

Assessment of the Tigris River Water Quality in Selected Iraqi Governments

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Abstract: *Given the importance of the Tigris River in Iraq as a major source for multiple purposes such as drinking water, irrigation, industry and others. Two methods were used for computing water quality index at each province (Nineveh, Baghdad, Maysan) for three years (2013-2015) which are Weighted Arithmetic Water Quality Index method and Bhargava method. Twelve factors have been used to assess the raw water quality of Tigris river by Weighted Arithmetic Water Quality Index method which are alkalinity, total hardness, turbidity, total dissolved solids (TDS), pH, Ec., Cl, Na, Mg, Ca, K and SO₄, while six parameters used by using Bhargava method which are T.H., TDS., pH, Ca, Cl and SO₄. Both WQI methods showed that the water quality of the Tigris River is classified as poor in northern Iraq to very polluted in the south, so it requires specific treatment to make the river water suitable for human use.*

Keywords: Water Quality Index, Tigris River, Iraqi Governments, physicochemical characteristic

1. Introduction

Extraction of water for domestic and agricultural use, mining, industrial production, power generation and external practices could lead to a deterioration in water quality and quantity 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 water courses 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]. Tigris river is one of the most important and largest rivers in Iraq [6]. It flows initially through Turkey for a distance of 432 km and constitutes the eastern boundary of Syria for only 44 km before the downstream in Iraq flows to 1,418 km [7], so approximately 58% of this river is located in Iraq, and there is no major branch joining the Tigris river south of Baghdad [8]. Due to the importance of Tigris river in Iraq, the aim of this research is to assess the water quality of Tigris river in Iraq by computing the water quality index for twelve parameters selected based on their importance and data availability in three Iraqi provinces, Nineveh in northern Iraq and Baghdad in central Iraq and Maysan in southern Iraq.

2. Study Area

Three governorates were selected on different sites from the Tigris river for the purpose of assessing the water quality of the river from northern Iraq to its south which are Nineveh, Baghdad and Maysan. Nineveh is the third largest Iraqi province in terms of size and occupies an area of 37,323 km² [9]. The province is in northern Iraq and Mosul is its capital city which is located between (37° 1'45.51" to 35°25'12.78" N) latitudes and (42°21'40.14" to 42°47'31.17" E) longitudes [10]. Baghdad is the capital of Iraq has an area of 800 km². Its coordinates are (33°14' to 33°25' N) latitudes and (44°31' to 44°17' E) longitudes [11]. Maysan province which has an area of about 16072 km² and is between (31°15' N to 32°45' N) latitude and (46°35' E to 47°45' E) longitude [12].

3. Data Collection

In order to know the quality of the raw water of Tigris River within the Iraqi territory, several parameters were studied through the data obtained from 2013 to 2015 in the governorates of Nineveh, Baghdad and Maysan, respectively, using two methods for water quality index. Since Nineveh province is located in northern Iraq and Baghdad in the center and Maysan in the south it can be said that the Tigris River has been studied along its length.

4. Calculation of Water Quality Index (WQI)

The index is a digital expression that refers to the level of water quality and is mainly used as a mathematical agent to convert the bulk of water quality data into a cumulative number one. Its value ranges between zero and hundred, and the high number means good quality in Bhargava method and vice versa in weighted arithmetic water quality index method [13]. The water quality index gives a number that reflects the total water quality at a given place and time, depending on numerous water quality criteria [11]. In this study two methods of calculation were selected and all the variables that have been studied in the raw water of Tigris river were related to their suitability for human consumption and based on the drinking water quality standards

recommended by the World Health Organization [14]. The methods that used were Weighted Arithmetic Water Quality Index method and Bhargava method.

4.1 Weighted Arithmetic Water Quality Index Method

Water quality index for twelve parameters which are alkalinity, total hardness, turbidity, total dissolve solids (TDS), pH, Ec., Cl, Na, Mg, Ca, K and SO₄ was calculated using the following equations [15]. To classify the quality of water Table (1) was used.

$$WQI = \frac{\sum q_i * w_i}{\sum w_i} \quad \dots (1)$$

Where:

the rating scale of quality (q_i) for each parameter can be calculated as follows:

$$q_i = \left(\frac{c_i - c_0}{s_i - c_0} \right) * 100 \quad \dots (2)$$

C_i: the estimated concentration of ith parameter

C₀: the ideal value of ith parameter in pure water equal to zero, except the value of dissolved oxygen which equal to 14.6 ppm, and pH value equal to 7.

