Assessment of Water Quality for Tigris and Euphrates Water within Iraqi Borders

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Abstract: The Tigris and Euphrates Rivers represent the main sources of water in Iraq. The recent water crisis in the region has prompted the necessity of assessing the quality of the rivers water. Water quality from 33 locations along the Tigris and Euphrates Rivers were investigated in November 2020, December 2020, January 2021, and February 2021 to test 3 water quality chemical parameters in the selected stations along the Tigris and Euphrates Rivers. These parameters are pH, TDS and EC. The variations of total dissolved solids (TDS) along the Tigris and Euphrates Rivers in the survey period ranged from 100 to 5057 ppm, and the average value of TDS concentration was 862.3 ppm. For pH, the values measured during the survey period ranged from 6.4 to 7.6, with an average value of 7.2. The average electrical conductivity measured in Tigris and Euphrates Rivers during the survey period was 1717.6 µS, ranged from 230 to 9870 µS. The weighted arithmetic method was applied to compute the water quality index (WQI) for the overall sampling locations along the whole length of the Tigris and Euphrates Rivers within the Iraqi borders. The results showed that the estimated water quality index (17.28) was within the "Excellent" range (< 50).

Keywords: Water Quality, Tigris river, Euphrates river, pH, EC, TDS

1. Introduction

Extraction of water for domestic and agricultural use, mining, industrial production and power generation could lead to a deterioration in water quality that not only affect the aquatic ecosystem, but also the availability of drinking water [1]. More recently, the monitoring of water quality is becoming an important issue in watercourses and rivers affected by pollutant disposal. The discharge of domestic and industrial effluents are the main sources of water pollution. Physical and chemical properties for example pH and DO (dissolved oxygen) may determine the safety of water ecosystem [2]. Water quality is influenced by the quality and quantity of supplies that coming from various sources. Thus, comprehensive planning and management of water resources are essential for different uses [3]. For the purpose of communicating information on water quality, the water quality index is usually used [4]. Water quality is identified by comparing physio-chemical properties of the water sample with guidelines for water quality or standards.
The guidelines and standards for the quality of drinking water aim to provide clean and harmless water for human consumption and thus to protect human health. These are generally based on scientifically acceptable levels of toxicity to both humans and aquatic organisms [1].

Iraq relies heavily on surface waters that cross its borders from neighboring countries [5, 6]. The aim of this study is to assess the water quality of Tigris and Euphrates Rivers in Iraq by computing the water quality index for three parameters selected based on their importance and data availability in thirty-three areas.

2. Data Collection

Along the Tigris and Euphrates Rivers, 33 locations were selected to directly measure 3 water quality parameters (pH, total dissolved solids (TDS) and electrical conductivity (EC)) in November 2020, December 2020, January 2021, and February 2021, using pH/EC/TDS/temperature combined meter (MARTINI, Romania) (Fig. 1). Field measurements were taken from the areas shown in Fig.2, from middle of the rivers.

![Fig. 1. pH/EC/TDS/temperature combined meter (MARTINI, Romania)](image-url)
3. Water Quality Assessment

In this paper, the water quality index (WQI) was calculated for three parameters (TDS, pH and EC) for the selected thirty-three stations along the Tigris and Euphrates Rivers to classify the quality of water [7]:

$$WQI = \frac{\sum Q_i \times W_i}{\sum W_i}$$  \hspace{1cm} (1)

$$Q_i = \frac{N_i - N_o}{ST_i - N_o} \times 100$$  \hspace{1cm} (2)

$$W_i = \frac{1}{ST_i}$$  \hspace{1cm} (3)

where $Q_i$ is the sub-index of the $i^{th}$ parameter, $W_i$ is the inverse weight of the standard value ($ST_i$) of the $i^{th}$ parameter, $ST_i$ is the standard value of the $i^{th}$ parameter, $N_i$ is the measured concentration value for the $i^{th}$ parameter, and $N_o$ is the ideal value for each parameter in water that has zero value, excluding the pH value which is equal to 8.5. For each survey location along the Tigris and Euphrates Rivers, the water quality rating (QWR) was given the deserve classification based on the category of the WQI (table 1).

