WATER QUALITY ASSESSMENT OF EUPHRATES RIVER IN QADISIYAH PROVINCE (DIWANIYAH RIVER), IRAQ

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ABSTRACT

This study was conducted to assess the water quality of the Diwanyiah River by the water quality Index (WQI) over the period from September 2015 to June 2016 .Four sites were selected along the river. The Canadian water Quality Guideline- water Quality Index (CCME-WQI) was applied to the Diwanyiah River in this study. Nine environmental parameters (water temperature, power of Hydrogen ion, dissolved oxygen, total dissolved solids, turbidity, total alkalinity, nitrite, nitrate and phosphate) were selected to assess the water quality for the protection of aquatic life. The water quality index results showed that the water quality of the river is ranged between poor to marginal.

Key words: Diwanyia river, environmental factors, water quality index, Euphrates River

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تقييم نوعية مياه نهر الفرات في محافظة القادسية (نهر الديوانية) ، العراق

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المستخلص

اجريت الدراسة على نهر الديوانية لتقييم نوعية المياه باستخدام دليل نوعية المياه الموديل الكندي (CCME-WQI) للفترة ايلول 2015 الى حزيران 2016. تم اختيار اربع مواقع على طول النهر للدراسة، حيث يمثل الموقع الاول المنطقة التي يتجه فيها نهر الحلة باتجاه مدينة الديوانية، الموقع الثاني والثالث يمثلان بداية دخول النهر مدينة الديوانية ووسطها اما الموقع الرابع فيمثل اسفل النهر جنوب المدينة بالقرب من معمل المطاط . تم تطبيق دليل نوعية المياه الكندية واستخدمت تسعة عوامل بيئية لتقييم المياه وهي : درجة حرارة المياه وقيمة درجة الاس الهيدروجيني والنتريت والنترات والفوسفات والقاعدية و المواد الصلبة الذائبة و الاوكسجين الذائب والعكارة. وبينت نتائج الدليل لنوعية مياه نهر الديوانية بان نوعيتها تتراوح بين فقيرة الى حافي .

الكلمات المفتاحية: نهر الديوانية، العوامل البيئية، نوعية المياه، الدليل الكندي، نهر الفرات

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INTRODUCTION

The hot desert climate is characterized by 70% of Iraqi territories (the sedimentary plain and western plateau). There are different periods of rain and drought, which effected on water resources in Iraq (14). The water scarcity was the most important issue worldwide due to the global climate change, in addition to the construction of dams on the rivers. The UN-ESCWA-BGR (38) pointed to a negative trend in discharge of the Euphrates river at Hussaybah (the site entry of the Euphrates river in Iraq), they recorded 15.5 BCM (Billion Cubic Meters) in the period 1999-2010. These annual discharges of water in the Euphrates River are continuing to decline due to the construction of large dams in both Turkey (GAP project) and Syria. The water quality of the natural surface water is taken as a priority for the governments and the societies concerned the human health at which these surface waters were the main sources of drinking water (42). Water quality (WQ) is defined as the set of variables that limit water use; each use has some common requirements for some variables. The water quality is affected by nature, such as geological, hydrological and climate and various anthropogenic such as discharge of municipal and industrial sewage water, and agriculture drainage (4, 27) .Water quality assessment (WQA) is a process of determining the physicochemical and biological properties. The water quality indices (WQI) aimed to give individual values to know the WQ in a simple and easier expression to interpret control data (12). Al-Shujairi (10) revealed that the most important parameter affecting water quality is total dissolved solids, total hardness, pH, dissolved oxygen, biological oxygen demand, nitrate and phosphate. The Canadian Council of Ministries of the Environment (CCME) developed the WQI which known as CCME-WQI. This index is flexible to select the variable and a set of the standard limit on which water specifications are acceptable. The index relies on intercourse three mathematical factors in calculating the final figure of the water condition and the values of the guide ranging from 0-100 (7). A study on Mackenzie River in Canada used the CCME-WQI to assess to the quality of this largest and longest river in Canada. The study revealed that the WQ of the river deteriorated due to the impact of turbidity and heavy metals (Lumb et al., 2006). Hoseinzadeh, et al. (22) used different WQ indices to assess to the Aydughmush River in Iran. They found similar results of indices except the River pollution index. The Euphrates river is the main water resources for the Western (Ramadi Province) and southern parts Iraq. Many agro-industrial activities threaten the water quality along the main stream (18). Many studies in Iraq used the CCME-WQI to evaluate the WQ in Tigris and Euphrates Rivers. Hassan et al. (20) applied this index on the Tigris River, in which ten parameters such as temperature, electrical conductivity, salinity, water flow, total dissolved solids, Total suspended solids, dissolved oxygen, biological oxygen demand, total nitrogen and total phosphorus were computed by CCME-WQI. The results of this study indicate that the values have ranged from 20.32 to 60.48, thus the WQ of the river is ranged from Poor to marginal. Another study on the Tigris River (7) confirmed the result of the previous study by Hassan et al. (20) and pointed out the pollution of the river. Al-Shujairi (10) revealed that the Euphrates River WQ was critically reduced and there was no large difference in WQ between dry and wet seasons. Salman et al. (33) applied the CCME-WQI on the Al-Hilla river (a branch of the Euphrates River), the results indicate that the river WQ was marginal quality due to different pollution impacts on the river. Ala Allah et al. (3) applied the CCME-WQI for assessment WQ of Al-Shamyia river for aquatic organism's life, the results showed that the river WQ is ranged from marginal to good. While the study on Kuffa river WQ indicated that the river WQ is ranged from good to marginal (21). The Diwaniya river is the main source of the drinking water of Al-Qadisiya Province and agro-industrial used. This study aimed to evaluate the water quality of the Diwaniya river (Eupharated river) by applying the CCME-WQI.