S_i: the standard value of ith parameter

w_i: the unite weight of ith parameter and can be calculated as follows:

$$W_i = \frac{1}{S_i} \quad \dots (3)$$

Table 1: Water quality classification based on WQI value [3]

WQI value	Rating of water quality
< 50	Excellent
50- 100	Good
100- 200	Poor
200 - 300	Very poor
300-400	Polluted
>400	Vary polluted

4.2 Bhargava Method

To classify water quality of Tigris river by Bhargava method, six variables was used for each province which are total hardness, total dissolve solids (TDS), pH, Ca, Cl and SO₄. The curves of drinking purpose were used to find the sensitivity function for each variable as shown in Figure (1). After computing the sensitivity function for all variables, the following equation was used.

$$WQI = [\pi_{i=1}^n f_i(P_i)]^{1/n} \quad \dots (4)$$

Where:

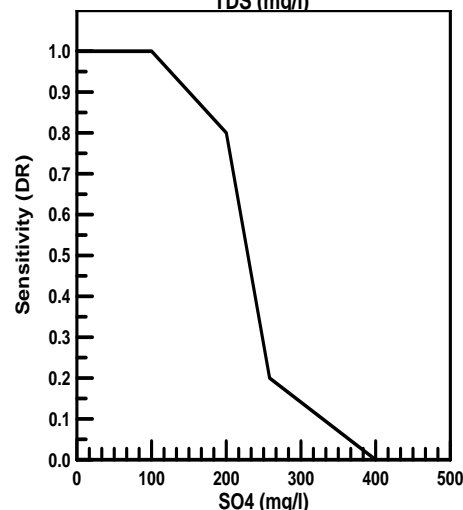
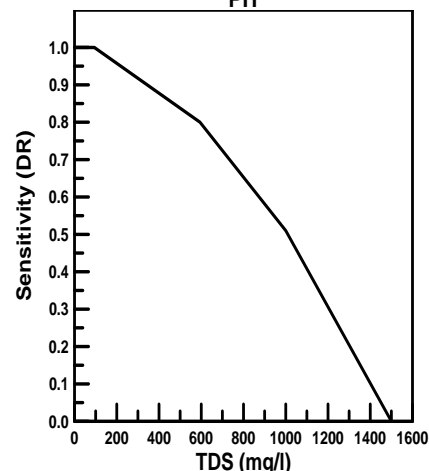
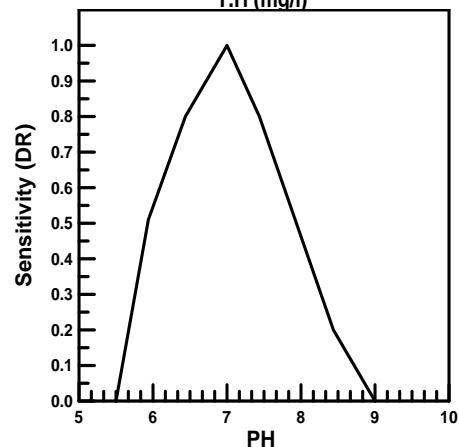
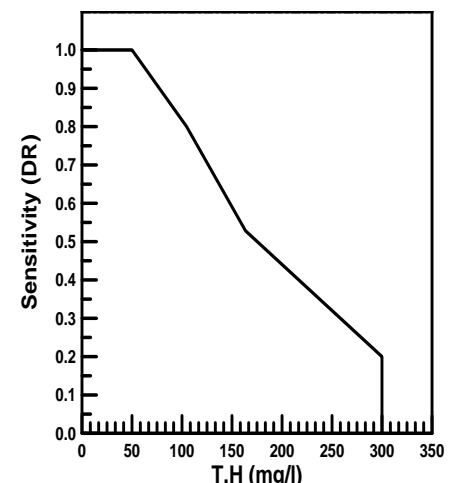
f_i(P_i): the sensitivity function for each variable including the effect of variable weight concentration which range from (0-1).

n: Number of variables [16]

Table (2) was used to classify the water quality according to Bhargava method.

