites No.				Standard limits (WHO, 2017)
	St.1	**St.2**	**St.3**	**St.4**	
Water Temperature (°C)	11-23 15.83±1.72	11-23 15.83±1.72	14-24 17.33±1.68	15-24 18±1.54	≥ 15
Turbidity NTU	6.80-70 28.8 ± 10	6.50-115 32.611±16.8	4.97-86 27.81±12.2	9-72 24.79±9.96	5
EC (µs.cm-1)	151-404 263.8±45.06	91-415 279.8±51.31	103-402 253.6±48.85	140-432 304.6±50.73	1600
TDS (mg.L-1)	75-202 144.3±19.6	46-207 150±23.4	53-201 141.1±22.9	71-216 160±21.1	500
pH	7.3-7.9 7.56±0.08	7.1-7.9 7.45±0.11	7.1-8.2 7.73±0.14	7.2-8.2 7.73±0.15	8.5-6.5
DO mg.L-1	6-8.2 7±0.38	5.5-8 6.8±0.40	6-8 6.78±0.32	6-7.5 6.41±0.23	> 5
BOD_5 mg.L-1	1-2.5 1.58±0.27	1.5-2.5 1.91±0.16	1-2.4 1.73±0.20	1.5-2.5 1.93±0.14	< 5
Total Hardness mg CaCO3. L-1	76-120 92.33±7.54	72-130 91.66±8.66	70-140 88±10.78	71-100 83.83±4.67	500
Total Alkalinity mg CaCO3 L-1	80-120 95.6±6.33	70-120 103.6±7.59	80-110 94±5.16	80-120 103.6±6.03	<200
Chloride mg.L-1	44-124 84.83±15.2	36-159 83.16±18.6	36-85 80.33±18.1	36-85 65±7.95	250
Sodium mg.L-1	18.4-34 26.1±2.43	19-33 27±2.47	17-43 28.3±3.67	13.7-38 23.7±3.38	200
Potassium mg.L-1	0.9-2.2 1.58±0.19	0.9-2 1.41±0.19	1.1-2.9 1.75±0.25	0.9-2.5 1.6±0.23	12
Sulphate mg.L-1	130-290 185±22.6	150-260 181.6±16.6	150-280 186.6±19.6	150-230 178±11.6	500
Nitrite (NO2) µg.L-1	0.40-1.15 0.67±0.136	0.41-1.16 0.69±0.137	0.40-1.17 0.67±0.139	0.39-1.16 0.67±0.139	3
Phosphate (PO4) µg.L-1	2.46-3 2.70±0.08	2.49-2.97 2.73±11.9	2.5-2.92 2.71±13.2	2.57-3 2.71±21.1	0.4
TPC CFU.ml^{-1}	200-304 252.3±17.3	180-260 203±29.3	160-240 207.3±32.5	100-244 188±51.9	< 100
T. Coliform cell. ml^{-1}	3-460 86.16±74.8	3-460 88.6±74.3	12-28 20.5±2.59	3-35 15.5±4.54	0.0

Turbidity ranged (4.97-115) NTU, it may be caused by mud particles, suspended matter, colloidal materials, the presence of microorganisms and phytoplankton in the water, and the remains of organic matter (Davies-Colley and Smith, 2001). It's used to determine WQ and environmental conditions (Hamilton *et al.,* 2020). Electrical conductivity is a crucial indicator of water quality and is influenced by temperature and dissolved solids in the water (Jayalakshmi *et al.*, 2011). TDS values ranged between (46-216) mg. L^{-1}, it presents in the water from natural sources, such as rainwater falling over salt-rich rocky terrain or they may originate from artificial sources, such as the drainage of agricultural lands (Hamad and Al-Salman ,2013). TDS were within the permissible WHO limits

pH values ranged between (7.1-8.2), its pH is important gauge of water quality and express the intensity water acidity or alkalinity (Hammer, 2011), the values were within WHO standards for drinking and domestic uses.

Dissolved oxygen values ranged from 5.5 mg. L^{-1} at site2 to 8.2 mg. L^{-1} at site 1. Its important role in assessing water quality for aquatic life (Abdel-Satar *et al.,* 2017). While BOD_5 is estimating the amount of organic matter that pollutes water (Ali et al., 2014). It's ranged between (1-2.5) mg.L-1.