MATERIAL AND METHODS

Site Study

The Diwanyiah river is represented the Euphrates river. The Euphrates river after Hindyia Barrage ramified into two branches, one of them passing Babylon province (formally named Al-Hilla River in this region) and then also ramified into two branches; Daghara and Diwanyiah rivers (15). Four sites were selected along the river in this study over the period between September 2015 to June 2016 .Site 1 is located at the point where the Hilla river turning to the Diwanyia river and Dagharah river. Sites 2 and 3 are located at the beginning of Diwanyia city and in the center city, respectively. While site 4 represents the downstream at the southern part of the city nearby Rubber factory (Figure 1 and Table 1). The river exposed to different anthropogenic sources due to the many small village households and agriculture drainage into the river without any treatments. Moreover, the municipal and industrial sewage waste during the river passed the city.

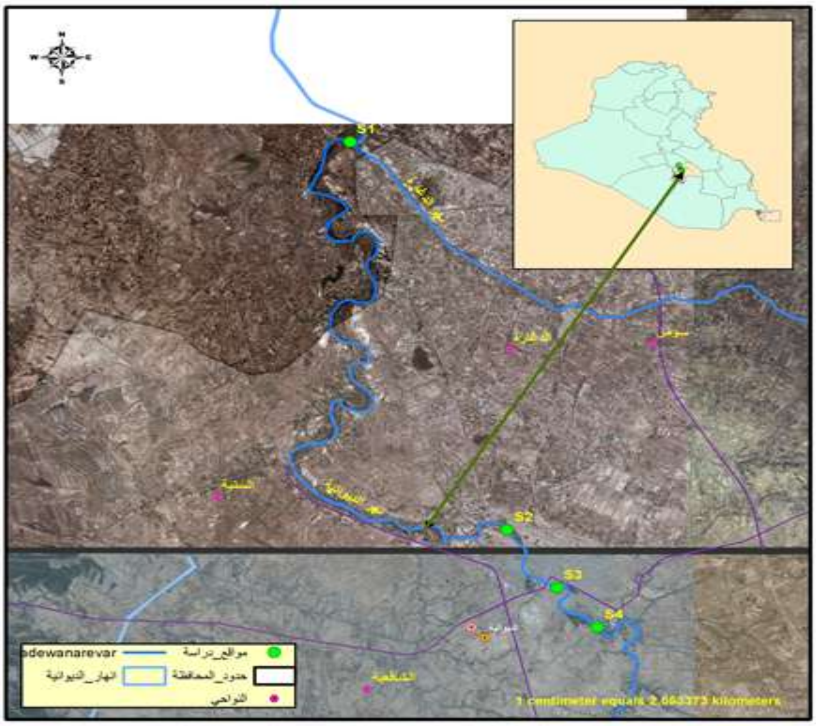


Figure 1. Map of the study sites.

Table 1. The Geographical Positioning System (GPS) of the selected sites

Sites	Latitude (North)	Longitude (East)
1	44° 48’ 26.84“	32°14’18.67“
2	44° 53’ 47.19“	32°0’ 59.75"
3	44° 55’ 28.55“	31°58’ 58.02"
4	44° 56’ 51.96“	31°57’36.86"

Source: from the Iraqi Ministry of Environment- the environmental office in Qadisiyah Province.)

Sampling

Monthly samples were taken from the selected sites over the period of Spetmber 2015 to June 2016. Nine parameters were determined to compute the CCME-WQI. These parameters were water temperature (WT), pH, total dissolved solids (TDS), Turbitity (TU), total alkalinity (TA), dissolved oxygen (DO), Nirite (NO_2), nitrate (NO_3) and phosphate (PO_4). The WT, pH, TDS were determined by using a thermometer, pH-meter (model pH200, Lovibond) and multimeter (model Con 200, Lovibond). TU was measured by the turbidity meter (model HI 93701 MICROPROCESSOR, HANNA) in the field. The Winkler method was used to measure DO [1]. The NO_2, NO_3 and PO_4 were measured by spectrophotometric method according to Parson (31). The assessment of WQ of the river was computed by CCME WQI equations (13). The values of environmental parameter were used in the calculation of the index guide and arranged in a matrix according to seasons and sites. The following equations were used as follows:

1. **Scope (F_1)**

$$F_1 = \left\{\frac{Number\ of\ failed\ Variables}{Total\ Number\ of\ Variables}\right\} \times 100$$

2. **Frequency (F_2)**

$$F_2 = \left\{\frac{Number\ of\ failed\ Tests}{Total\ Number\ of\ Variables}\right\} \times 100$$

