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Water quality assessment of Diyala river in Diyala province, Iraq

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Abstract

Water quality of natural lotic systems became important due to the water scarcity in most regions. This study conducted to assessment of water quality of the Diyala river as one of the Tigris river tributaries for the period from for four seasons. Three sites were selected along the river and eight environmental factors were chosen for this purpose as follow: water temperature, pH, total dissolved solids, dissolved oxygen, biochemical oxygen demands, total alkalinity, total phosphorus and total nitrogen. The results showed that the river water quality ranged from poor to marginal for the protection of aquatic life.

Key words: Lotic system, Diyala river, Water quality index, physicochemical parameters

Introduction

The freshwater is the most important for different human being activities such as drinking water, irrigation and also other ecosystems operations [1,2]. Its quality is important for environmental sustainability [3]. All Agra-industrial activities build on the banks of the river in addition to municipal discharge along the river through its passing from upstream and downstream [4]. The most important risk is the water scarcity, this problem is obisvely severed the Iraqi rivers the several years and expected to continue after the building, a huge number of dams in the upstream of Iraqi in Turkey and Iran [5].

Water quality refers to the water charchterized feature such as physical, chemical and biological, these character features are requirements to the life of organisms or to human use or needs which is related toenvironmental health [6]. The mostlimited environmental factors on water quality are dissolved oxygen, biochemical oxygen demands, total alkalinity, total hardness, pH, total dissolved solids and temperature [7]. The simple way to assessment of water quality is using the water quality index (WQI). These WQI explained the data collected for measurement of physicochemical parameters of the water body to obtain the degree of water quality assessment [8]. There are many types of indices such as; Oregon water quality index (OWQI), national sanitation foundation's water quality (NSF-WQI), heavy metals pollution index (HMPI) and Canadian water quality guideline-water quality index (CCME-WQI) [9, 10, 11; 12]. The CCM-WQI is one of filxable WQI used the different parameter to assess the water quality to different purpose and give a general perception of the health of water and its suitability for human uses [13]. This index used three formulas to calculate scope, frequency and amplitude of the selected parameters and obtain the degree of water quality from 0 to 100[14; 15]. The CCM-WQI was applied in different regions. Lumb et al. [10] used the idex to assesst the Mackenzie river in Canada. Hoseinzadeh et al. [16]used the CCM-WQI to evaluate the Aydughmush river in Iran. In Iraq, many authors applied the index in Tigris river and Euphrates river [17, 18,19].The Diyala river is one of the tributaries of the Tigris river and the main water source in Diyala province. This work aimed to assess the water quality of Diyal river for the protection of aquatic life.

Materials and Methods

The Diyala river flows from the Zagros mountains in Iran and continue it flows through the Diyala province before join with the Tigris river at the south of Baghdad city. The total length of the river is 443 km and its drain an area of 32,600 km^2 [20]. The climate of the Diyala province is arid or semi arid [21] and mean annual rainfall is 420 to 36 ℃ in terms of annual mean. Three dams controlled their flow in Iraq. These dams as flows; Derbendikhan, Hemrin and Diyala Weir [22] The study sites selected along the Diyala river (Fig. 1 and Table 1). The site 1 is represented the upstream and the site 2 located at the center of Baquba city while the site 3 represented the downstream of the river. The water temperature (WT) measured by mercury thermometer, pH-meter used for pH and TDS meter for total dissolved solids (TDS). The dissolved oxygen (DO), biochemical oxygen demands (BOD), total alkalinity (TK), total nitrogen (TN) and total phosphorus (TP) were determined following APHA [23].

