International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Assessment of the Tigris River Water Quality in Selected Iraqi Governments

Sura K. Ali

Faculty Member, Civil Engineering Department, Baghdad University

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 methodwhich are alkalinity, total hardness, turbidity, total dissolved solids (TDS), pH, Ec., Cl, Na, Mg, Ca, K and SO_4, while six parameters used by using Bhargava method which areT.H., TDS., pH, Ca, Cland SO_4.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 isbecoming 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]. 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 andoccupies an area of 37,323 km^2[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 km^2.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 km^2 and is between (31º15 N to 32º45 N) latitude and (46º35 E to 47º45 E) longitude [12].

3. Data Collection

In order to know the quality of the raw water of Tigris River within the Iraqi territory, severalparameters 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 versain 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.

4.1Weighted 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 $SO_4$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 (qi)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 i^{th} parameter
$C_{0:}$ the ideal value of i^{th} parameterin pure waterequal 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 i^{th} parameter
w_i: the unite weight of i^{th} 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 BhargavaMethod

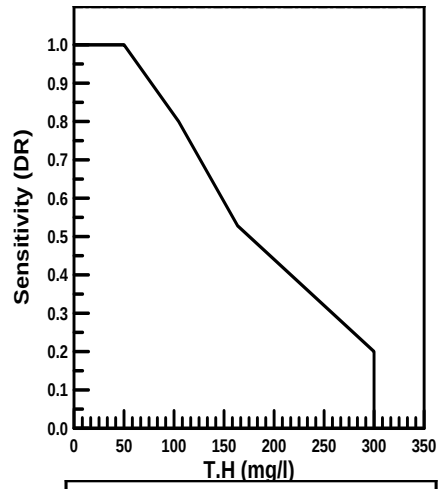
To classify water quality of Tigris river by Bhargava method, six variables was used for each province which are total hardness, total dissolve solids (TDS), pH,Ca, Cl and SO_4.The curves of drinking purpose were used to find thesensitivity function for each variable as shown in Figure (1). After computing the sensitivity function for all variables,the following equation was used.

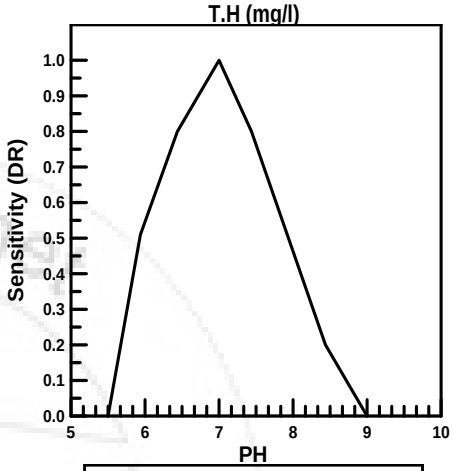
$$WQI = [\pi_{i=1}^{n} f_i(P_i)]^{1/n} \quad \dots (4)$$

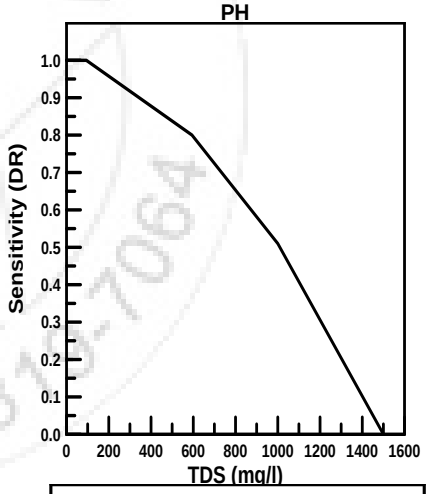
Where:
$f_i(P_i)$: the sensitivity function for each variable including the effect of variable weight concentration which range from (0-1).
n: Number of variables[16]
Table (2) was used to classify the water quality according to Bhargava method.