3. **Amplitude (F_3)**

a. Compute Excursion:

a.1. If the values are higher than the set values of the model

$$Excursion\acute{\imath} = \left\{\frac{Failed\ Test\ Value\ i}{Objective\ j}\right\} - 1$$

a.2. if the values are lower than the set values of the model

$$Excursion\acute{\imath} = \left\{\frac{Objective\ j}{Failed\ Test\ Value\ i}\right\} - 1$$

b. The nes (the sum of the standard deviations)

$$nse = \frac{\sum_{i=1}^{n} Excursion}{number\ of\ tests}$$

c. Calculation of F_3

$$F_3 = \frac{nse}{0.01nse + 0.01}$$

4. The CCME WQI equation

$$CWQI = \frac{\sqrt{{F_1}^2 + {F_2}^2 + {F_3}^2}}{1.732}$$

Then the results of the index were compared with the numerical scale which is divided into five categories describing the WQ as follows:

1. 100 -95 (Excellent; WQ is closed to natural levels)
2. 94-80 (Good;WQ has reached a minor degree of impairment)
3. 79-60 (Moderate;WQ is occasionally impairment and undesirable levels sometime)
4. 59-45 (Marginal; WQ is frequently ranged between impaired to often undesirable levels)
5. 44-0 (Poor; WQ is always impaired and usually undesirable levels)

Statistical Analysis

The correlation coefficient (r), and the comparison of averages were used the statistical package for the social sciences (SPSS).

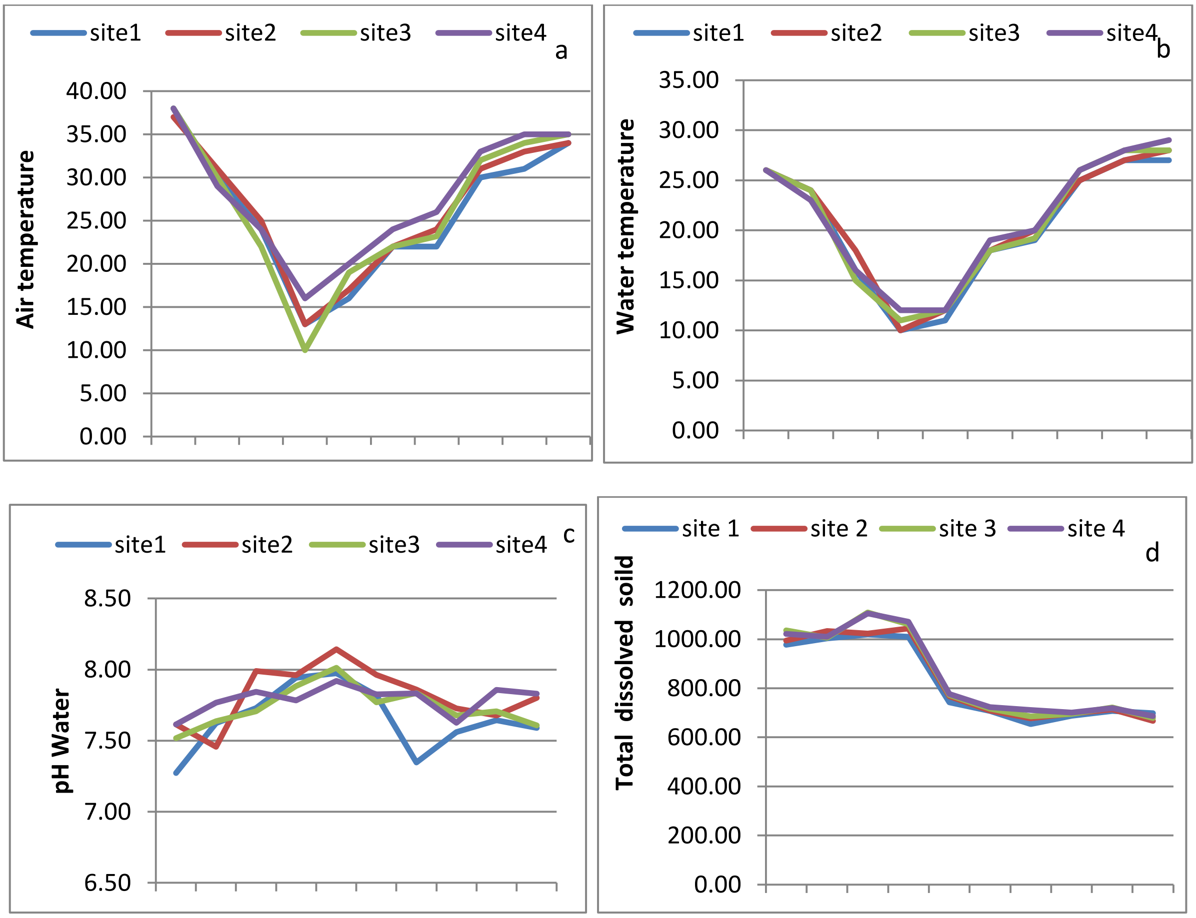
RESULTS AND DISCUSSION

The results of the parameters were illustrated in Table 2. Temperature is the most important factors in the ecosystem, the water temperature is an important factor in river ecology which due to its impact on water quality (39). The lowest value of temperature of air and water was recorded in December 2015 while the highest values for both were in September 2015 and June 2016, the water temperature followed the air temperature is due to the shallow depth and increase the surface area of water compared to the size of the river basin (11). The results showed a variation in the values among the study period followed the seasonal cycle (Figure 2) and this finding due to the arid climate of the region (16, 17).

Table 2. The mean, standard deviation and range of the selected factors in the study area during 2015-2016.