Table 2: Water quality classification according to Bhargava [17]

WQI value	Rating of water quality	class
100-90	Excellent	I
89-65	Good	II
64-35	Acceptable	III
34-11	Polluted	IV
<10	Severe Polluted	V



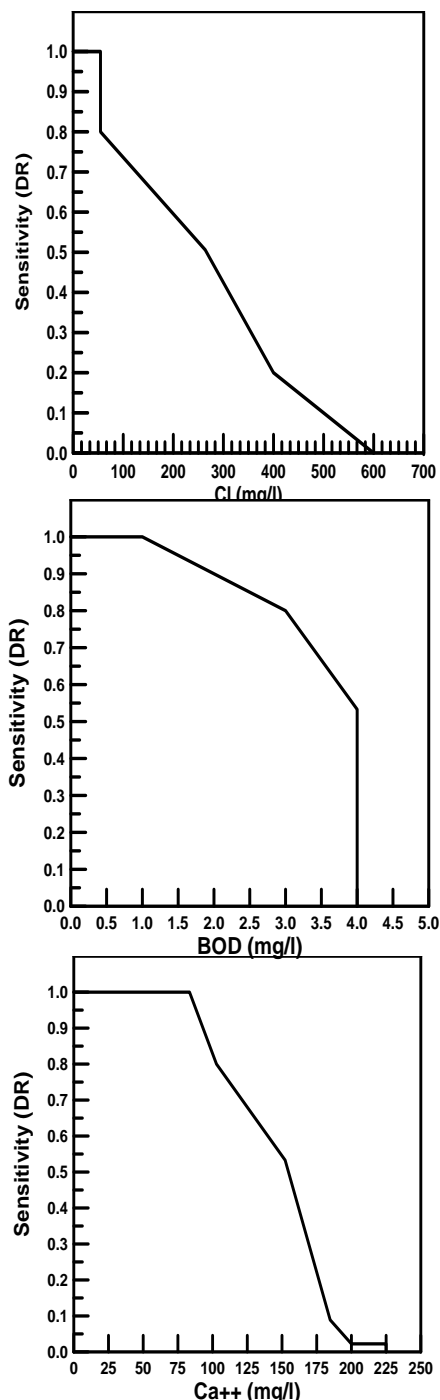


Figure 1: Sensitivity functions curves according to Bhargava for drinking use [17]

5. Result and Discussion

Two methods were used for computing water quality index at each province (Nineveh, Baghdad, Maysan) for three years (2013-2015). Twelve variables were selected to be examined by using Weighted Arithmetic Water Quality Index method, the procedure of this method was shown in Table (3) depends on equations (1), (2) and (3) that have been mentioned above and the results that have obtained appear in Table (4). From Table (5) it found that the quality of Tigris River water in the province of Nineveh was poor over the three years, the main cause of this result was the high rate of turbidity in the river water where its value was above 5 NTU during these years. The water quality in the province of Baghdad was very polluted during 2013 and it was changed

to very poor during the years 2014 and 2015, this was due to significant impact of turbidity on the quality of water where it was exceeded the allowable limit during 2013 at a value of 47 NTU while decreasing its value to 27 NTU and 23 NTU during the years 2014 and 2015 respectively. Also, the results showed that the Tigris River in the province of Maysan was very polluted during all years of examination due to the high rate of the following parameters in the three years: turbidity, total hardness, total dissolved solids and electrical conductivity. As is known, Iraq is located in a sedimentary plain and it has a clay soil, so turbidity and total dissolved solids and total hardness and salts increase as we move from north to south. Also, the pollutants that are thrown in the river from the factories and other sources have significantly impacts on the water quality of Tigris River. All these factors were a major cause of the results obtained and are shown in Table (4) and Figure (2). Since Nineveh is closer to the source of the Tigris River than the provinces of Baghdad and Maysan, so its water quality is better, where the quality of water declines as the river flows southward for the reasons mentioned above.