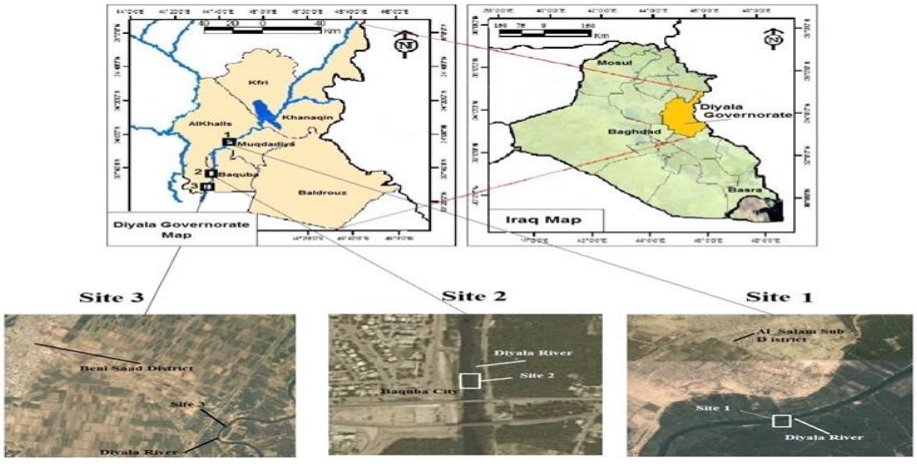

Fig. 1: The study sites map and satellite images for each site

Table 1. The geographical positions (GPS) of the sampling sites

Sites	Longitude (eastwards)	Latitudes (northward)
1	44° 43' 17"	33°55'07"
2	44° 37' 53"	33°44' 44"
3	44° 35' 01"	33°32' 58"

WQI was calculated according the formula of CCM-WQI (24) 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)

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

3.Amplitude (F_3)

3-1. Excursion: there are two cases:

a. If the parameter data above the standard value used the following formula

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

b. If the data less than the standard value the following formula used:

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

3.2. NSE

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

3.3. Calculting F_3

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

4. The WQI was calculated by the following formula:

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

The WQI is represented the CCM-WQI.

The values of WQI were matched with water quality ranks in table 2.

Table 2. The WQI ranks of water quality

CCME WQI values	Ranks
100-95	Excellent
94-80	Good
79-60	Fair
59-45	Marginal
44-0	Poor

Statistical Analysis

The statistical analysis system [25] was used for statistical analysis.

Results and discussion

The water temperature is important in water quality and the distribution of organism in an aquatic ecosystem in addition to its role in many metabolism and other transformation in a water body [26]. The lowest value of WT was 11℃ in the winter at site 1 while the highest value was 28.9℃ in the summer at site 2 (Table 3 and Fig. 2). These variations in WT between sessions are well known in Iraqi climate that it's characterized by the hot desert climate [2, 27]. A negative significant correlation noticed between WT and DO ($P<0.05$). The Iraqi aquatic systems is characterized by its high buffer capacity due to their carbonate contents [28]. pH values ranged from 7.89 to 8.40. TDS is represented the values of inorganic and organic dissolved materials [29]. TDS values ranged from 440mg/l at site 1 in the autumn to 1376 mg/l at site3 in the summer. Gupta et al. [30] reported that the TSS has an impact on the other water physicochemical parameter. A significant correlation noticed between TDS and TN ($r=0.676$, $P<0.05$). DO concentration in an aquatic ecosystem is important to water quality, organism life andcontrol many chemical transitions [26]. TA is an indicator of the carbonates and bicarbonate content in water [23, 31]. TA values ranged 105.2-212.7mg/l in the autumn and the winter, respectively.

Table 3.Mean ± SD of the selected environmental parameter during the study period from October 2016 to June 2017.

Parameter	Site 1	Site2	Site3
Water temperature℃	19.42± 3.26 a	20.80 ±3.68 a	18.60 ± 3.64 a
pH	7.85± 0.09 a	7.97 ± 0.08 a	8.10± 0.17 a
Total alkalinity	166.51 ± 21.45 a	163.92 ± 11.01 a	124.35 ± 6.85b
TDS mg/l	859.80±a 179.75	776.50±135.54 b	766.57± 124.62b
DO mg/l	8.05 ± 0.96 a	7.25 ± 1.25 a	8.02 ±0.55 a
BOD mg/l	1.185 ± 0.16 b	1.550 ± 0.13 a	1.187 ± 0.22 b
Total Nitrogen µg/l	21.17 ± 1.31 a	19.83 ± 1.42 a	20.67 ± 2.01 a
Total Phosphours µg/l	0.024 ± 0.002 a	0.025 ± 0.003 a	0.0195 ± 0.005 a

Different letters within each row indicate a significantdifferencebetweenthe samples ($p<0.05$).