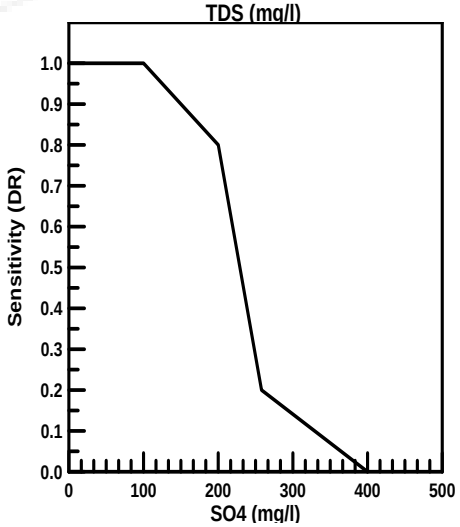
Table 2: Water quality classification according to Bhargava [17]

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









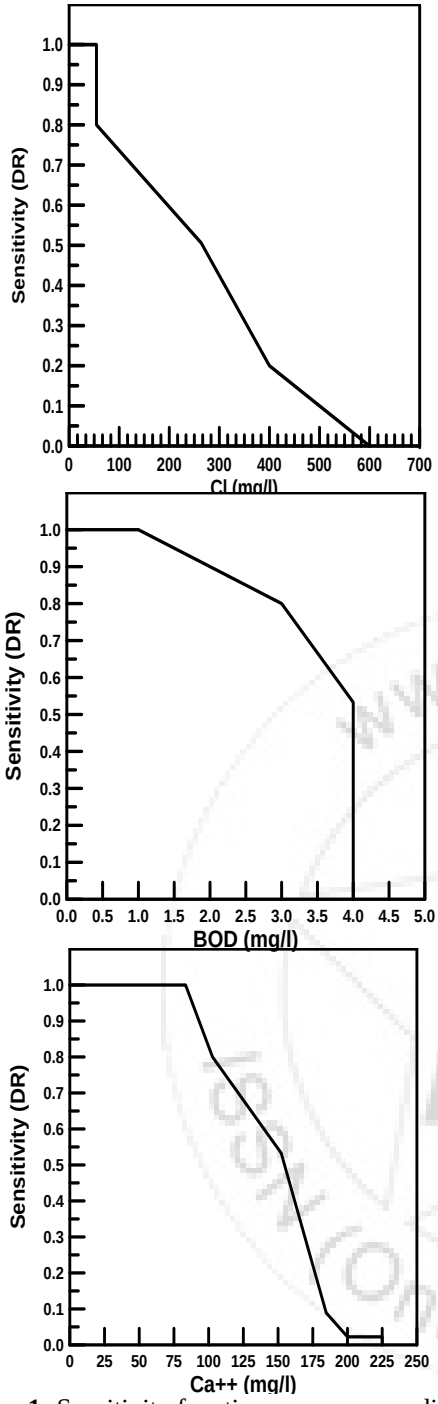


Figure 1: Sensitivity functions curves according to Bhargava for drinking use [17]

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 23NTU 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 yearsturbidity, 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 are increase as we move from north to south. Also, the pollutants that are thrown in the river from the factories and other sources are 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).SinceNineveh is closer to the source of the Tigris River than the provinces of Baghdad and Maysan, soits 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 methodin Nineveh during 2013

parameter	*Ci*	*Si*	*Wi*	*qi*	*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 2015using 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

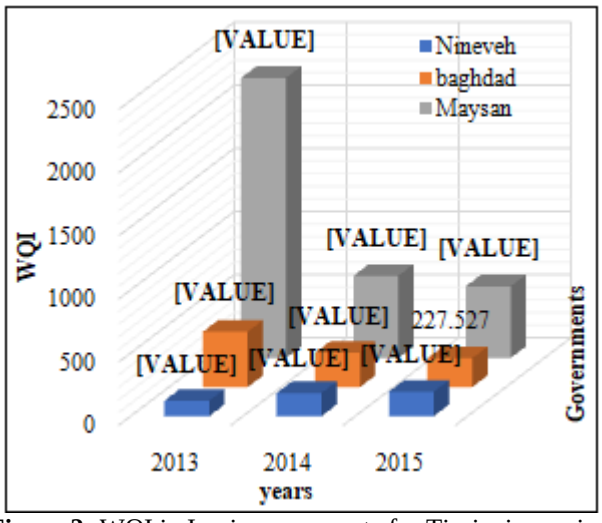


Figure 2: WQI in Iraqi governments for Tigris river using Weighted Arithmetic Water Quality Index method

Table (6) appears the results ofBhargava 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 methodwith the results obtained by using the Bhargavamethod 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 parametersin both methods, in addition to the development of curves of the sensitivity function adopted in the Bhargava method.