Table 3: Water quality calculation for Tigris river using Weighted Arithmetic Water Quality Index method in Nineveh during 2013

parameter	C_i	S_i	W_i	q_i	WQI
Turbidity	11.28	5	0.200	225.60	45.120
Total hardness	205	200	0.005	102.50	0.513
Alkalinity	144	120	0.008	120.00	1.000
T. dissolved solids	268	500	0.002	53.60	0.107
pH	7.88	8.5	0.118	58.67	6.902
Chloride	17	250	0.004	6.80	0.027
Magnesium	17	200	0.005	8.50	0.043
Calcium	53	200	0.005	26.50	0.133
sodium	9	250	0.004	3.60	0.014
potassium	1.63	10	0.100	16.30	1.630
Sulfate as SO_4	60	200	0.005	30.00	0.150
Electrical conductivity	490	1000	0.001	49.00	0.049
Sum			0.457	701.066	55.687
Overall $WQI = \frac{55.687}{0.457}$					= 121.859

Table 4: WQI for the three governments from 2013 to 2015 using Weighted Arithmetic Water Quality Index method

overall WQI			
year	Nineveh	Baghdad	Maysan
2013	121.859	437.913	2219.07
2014	182.96	271.262	650.618
2015	193.71	227.527	567.765

Table 5: WQI classification for the three governments from 2013 to 2015 using Weighted Arithmetic Water Quality Index method

year	Nineveh	Baghdad	Maysan
2013	Poor	Very polluted	Very polluted
2014	Poor	Very poor	Very polluted
2015	Poor	Very poor	Very polluted

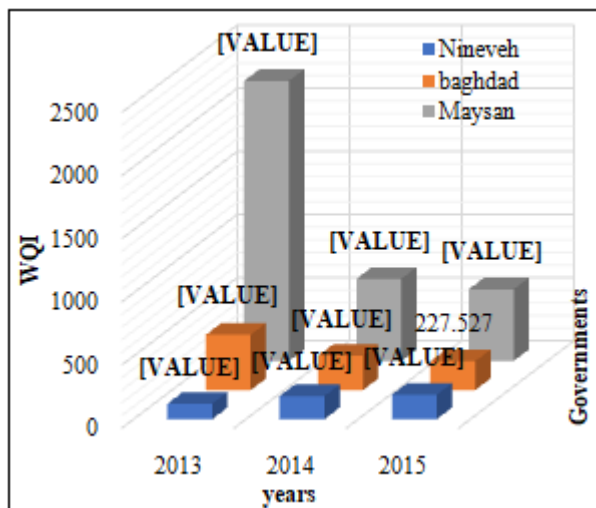


Figure 2: WQI in Iraqi governments for Tigris river using Weighted Arithmetic Water Quality Index method

Table (6) appears the results of Bhargava method where its calculation depends on equation (4). The classification in Table (7) showed that Nineveh governorate was classified as second class in 2013 and 2014, then the water quality of the Tigris was reduced to the fifth class in 2015 because the total hardness where it was over the range in the curve of sensitivity function of drinking water in 2015. The water quality of the Tigris in Baghdad and Maysan was in the fifth class for three years. In Baghdad the main cause for bad water quality was also the rise of total hardness while the bad water quality in Maysan was due to the rise of total hardness, sulfate and total dissolved solids as they exceeded the limits of the allowable range in the curve of sensitivity function of drinking water during the years from 2013 to 2015. Comparison between Table (5) and Table (7) shows that the results in the Bhargava method contrasted with Weighted Arithmetic Water Quality Index method. This contradiction is due to the fact that the number of parameters used in Bhargava is half the number of parameters used in Weighted Arithmetic Water Quality Index method. The results obtained in this research agree with [1,2,3, 4, 6 and 11].

Table 6: WQI for the three governments from 2013 to 2015 using Bhargava method

WQI			
year	Nineveh	Baghdad	Maysan
2013	80.776	0	0
2014	70.156	0	0
2015	0	0	0

Table 7: Water quality classification for the three governments from 2013 to 2015 according to Bhargava method

year	Nineveh	Baghdad	Maysan
2013	II	V	V
2014	II	V	V
2015	V	V	V

6. Conclusion

- 1) The quality of the Tigris water 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.

- 2) From Weighted Arithmetic Water Quality Index method found that the worst water quality found in Maysan while Bhargava method appeared that Baghdad and Maysan have the bad quality of water.
- 3) In general, both methods used demonstrated that the water quality of the Tigris River is of good quality in Nineveh governorate and deteriorates its quality as the flow goes downwards
- 4) When studying the same governorates during the same period of time, there was a difference between the results obtained from the Weighted Arithmetic Water Quality Index method with the results obtained by using the Bhargava method and the reason in this was that twelve parameters were chosen in the first method while six parameters were selected in the second method.
- 5) For better comparison between these methods, it is preferred to study of similar parameters in both methods, in addition to the development of curves of the sensitivity function adopted in the Bhargava method.

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Author Profile



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