Factors	Sites			
	1	2	3	4
Air temperature	26.00±1.40 a 38 – 13	26.70±1.38 a 37 – 13	26.60±1.53 a 38 – 10	28.00±1.27 a 38 – 16
Water temperature	20.30±1.14 a 27 – 10	20.80±1.11 a 28 – 10	20.80±1.15 a 28 – 11	21.10±1.11 a 29 – 12
pH water	7.65±0.04 b 7.97 – 7.35	7.82±0.04 a 8.14 – 7.46	7.74±0.03 a 8.01 – 7.52	7.79±0.02 a 7.92 – 7.61
TDS mg/l	820.57±27.83 a 1019 – 654	832.57±29.38a 1044 – 667	848.07±31.66a 1109 – 679	852.60±30.82a 1105 – 687
Turbidity NTU	8.43±0.57 b 12.13 – 4.87	9.81±1.02 b 17.97 – 3.65	13.97±1.26 a 30.66 – 7.54	14.15±1.31 a 27.37 – 7.80
Dissolved Oxygen mg/l	7.98±0.15 b 9.50 – 6.83	8.75±0.21a 11.10- 7.37	8.12±0.17 b 9.50 – 6.87	8.26±0.19 ab 9.45 – 6.73
Total alkalinity mg/l	120.73±2.62 a 140.67 –102.67	126.33±4.08a 166 – 102	126.87±3.41 a 160 – 102	129.40±3.27a 164.67 -106
Nitrate	9.22±0.60 b 15.74 – 3.55	9.15±0.52 b 12.73- 2.98	9.37±0.54b 15.35- 3.04	11.52±0.61 a 16.94 -6.25
Nitrite	2.18±0.15 ab 4.04 – 1.37	2.32±0.16 ab 3.62 – 1.17	1.86±0.11b 3.04 – 1.08	2.43±0.20 a 4.60 – 1.11
Reactive phosphate	0.84±0.03 a 1.29- 0.68	0.88±0.04 a 1.50 – 0.74	0.88±0.05 a 1.56- 0.73	0.96±0.07 a 1.81 – 0.71

*** Averages that share the same letter or alphabet for each factor and each ovelap are not significantly difference between them according to the Duncan test at the level of robability**



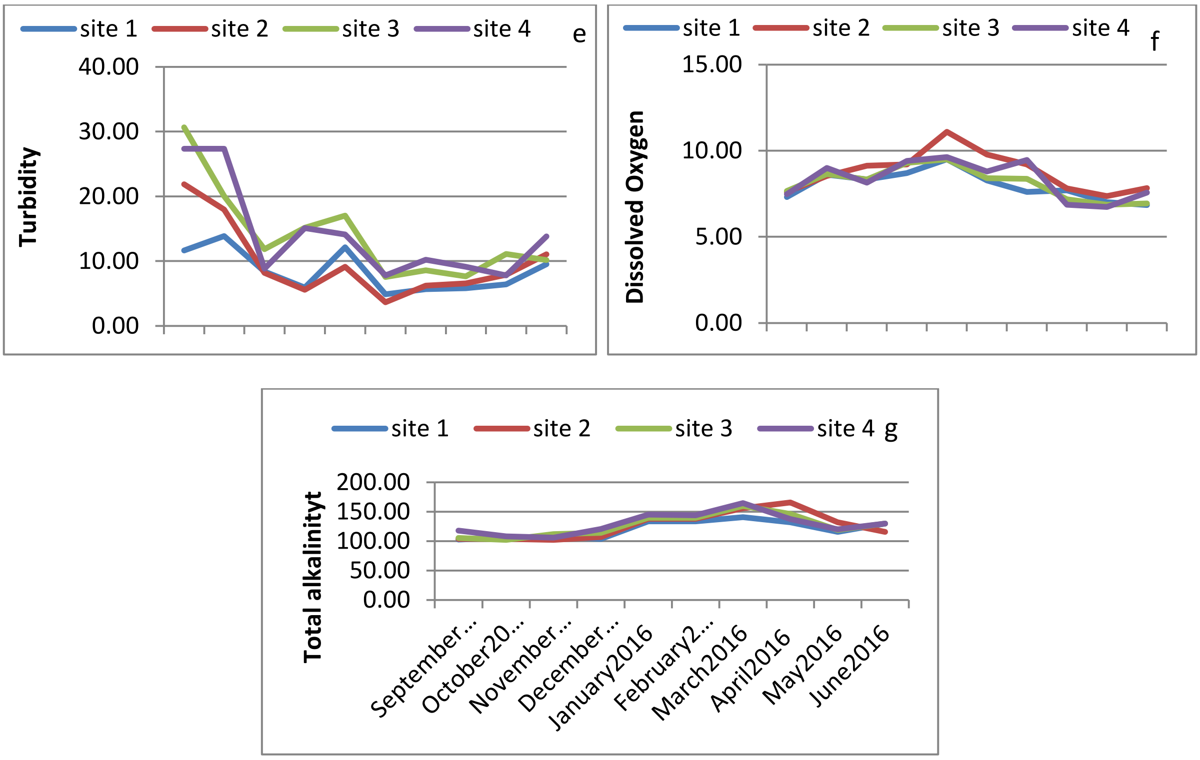


Figure 2. Monthly variation in the air temperature (a), Water temperature (b), pH (c), TDS (d), TU (e), DO (f) and TA (g) in the study area during 2015-2016.