References

[1] Al-Janabi Z. Z., Al-KubaisiA.and Al-Obaidy J. M. A., 2012, "Assessment of Water Quality of Tigris River by Using Water Quality Index (CCME WQI)", Journal of Al-Nahrain University, Vol.15 (1), March 2012, pp.119-126.
[2] Al-Obaidy J. M. A., Al-Janabi Z. Z. and Shakir E., 2015, "Assessment of Water Quality of Tigris River Within Baghdad City", mental Journal Mesopotamia Environ, 98 -pp. 90:35, Vol.1, No.201.
[3] Alsaqqar S. A., Hashim A. and Ali M. A., 2015, "Water Quality Index Assessment using GIS Case study: Tigris River in Baghdad City". International Journal of Current Engineering and Technology, E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.
[4] Bashar J. J, 2016, "Application of Water Quality Index to Assessment of Tigris River**",** International Journal of Current Microbiology and Applied Sciences. 5(10): 397-407**.**
[5] Fawzi A. N. and Mahdi A. B., 2014, "Iraq's Inland Water Quality and Their Impact on the North- Western Arabian Gulf". Marsh Bulletin 9(1) (2014) :1-22
[6] Kadhem J. A., 2013," Assessment of Water Quality in Tigris River-Iraq by Using GIS Mapping".Natural Resources, 2013, 4, 441-448.
[7] Helu T. A., 2015, "Integrated Water Losses Assessment and Water Balance Study Over Arid and Semi-Arid Basins Located in Developing Countries". Ph.D. thesis.
[8] Ali A. A., Al-Ansari A. N., and Knutsson S., 2012, " Morphology of Tigris River within Baghdad City", Hydrol. Earth Syst. Sci., 16, 3783–3790, 2012
[9] NGO Coordinating Committee for Iraq (NCCI), 2010.
[10] Najam A. L., Tawfiq F. N. and Younis M. E., 2014, "Radon Emanation from Drinking Water Samples of Nineveh Province (IRAQ)", American Journal of Modern Physics, 2014; 3(6): 257-260.
[11] Khudair H. B., 2013,"Assessment of Water Quality Index and Water Suitability of the Tigris River for

Drinking Water Within Baghdad City, Iraq",Journal of Engineering, Volume 19Number 6.
[12] Bashar J. J., 2014,"Evaluation of Water Quality Index of Tigris River for Irrigation Purposes in Amara city, Southern Iraq", Kufa Journal of Agricultural Sciences, Volume 6 Number 4.
[13] Al-Shujairi H. O. S., 2013, "Develop and Apply Water Quality Index to Evaluate Water Quality of Tigris and Euphrates Rivers in Iraq", International Journal of Modern Engineering Research (IJMER), Vol. 3, Issue. 4, Jul - Aug. 2013 pp-2119-2126.
[14] World Health Organization, 2006, "Guidelines for Drinking Water Quality", 3rd Ed. WHO, Geneva.
[15] Tyagi S., Sharma B., Singh P. and Dobhal R., 2013, "Water Quality Assessment in Terms of Water Quality Index", American Journal of Water Resources, 2013, Vol. 1, No. 3, 34-38.
[16] Parmar K. and Parmar V., 2010, "Evaluation of Water Quality Index for Drinking Purposes of River Subernarekha in Singhbhum District", International journal of environmental sciences Volume 1, No1,2010.
[17] Bhargava D. S., 1983, "Use of a Water Quality Index for River Classification and Zoning of Ganga River". Environmental Pollution (Series B) 6 (1983) 51-67.

Author Profile

Sura Kareem Ali received the B.SC. in civil engineering from Baghdad University in 1990. She received her PhD. in sanitary engineering since 2010, she is a faculty member in Civil Engineering department since 1995.