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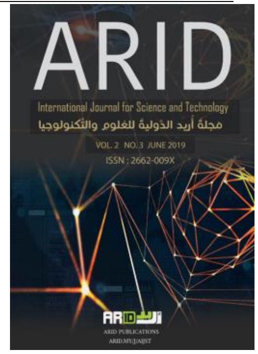

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ASSESSING THE WATER QUALITY OF TIGRIS RIVER FOR DRINKING PURPOSE USING WATER QUALITY INDEX APPROACH

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تقييم نوعية مياه نهر دجلة لأغراض الشرب باستخدام نهج مؤشر نوعية المياه

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Abstract

The Tigris River is considered as the main source of drinking and irrigation in Baghdad. The objective of this research is to assess the quality of Tigris River water for drinking purposes by calculating the Water Quality Index (WQI). The samples were collected from ten stations in January in which five water quality parameters were analyzed: Turbidity, total dissolved solids, concentration of hydrogen ion, dissolved oxygen, biological oxygen demand. The water quality for all the monitored stations was calculated via WQI in which all the stations showed unsuitable quality of water for drinking where the highest value is 534.26 in station 8. The WQI was re-estimated for all the stations excluding the turbidity and total dissolved solids parameters in which station 5 solely shows good quality of water with WQI equals to 46.21. This interprets the condition of the river which can help the local authority in taking action by identifying the sources of pollution and improving the water quality. The stakeholders should be involved in the decision making and mitigation alternatives.

Keywords: WQI, Tigris River, Water Quality, Control Measures, Baghdad

الملخص

يعتبر نهر دجلة المصدر الرئيسي للشرب والري في العاصمة بغداد. الهدف من هذا البحث هو تقييم جودة مياه نهر دجلة لأغراض الشرب من خلال حساب مؤشر جودة المياه. تم جمع عينات من المياه من عشرة محطات في كانون الثاني/يناير تم فيها تحليل خمسة مؤشرات لنوعية المياه: التعكر ، مجموع المواد الصلبة المذابة ، تركيز أيون الهيدروجين ، ألاوكسجين المذاب ، أحتياج الأوكسجين البايولوجي. وتم حساب نوعية المياه لجميع المحطات المرصودة عن طريق مؤشر نوعية المياه الذي أظهرت فيه جميع المحطات نوعية غير ملائمة من المياه للشرب حيث تبلغ القيمة الأعلى 534.26 في المحطة 8. وقد أعيد تقدير مؤشر نوعية المياه لجميع المحطات باستثناء التعكر ومجموع المواد الصلبة المذابة التي تظهر فيها المحطة 5 فقط نوعية جيده من المياه مع مؤشر نوعية المياه يساوي 46.21. وهذا يفسر حالة النهر التي يمكن ان تساعد السلطة المحلية في اتخاذ الإجراءات من خلال تحديد مصادر التلوث وتحسين نوعية المياه. وينبغي اشراك أصحاب المصلحة في اتخاذ القرارات وبدائل التخفيف.

1. Introduction

The main drinking sources in Iraq are represented by the surface waters for both or Tigris and Euphrates Rivers. Tigris River is considered as the main and only drinking source in Baghdad. Besides the surface water, ground water and springs can be considered as supporting sources [1]. Nowadays, Iraq facing a real water crisis as the discharge in both of Tigris and Euphrates goes down to a remarkable value which affects the drinking, irrigation and other uses in the country. This is due to the building of many dams on both of the rivers in the riparian countries, climate change and the severe decrease in annual precipitation which reduces Iraqi share of water [2]. With the available quantity of water, the quality is highly recommended to be investigated. According to the Ministry of Water Resources, 32 percentages of Iraqis has an access to clean drinking water and only 19 percentages has an access to an acceptable sewage system [3] and [4]. There are varieties of pollutants being disposed into both rivers from the non-point sources (i.e. runoff) and point sources (like industrial wastes, agricultural and sewage) [5]. This necessitates more studies on water quality in Iraqi rivers in order to identify the major sources of pollution and mitigation alternatives.