The high values of TA in winter might be related to the rainfall, which it leads to scrape and remove basal ions from the river banks [32]. The DO concentration in this study was not recorded anoxia condition, and

ranged from 4.2 mg/l in the summer to 10.4 mg/l in the winter (Fig. 2). The less concentration of DO in the summer caused by high temperature value which it accelerated the organic decomposition processes [33]. BOD values were less than 2 mg/l during all the study period (Fig 2). Arimoro et al. [34] explained that the high value of BOD caused by the decrease in the water level in the river and the high decomposition processes by microbial organism due to the elevation of temperature.Nitrogen exists in an aquatic ecosystem as inorganic form and organic form the best represented the all nitrogen forms are total nitrogen [35]. The results of TN showed lowest concentration (17.2 µg/l) in the winter at site 2 while the highest concentration (26.6 µg/l) was recorded in the summer at site 1. Phosphorus exists in the environment as inorganic and inorganic forms, also as dissolved or particulate [23]. TP concentrations ranged from 0.007 µg/l in the summer at site 1 to 0.036 µg/l in the winter at site2 (Fig. 2). The highest concentration was due to the watering the soil containing phosphorus compounds on both banks into the river [36]. WQI values at site 1 ranged from 44.5 in the autumn to 58.0 in the winter. For other sites were ranged as follows: 43.8-53.2 and 44.8- 52.8 at sites 2 and 3in the autumn and the summer (for site2) and in the autumn and the spring (site3), respectively (Fig. 3). The river WQI ranged from 43.8 to 58 and the statistical analysis showed a nonsignificant difference between seasons except in the winter and there was no significant difference between sites ($P< 0.05$) (Table 4). These results of WQI of the Diyala river indicated to the poor to marginal ranks. The Iraqi river's water quality ranged from poor to marginal, this indicated the deterioration of these river quality due to the lack of awareness to protect these rivers and their tributaries.