The Iraqi water ecosystems are characterized by high capacity of buffering with narrow range variations of pH due to high contents of bicarbonate and carbonate in Iraqi water systems (2, 18). The TDS was ranged from 654 mg/l at site 1 in March 2016 to 1109mg/l at site 3 in November 2015 (Table 2, Figure 2d). There are many factors affect the TDS values such as rainfall, water level, soil erosion and waste disposal into the river (41). The TDS values showed a positive correlation with TU (r= 0.51, P< 0.05) and PO_4 (0.050, P< 0.05). The results of TDS values (< 1000 mg/l) indicate the undesirable water for domestic use (41). The TU values were varied among sites during the study period (Table 2). The lowest values were recorded in January 2016 (3.65 NTU) at site2, while the highest value was 30.66 NTU in September 2015 at site 3 (Figure 2e). The dilution factors due to rainfall season and the existing of macrophytes in the river have a big role in seducing the TU values (29). Moreover the discharge of different waste water and soil erosion from the river banks into river led to increased the TU values (28).The results of DO values indicate that the river well aerated (>6 mg/l) over all the study period. A negative correlation recorded between DO and water temperature (r= -0.789, p< 0.01). This finding was in accordance with other studies (24, 32) .The TA values were ranged from 102 mg $CaCO_3$/l at site 3 in October 2015 to 166 mg $CaCO_3$/l at site 2 in April 2016. The alkaline properties of Iraqi water are noticed by other authors (6, 19). This alkaline properties might be due to the bicarbonate and carbonate contents in the aquatic systems which these ions are the main responsible ions of water alkalinity (40). Nitrite is an intermediate phase of oxidation and reduction of both ammonia and nitrate, their concentrations are very low in natural water systems [37]. Its concentration is ranged from 1.08 µg N-NO_2/l at site 3 in November 2015 to 4.60 µg N-NO_2/l. This result indicates the presence of organic pollutant due to the discharge of sewage directly into the river in spite of the well aeration in the river, moreover the rainfall might be led to the flow of fertilizers from agricultural land nearby the river [5, 35]. The lowest nitrate concentration (2.98 µg N-NO_3/l) was recorded at the site 2 in

June 2016, while the highest concentration (16.94 µg N-NO_3/l) was in December 2015 at site 4 (Figure 3). The statistical analysis showed a significant difference between the study months in September 2015 and January 2016 (Table 3). The concentration of DO and high value of temperature were the main factors affect nitrate concentration (26, 36).The phosphate concentrations were ranged from 0.68 µg /l at site 1 in March 2016 to 1.81 µg /l at site 4 in December 2015. The dilution factor and its affinity to form a complex with calcium, which led to reduce its concentration in the river. The anthropogenic sources have a role in increase the phosphate concentrations, such as the phosphors fertilizers, other discharges of wastewater and the decomposition activity (23, 34).

Table 3. Monthly variation (Mean and standard deviation) of the selected factors in the study area.

Factors	Months									
	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Air temperature	37.75±0.13 a	30.00±0.21 e	23.75±0.33 f	13.00±0.64 i	18.00±0.48 h	22.60±0.31 g	31.50±0.34 d	23.71±0.41 f	33.25±0.45 c	34.50±0.15 b
Water temperature	26.00±0.00 b	23.75±0.13 c	16.25±0.33 f	10.75±0.25 h	11.75±0.13 g	18.30±0.15 e	25.50±0.15 b	19.50±0.20 d	27.50±0.15 a	28.00±0.21 a
pH water	7.50±0.04 f	7.62±0.03 e	7.82±0.03 bc	7.89±0.02 b	8.01±0.03 a	7.86±0.02 b	7.65±0.02 de	7.74±0.06 cd	7.72±0.02 cde	7.71±0.03 de
TDS mg/l	1007.25±6.94 c	1012.67±3.63 c	1063.92±13.06 a	1046.17±7.07 b	764.67±4.02 d	713.40±2.30 e	695.25±1.59 f	687.07±6.23 f	715.67±1.68 e	682.83±3.40 f
Turbidity NTU	22.89±2.17 a	19.81±1.48 b	9.31±0.44 de	10.42±1.41 cde	13.11±0.87c	5.65±0.59 f	7.29±0.38 ef	7.65±0.47 ef	8.31±0.52 def	11.13±0.49 cd
Dissolved Oxygen mg/l	7.51±0.06 d	8.69±0.06 c	8.48±0.13 c	9.15±0.09 b	9.93±0.21 a	8.89±0.21 bc	7.38±0.12 de	8.53±0.17 c	6.99±0.08 e	7.29±0.13 de
Total alkalinity mg/l	107.50±1.92 ef	105.00±0.81 f	107.00±1.17 ef	111.50±1.97 e	139.33±1.31 c	138.80±1.38 c	145.33±3.94 b	153.14±2.79 a	121.83±1.87 d	126.50±1.89 d
Nitrate	9.92±0.28 c	12.87±0.57 a	12.26±0.40 ab	13.54±0.90 a	11.16±0.46 bc	11.11±0.71 c	7.46±0.28 d	8.10±0.24 d	4.86±0.55 e	7.35±0.71 d
Nitrite	1.20±0.03 e	2.42±0.39 bc	1.72±0.18 d	1.99±0.04 cd	1.91±0.02 cd	2.63±0.33 b	2.47±0.17 bc	2.20±0.09 bcd	3.71±0.14 a	1.79±0.12 d
Reactive phosphate	0.88±0.02 c	0.88±0.02 c	0.84±0.02 cd	1.54±0.06 a	1.01±0.10 b	0.72±0.01 d	0.75±0.01 d	0.73±0.01 d	0.80±0.01 cd	0.75±0.01 de

* Averages that share the same letter or alphabet for each factor and each overlap are not significantly different between them according to the Duncan test at the level of probability 5%.