Table 1. Water quality rating classification based on WQI value [7].

| Value of WQI | Water quality rating (QWR) |
|--------------|---------------------------|
| < 50         | Excellent                 |
| 50–100       | Good                      |
4. Results and Discussion

The results of the field measurements for the water quality parameters analyzed in all the sampling locations during the survey period are shown in Table 1. The variations of total dissolved solids (TDS) along the Tigris and Euphrates Rivers in the survey period ranged from 100 to 5057 ppm, and the average value of TDS concentration was 862.3 ppm. For pH, the values measured during the survey period ranged from 6.4 to 7.6, with an average value of 7.2.

The average electrical conductivity measured in Tigris and Euphrates Rivers during the survey period was 1717.6 µS, ranged from 230 to 9870 µS.

The increase in TDS was observed with the flow of the two rivers in Iraq due to the waste, sewage and pollutants discharged along the river and due to low water levels in these rivers. It was also observed that the water of the Tigris River, according to the acidity (pH) measurements, is more acidic than the measurements of the Euphrates, especially from Mosul to Baghdad. The reason is that the nature of those lands that the river passes through contains sulfur minerals that affect the nature of the river’s water. For the Euphrates, it is more alkaline because of the nature of its soil in Anbar province that contains gypsum rocks and others that affect the nature of the water and its transformation more alkaline.

The results of water quality index calculations, based on average values for all sampling locations are presented in Table 2. The values of the water quality rating in these stations were good (WQI = 17.28 < 50). So, the water quality was classified as "Excellent" rating based on the WQI values at these sampling locations.

Table 2. Results of the field measurements for the water quality parameters.

| No. | City/area            | TDS (ppm) | pH  | Conductivity (µS) |
|-----|----------------------|-----------|-----|-------------------|
| 1   | Al-Musil             | 100       | 7.5 | 230               |
| 2   | Al-Shorkat           | 180       | 6.7 | 392               |
| 3   | Baiji                | 210       | 6.8 | 405               |
| 4   | Tekrit               | 305       | 6.9 | 620               |
| 5   | Balad                | 310       | 7   | 632               |
| 6   | Baghdad              | 420       | 6.4 | 780               |
| 7   | Al-Aziziya           | 540       | 6.9 | 1074              |
| 8   | Al-Zubaidiya         | 560       | 7.3 | 1194              |
| 9   | Wassit               | 610       | 7.2 | 1220              |
| 10  | Ali Al-Gharbi        | 660       | 7.4 | 1308              |
| 11  | Ali Al-Sharqi        | 710       | 7.5 | 1420              |
| 12  | Missan               | 860       | 7.1 | 1670              |
Table 2. Water quality calculation for Tigris and Euphrates rivers using Water Quality Index method.

| Parameter         | Nᵢ  | ST  | Wᵢ  | Nₒ  | Qᵢ  | WQI  |
|-------------------|-----|-----|-----|-----|-----|------|
| TDS (ppm)         | 862.3 | 500 | 0.002 | 0   | 172.46 | 0.344 |
| pH                | 7.2  | 8.5 | 0.117 | 7   | 13.33  | 1.568 |
| Conductivity      | 1717.6 | 1000 | 0.001 | 0   | 171.76 | 0.171 |
| Overall WQI       | 2.08/0.12=17.28 |  

5. Conclusions
The quality of the Tigris and Euphrates Water Rivers deteriorates over time when the flow of the river flows downward. The increase in pollution is due to the discharge of effluents from various sources such as domestic wastewater, factories and irrigation water. From Weighted Arithmetic Water Quality Index method, the water quality was evaluated to be good, based on results of field pH, EC and TDS measurements.

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