Hardness refers to express the characteristics of highly mineralized waters particularly calcium and magnesium ions (APHA, 2005). The values ranged between (70-140) mg. L-1. Total alkalinity values ranged (70-120) mg. L-1, which results in the presence of bicarbonate ions, carbonates, and hydroxides, determines whether it is suitable for use for various purposes (APHA, 2003). These results were close to the study of Darweesh, 2017 and Abed et al., 2019.These values within the permitted WHO standards for drinking water.

Chlorides concentrations ranged 36 mg. L^{-1} to 159 mg. L^{-1} were within the permissible limits throughout the study period. The results of the study showed that sodium and potassium concentration ranged between (13.7-43) mg. L^{-1} and (0.9-2.5) mg. L^{-1} respectively. Sodium and potassium were one of the most prevalent forms found in water and nature (Al-Hamim, 1986). Sodium's concentration in natural bodies of water is significantly larger than potassium's, these ions concentration might be a concern for healthy humans (WHO, 2009).

The results of the present study showed that the SO4 concentration ranged between (130-280) mg. L^{-1} in site1 and 3 respectively. It is due to the dissolution of rocks such as gypsum rocks, and anhydrite is the source of sulfates in water (Abdullah & Hussain, 2015).

Nitrite concentrations ranged between (0.39-1.17) µg. L^{-1}, it increased may be due to sewage water and other anthropogenic activities as well as the soil corrosion and agricultural fertilizers (Shraddha *et al*., 2011). Phosphate ranged (2.46-3) µg. L^{-1}, the significant increase which might be due to the phosphatic fertilizers use and the anthropogenic activities (Sharpley, 2005), PO4 has exceeded the permissible standards limits.

The increase in nitrite also provides sufficient evidence of deterioration in water quality as a result of the entry of sewage waste into the river (Shraddha *et al*., 2011).

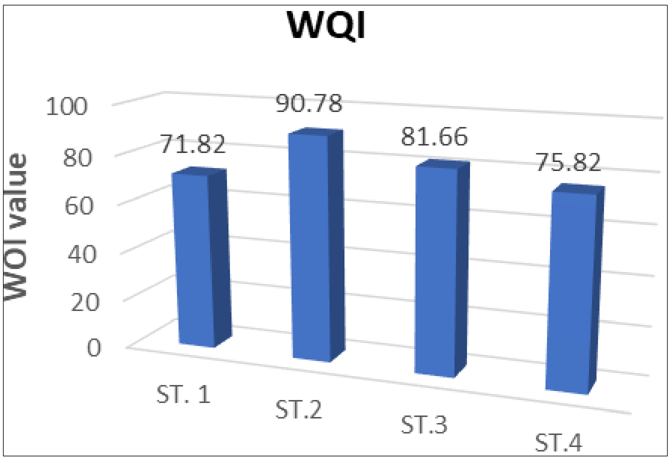

Figure 2 The WQI values of the Tigris River for drinking use

The Total plate count of bacteria ranged between (100-304) CFU. ml^{-1} in the site 4 and 1, the increased may be related to the disposal of sewage water as well as animal waste, as it is an agricultural area. And Total coliform bacteria were high, ranged (3-460) cell. ml^{-1}. Total coliform bacteria may be present in the river due to rainwater runoff, human activity, and animal waste.

The WQI values ranged from 71.28 to 90.78 and therefore can be categorized as poor to very poor in the study sites, this may be due to exceeding most parameters involved in the calculation of the water quality index the desirable levels.

This indicates that the Tigris River's water quality is unsuitable for drinking purposes (Table 3, Fig.2). This result is consistent with the study Chabuk *et al.,* 2020, and Ali *et al.,* 2021.

The results of WQI values revealed the poor water quality of the Tigris River, which indicated that pollutants were being released into the river from the Baiji refinery and Baiji thermal power station, as well as human and agricultural activities.

4. Conclusion

The WQI values of the Tigris River of the study area were generally poor to very poor, referring that the river is unsuitable for drinking purposes. It may be discharged several pollutants along the pathway of the river. Before usage, it needs to be controlled the pollution source and advanced treatment.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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