The Water Quality Index (WQI) of 11 streams and the receiving UM- Al Naaj marshland at Misan governorate, Iraq have been assessed using five water quality parameters in which it is indicated that the quality of water ranging from good to excellent [6]. The drinking water quality of Al-Kufa River have been assessed for duration of 12 months using the WQI and the Geographic Information System (GIS) in which it is indicated that the quality of Al-Kufa River is classified as very poor. This is due to the human activities along the river banks [2]. Another study has been performed for evaluating the water quality via WQI of Al-Gharraf River, branch of Tigris River in the southern parts of Iraq in which samples were collected from five stations for duration of one year and eleven water quality parameters were considered. Results showed different index for different stations in which the water is poor in stations 1, 2, 3 and 4 whereas showed very poor quality in station 5 [7]. Ten water quality parameters were adopted to estimate the WQI in Dokan lake in northern parts of the country in which results showed that the quality of water is deteriorating which was good in years 1978, 1979, 1980, 1999, 2000 and 2008 to be a poor quality in 2009 and it is recommended the continuous monitoring of the water quality in the lake for proper management and action [8].

The aim of this research is to assess the water quality of Tigris River in Baghdad via using the water quality index (WQI) approach based on five parameters. This is very significant to the decision makers to give decisions based on the calculated index.

2. Materials and Methods

2.1 Data Collection

The study area is located in the capital Baghdad as illustrated in Figure 1 which starts from Al-Wazeria (Al-Sarafia bridge) to Bab Al-Moadam (Medical City Bridge). This distance of the river receives discharge from the medical city which is affects the quality of the river water. Data collection includes water quality samplings that have been collected from ten stations in which each station consists of three locations (i.e. left, middle and right of the river) as illustrated in Figure 1.

Figure (1): Water quality sampling stations

Water samples were collected in January. Samples were analyzed according to American Public Health Association standard methods [9]. Table 1 presents the monitored water quality parameters.

Table (1): Monitored water quality parameters

No.	Parameter	Unit	Site
1	Turbidity	NTU	Laboratory
2	TDS	mg/l	Laboratory
3	DO	mg/l	In situ
4	pH	pH units	In situ
5	EC	µS/cm	In situ
6	BOD	mg/l	Laboratory

2.2 Estimating Water Quality Index

In estimating the WQI of the river, the weighted arithmetic index method was adopted in which five parameters were considered in the calculation as illustrated in Table 2 for ten stations as shown in Figure 2. In each station, there are three sampling points: (i.e. left side, middle and right side of the river). The weighted arithmetic water quality index method was applied [10] in which the water quality parameters were multiplied by a weighting factor and are then aggregated using a simple arithmetic mean using the following equations:

$$\mathrm{Qi} = \left(\frac{\mathrm{Mi} - \mathrm{Li}}{\mathrm{Si} - \mathrm{Li}}\right) \mathrm{x}\ 100$$

$$\mathrm{Wi} = \frac{\mathrm{K}}{\mathrm{Si}}$$

$$\mathrm{WQI} = \sum_{i=1}^{n} \frac{WiQi}{\sum_{i=1}^{n} Wi}$$

Where, Qi is the sub index of the ith parameter, Wi is the unit weightage of the ith parameter, n is the number of parameters included, Mi is the monitored value of the parameter, Li is the ideal value, Si is the standard value of the ith parameter.

Table 2 illustrates the water quality classification based on WQI [11].

Table (2): Water Quality Index Classification

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

3. Results and Discussions

Based on the equations listed earlier, the WQI for the ten stations monitored in the study area was calculated using the weighted arithmetic index method for five parameters mentioned earlier. The results of water quality monitoring for the ten stations are presented in Table 3. In each station, three samples are collected (left side, middle and right side of the river) and then average values for each station were adopted. Based on the results of monitoring in the river, there are some differences in water quality parameters within the ten stations. WQI calculations showed that the last stations got high index values in which it can be attributed to the discharge from the medical city complex. The water quality in this area is highly affected by the discharge of sewage and the erosion of the riverbank which introduces high turbidity and total dissolved solids in the water body [12] and [13].

Table 5 illustrates the results of WQI for all the monitored stations from station 1 to station 10 which are 486.23, 510.66, 514.72, 480.55, 431.35, 527.7, 464.18, 534.26, 525.78 and 531.67 respectively in which the water quality in all stations is classified as unsuitable for drinking.

As mentioned earlier, the turbidity and TDS can be considered as the main water quality parameters which affect the quality of the river water [14]. The turbidity values for all the stations are much higher than the standard value < 5 NTU according to the World Water Organization. In station 10 which is very close to the disposal of the medical city complex, the

TDS value is very high as compared with TDS values of other stations. The standard value of the TDS is 1000 mg/l [3].