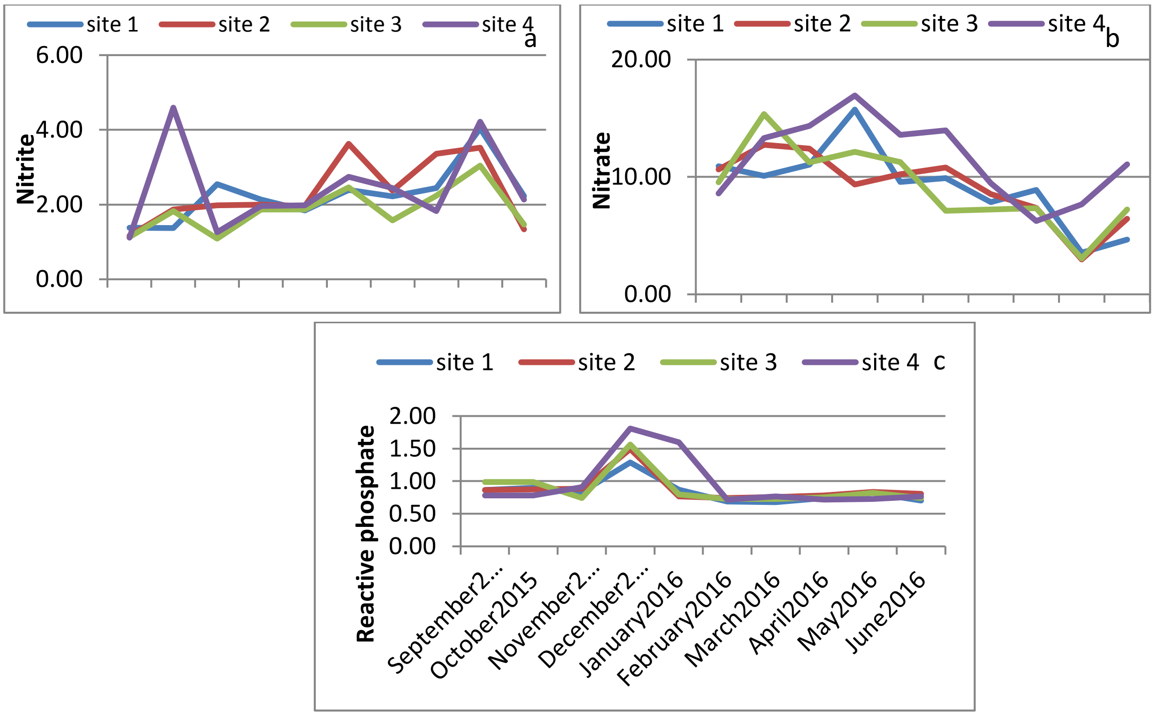


Figure 3. Monthly variation in NO_2 (a), NO_3 (b) and PO_4 (c) in the study area during 2015-2016.

The water quality reflexed an aquatic system status and it gives a summary of the ecosystems held for different purposes (25). The value of CCME has ranged from 30 at site 1 in winter to 48 at site 2 in the autumn. These results indicate that the river is ranged between Poor to Marginal. The lower value of CCME at site 1 was 30 in the autumn and the highest value was 43 in the winter. The value of the index ranged from 35 to 48 at site 2 in the autumn and the winter, while in the site 3 (which represents the city center) was recorded high values in comparison with other sites (35-44). The index value ranged 31-39 at site 4 in the summer and the winter, respectively (figure 4). These index results might be due to the deviation of the selected factors used in computing the index from the criteria set for the index manually (table 4) (13). The values of TDS, TU, NO_3 and PO_4 were the most factors that exceed the normal and were determined by the index guide in this study. These results were consistent with the values of the Shannon –Weaver index (unpublished data). The river has been under severe threat of different pollutant discharge into the river without any monitoring program from the province authority. These anthropogenic sources reduced the quality of the river [8, 30]. The results of the index are in accordance with Al-Shammary (9) study on Al-Hilla river and Al-Obaidy et al. [7] Study on the Tigris river while it's less than values

Table4: Global standard of variables used in the CCME guideline for the protection of the aquatic organism.