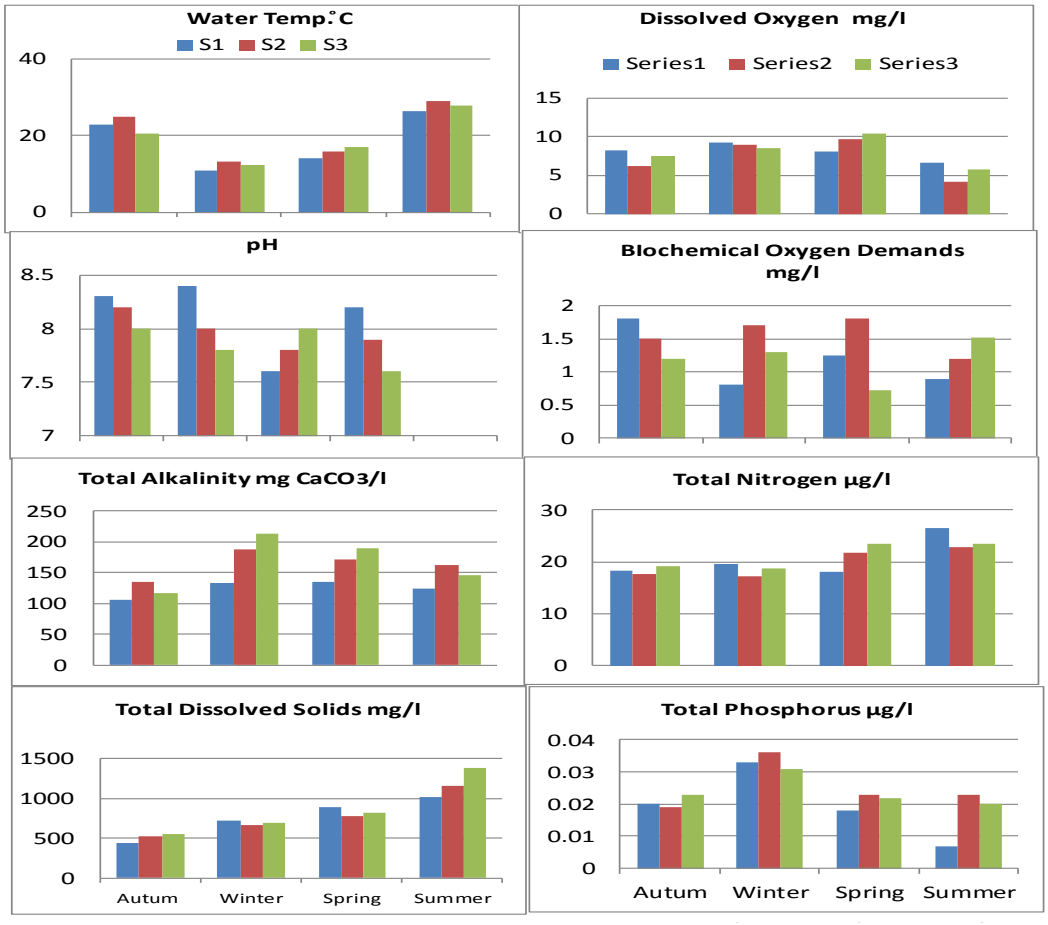

Fig. 2: Seasonal variation of some studied parameters during the studied period from October 2016 to June 2017.

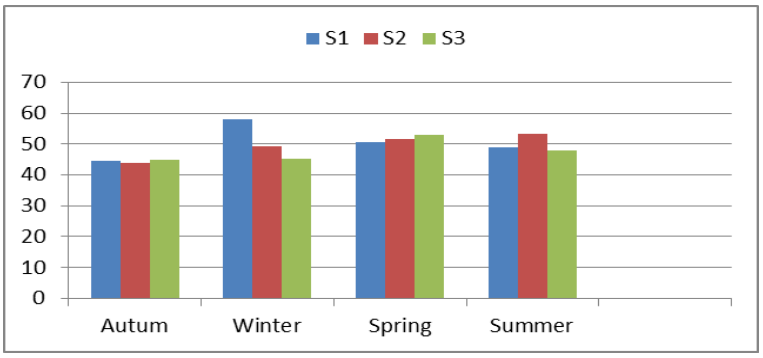

Fig. 3:Seasonal variation of mean value of WQI for aquatic protection in Diyala river during the study period from October 2016 to June 2017.

Table 4.WQI values in all sites during the study period

Season	Sites			LSD value
	S1	S2	S3	
Autumn	44.5±2.37	43.8±2.25	44.8±2.16	4.618 NS
Winter	58.0±3.09	49.4±2.51	45.1±2.40	6.783*
Spring	50.6±2.15	51.7±2.66	52.8±2.71	4.438NS
Summer	48.9±1.98	53.2±2.27	48.0±2.64	5.356NS
LSD value	6.461*	5.958*	5.693*	
NS,(P<0.05)*:No significant				

Table 5 illustrated the values of WQI for the Euphrates river and The Tigris river in many regions in Iraq. The study results agree with [12, 29] studies on the Tigris river, also with a few studies on the Euphrates river [2, 37, 38, 39, 40]. The results of WQI in this study were resulted due to the deviation of the data of the studied parameters from standard guide of the index (table 6).

Table 5. Comparison of WQI values in different Iraq's river

River	CWQI Value	Reference
Tiger River	Marginal to poor for drinking water, 40.3-58.4 Fair to marginal for aquatic life, 47-71.8 Good to marginal for irrigation, 53.8- 93.9	29
Euphrates River	Marginal for irrigation purposes, 47- 67.9	40
Tigris River	Marginal to poor for aquatic life	12
Diwanyiah River	Marginal to poor for aquatic life, 30-48	2
Mahrut River	Marginal for irrigation purposes, 43.545.1	9
Al-Gharraf River	Poor for aquatic life, 30-39 and Marginal for irrigation purposes, 38-39	38
Shatt Al-Arab	Poor for irrigation and marginal for aquatic life	39
Kuffa River	Fair to good for aquatic life	37
Diyala River	Poor to marginal for aquatic life	Present study

Table 6. The standard guide of environmental study in the CCM-WQI.

Parameters	CCME guideline
Water Temp.(°C)	15
pH	6.5- 9
Total Alkalinity mg CaCO3/l	>20
TDS mg/l	500
DO mg/l	5.5- 9
BOD5 mg/l	<3
Total Nitrogen µg/l	1
Total Phosphorµg/l	0.05

Conclusion:

The water quality of the Diyala river ranged from poor to marginal ranks. There were no temporal and spatial a significant difference except in the winter.

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