Table (3): Monitored values of water quality parameters

Parameter	St.1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10
Turbidity	80	85	87	79	73	88	81	89	86	88
TDS	1055	1030	1063	1056	1068	1059	1065	1062	1065	5500
DO	7.1	6.7	6.4	6.9	7.5	6.5	7.0	6.3	6.6	6.4
pH	6.5	6.7	7	6.6	7.1	6.8	7.3	6.8	6.5	6.7
BOD	2	2.61	3.2	2.52	1.8	3.3	2.5	3.4	3	3.2

The DO is an important water quality parameter in evaluating the quality of water since it is essential in bacterial actions in breaking down the organic matter available in water [15]. The DO values monitored in the river are higher than the standard value 5 mg/l. Regarding the pH values; they are different between stations within acceptable levels with a standard value of 7.5

Eventually, the BOD values for the stations of one to ten recorded lower values than the standard value of 5 mg/l. The ideal values and standard values for the five water quality parameters are presented in Table 4.

Table (4): Standard and ideal values of the monitored parameters

Parameter	Standard value	Ideal value
Turbidity	5	0
TDS	1000	0
DO	5	14.6
pH	7.5	7
BOD	5	0

The estimated water quality index values for the ten stations were calculated via excel data sheet and presented in Table 5.

Table (5): Water quality index for the ten stations

Station	WQI	Quality
1	486.23	Unsuitable for drinking
2	510.66	Unsuitable for drinking
3	514.72	Unsuitable for drinking
4	480.55	Unsuitable for drinking
5	431.35	Unsuitable for drinking
6	527.7	Unsuitable for drinking
7	464.18	Unsuitable for drinking
8	534.26	Unsuitable for drinking
9	525.78	Unsuitable for drinking
10	531.67	Unsuitable for drinking

As highlighted in Table 5, the WQI index values for all the stations show that the water is "unsuitable for drinking". This is attributed majorly to the high turbidity and TDS values that exceed the standard values [3]. The original WQI values and the WQI (excluding turbidity and TDS) were presented in Table 6.

Table (6): Comparison between the original WQI and the WQI without turbidity and TDS

Station	WQI	Quality	Station	WQI (Excluding TDS and Turbidity)	Quality
1	486.23	Unsuitable for drinking	1	69.28	Poor
2	510.66	Unsuitable for drinking	2	65.41	Poor
3	514.72	Unsuitable for drinking	3	56.02	Poor
4	480.55	Unsuitable for drinking	4	68.96	Poor
5	431.35	Unsuitable for drinking	5	46.21	Good
6	527.7	Unsuitable for drinking	6	66.39	Poor
7	464.18	Unsuitable for drinking	7	63.43	Poor
8	534.26	Unsuitable for drinking	8	67.91	Poor
9	525.78	Unsuitable for drinking	9	78.74	Poor
10	531.67	Unsuitable for drinking	10	71.02	Poor

As illustrated in Table 6, the original water quality index for all the stations indicates that the water is unsuitable for drinking but when the TDS and turbidity were exempted; the WQI values were changed in which the water quality is poor in all stations except station number 5 which show a good quality of water. Based on that, the water quality can be improved by reducing the TDS and turbidity values to desirable limits. The TDS values can be minimized by treating the sewage from the medical city complex prior to their direct disposal into the river and reducing human activities that have a direct impact to the water body [16]. For the turbidity values, it is highly recommended that erosion, sediment and drainage control measures are installed along the river banks [17], [18], [19], [13], [20] and [21].

4. Conclusions and Recommendations

Tigris River has a main drinking and Irrigation source for the capital Baghdad. This work aimed to evaluate the water quality of Tigris River in Baghdad via estimating the WQI of the river based on five parameters. Based on the monitored water quality parameters for the ten stations, the WQI values indicate a quality of water which is unsuitable for drinking. This is attributed to the disposal of sewage in the vicinity and runoff of water to the water body. It is noticed that the turbidity and TDS values were higher than the standard values in remarkable values. The WQI for the ten stations were re-calculated without considering the turbidity and TDS. Nine of the stations were recorded poor quality of water and one station only showed good quality. Thus, this is emphasis on adopting control measures (erosion, sediment and drainage controls) to improve runoff quality. Furthermore, it is recommended to take more samples during different months of the year to give a better representation of the data and involving more parameters. Finally, stakeholders must be involved in the decision making and mitigation alternatives.

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List of Abbreviations

WQI	Water Quality Index
GIS	Geographic Information System
TDS	Total Dissolved Solids
DO	Dissolved Oxygen
EC	Electrical Conductivity
BOD	Biological Oxygen Demand

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