Parameter	CCME guideline
DO (mg/L)	5.5-9
pH	6.5-9
Water Temp. (°C)	15
TDS (mg/L)	500
Turbidity (NTU)	5
Alkalinity mg CaCO3/I	20>
NO_3 (mg/L)	13
NO_2 (mg/L)	0.06
PO_4 (mg/L)	0.3

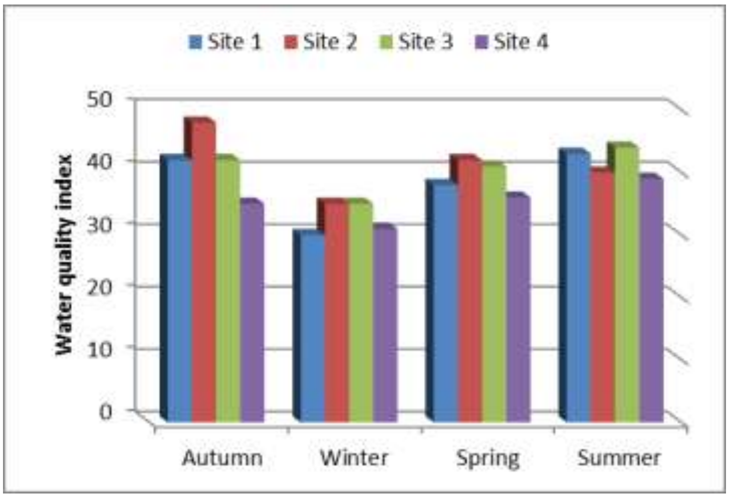


Figure 4. Seasonal variation of the CCME-WQI values in the study area during 2015-2016.

The Al-Diwaniyah river has been threatened by different pollutants due to the illegal discharge of the waste water into the river directly without any treatment and environmental monitoring programs. The water quality index revealed that the river was ranged from Poor to Marginal which is effected on the biodiversity of the river and determined the use of river water for different purposes.

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REFERENCES

1.APHA, American Public Health Association. 2005. Standard Methods for the Examination of Water and Waste Water, 21st Edition, Washington, DC. pp:1200.

2.Al- Saadi, A.H.; I. Kassim; Thaer; Al-lami, A. Ali, and S. Salmon, 2000. Spatial and seasonal variations of Euphrates river, Iraq. Limnologica. 30: 83-90.

3.Ala Allah, S. K., K. A. Rasheed and M. R. Nashaat. 2014. Assessment of Al- Shamyia river water quality by using CCME water quality index. Euphrates J. Agric. Sci, 6 (1): 263-275.

4.Alam, W. and R. J. Laishram. 2017. Spatial and Temporal Assessment of Water Quality of Nambul River Within Imphal City, Manipur. International Conference on Natural Resources Management and Technology Trends (ICNRM-17), at Manipur University, Imphal. pp:108-109.

5.AL-Lami, A. A., H. A. AL-Saadi, T. I. Kassim, and R. K. Farhan. 1999. Seasonal changes of epipelic algal communities in North Part of Euphrates River, Iraq. J. Coll., Educ. For Women, Univ, Baghdad, 10 (2): 236-247.

6.AL-Mousawi, A. H. A., H. A. AL-Saadi, and F. M. Hassan. 1994. Spatial and seasonal variations of phytoplankton population and related environments in AL-Hammar marsh, Iraq. Basrah. J. Sci, B, 12 (1): 6-20.

7.Al-Obaidy, A. M., Z. Z. Al-Janabi, and E. Shakir. 2015. Assessment of water quality of Tigris River within Baghdad City Mesop. Environ. J. 2015, 1(3): 90-98.

8.Al-Obaidy, A. M. J. and N. Al-Khateeb, 2013. The challenges of water sustainability in Iraq. Eng. & Tech. J., 31 (5), Part (A): 828-840.

9.Al-Shammary, A. A. S. 2014. A Study of Aquatic Plants Biodiversity and Applications of Water Quality Indices in Hilla river, Iraq-PhD Dissertation, College of Science University of Babylon.pp: 121.

10. Al-Shujairi S. H. 2013. Develop and apply water quality index to evaluate water quality of Tigris and Euphrates Rivers in Iraq, International J. Modern Engineering Research (IJMER), 3 (4): 2119-2126.

11. Benyalys, L., D. Caissie, A. St- Hilaire, M. J. Ouarda, T. B. and M. J. Bobée. 2007. A review of statistical water temperature models. Can. Wat. Res. J., 32 (3): 179-192.

12. Bhart, N. and D. Katyal. 2011. Water quality indices used for surface water vulnerability assessment. International J. of Environ. Sci. 2(1): 154-173.

13. CCME, (Canadian Council of Ministers of the Environment). 2001. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Canadian Water Quality Index 1.0 Technical Report. In Canadian Environmental Quality Guidelines, Winnipeg, Manitoba. http://www.ccme.ca/ assets/pdf/ wqi_usermanualfctsht_e.pdf

14. Central statistical Organization (CSO). 2012-2013. Annual Statistical Abstract. Issued by the Iraqi Ministry of Planning. pp: 1-41.

15. Hassan, F. M. 2004. Limnological features of Diwanyia River, Iraq. J. of Um- Salma for Sci., 1(1):119-124.

16. Hassan, F. M. and S. H. Al- Abdulameer. 2014. Qualitative and quantitative study of epipelic algae in Tigris river within Baghdad city, Iraq. Baghdad. S. j. 11(3): 1074-1082.

17. Hassan, F. M., N. F. Kathim, and F. H. Hussein. 2008. Effect of chemical and physical properties of river water in Sjatt Al-Hilla on phytoplankton communities. E-J Chem., 5 (2):323-330.

18. Hassan, F. M. and A. O. Shaawiat. 2015. A contribution to the epipelic algal ecology in lotic ecosystem of Iraq. J. Environ. Protection,6: 85-95.

19. Hassan, F. M., M. M. Salah, and J. M. Salman. 2007. Quantitative and qualitative variability of Epiphytic algae on three aquatic plants on Euphrates river, Iraq. Iraqi J.of Aqua . 4(1):1:16.

20. Hassan, F. M., N. A. AL-Zubaidi, and W.A. Al- Dulaimi. 2013. An ecological assessment for Tigris River within Baghdad, Iraq J. of Babylon Univ. 21S (3S): 28-39.

21. Hassan, H. A., M. R. Nashaat, and K. A. Rasheed. 2014. Assessing water quality of Kuffa for aquatic life by using Canadian Water quality index (CCME-WQI). Euphrates J. Agric. Sci., 6 (1): 276-290.

22. Hosinzadeh, E., H. Wei, C. Khorsandi, and M. Alipour. 2014. Evaluation of Aydugmush River water quality using the National Sanitation Foundation water quality index (NSFWQI), River Pollution Index (RPI), and Forestry Water Quality Index (FWQI). Desalination and Water Treatment, DOI:10.1080/19443994. 2014. 913206.

23. Ibanez, J. G., M. H. Esparza, C. D. Serrano, A.F. Infante, and M. M. Singh, 2007. Environmental chemistry fundamentals. Springer, New York, USA. pp: 323.

24. Kadhim N. F., M. J. Al-Amari, and F.M. Hassan, 2013. The spatial and temporal distribution of epipelic algae and related environmental factors in Neel stream, Babil province ,Iraqi IJAS,4(2):23-32

25. Lamare, R. E. and O. P. Singh. 2016. Application of CCME water quality index in evaluating the water quality status in limestone mining area of Meghlaya, India. The ECOSCAN, 10 (1&2): 149-154.

26. Likanen, A., M. puustinen, J. kosklaho, T. Vaisanen, P. Marlikainen, and H. Harlikainen. 2004. Phosphorus removel in a wetland constructed on former arable land. Technical Reports.J. Environ. Qual., 33:1124-1132.

27. Meybeck, M., A. Kuusisto, A. Mäkelä, and E. Mälkki. 1996. Water quality (Chapter 2). In: Bartram, J. and Balance, R (Ed.) Water Quality Monitoring: A Practical Guide to The Design And Implementation of Freashwater Quality Studies and Monitoring Programmes. UNEP/WHO.pp. 13-36.

28. Mustafa, O. M. 2006. Impact of Sewage Wastewater on the Environment of Tanjero River and its Basin within Sulaimani City/ NE- Iraq. M.Sc. Thesis. Sci. Coll- Baghdad University. pp:142.

29. Nomman, M. M. 2008. Effect of Industrial Influent on Water Quality of Tigris River and Upon The Performance Treatment Plant Within Sector Baiji- Tikrit. M.Sc. Thesis ,Coll. of Engn. ,Tikrit Uni. pp:199.

30. Parmar, K. and V. Parmar. 2010. Evulation of water quality index for drinking of river subernarekhe in Singhbhum District. Intern. J. Environ. Sci, 1 (1): 77- 81.

31. Parson, T. R.; Y. Mait, and C. M. Laui. 1984. A manual of chemical and biological methods for sea water analysis. Pergamine press, Oxford. pp: 173.

32. Salman, J. M. and A. J. Nassar. 2012. Variation of some physcico-chemical parameters and biodiversity of Gastropods species in Euphrates river in Iraq. IJESD, 5(3): 328- 331. DOI:10.7763/ IJESD. 2014. V5.502.

33. Salman, J. M.; N. A. Abd-Al-Hussein, and O. A. H. Al-Hashimi. 2015. Assessment of water quality of Hilla river for drinking water purpose by Canadian index (CCME-WQI). IJRSR, 6 (2): 2746-2749.

34. Sharplrey, A. 2005. Managing Phosphorus Agriculture and the Environmental. College of Science, the Pennsylvania State University. pp:8.

35. Shraddha, S., V. Rakesh, D. Savita, and J. Praveen. 2011. Evaluation of water quality of Narmada River with reference to physcochemical parameters at Hoshangabad city, MP, India. Res. J. Chem. Sci., 1 (3): 40-48.

36. Shrimali, M. and K. P. Singh. 2001. New methods of nitrate removal from water. Environ. Pollut. 112 (3): 9-351.

37. Philips, S., H. J. Laanbroek, W. Verstraete. 2002. Origin, causes and effects of increased nitrite concentrations in aquatic environments. Reviews in Environmental Science and Biotechnology, 1 (2): 115-141.
38. UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften and Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut. pp.1-12.
39. Van Vliet, M. T. H., F. Ludwing, J. J. G. Zwolsman, G. P. Weedon. and P. Kabat, 2011.
40. Global river temperatures and sensitivity to atmospheric warming and changes in river flow. Water Resour. Res., 47 (2) W02544: 1-19. DOI:10.1029/ 2010WR009198.
41. Wetzel, R. G. 2001. Limnology, Lake and River Ecology (3rd ed.). San Diego, Academic Press. pp: 729.
42. WHO (World Health Organization). 1996. Guidelines for Drininking Water Quality. 2nd ed. Vol.2. Health criteria and other supporting information, Geneva. PP:973.
43. WHO and UNCIF. 2000. Global Water Supply and Sanitation Assessment 2000 Report. USA. pp: 77.