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Assessment of the Water Quality Index of the Tigris River between the University of Baghdad and Diyala River

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K E Y W O R D S

Discharge
Heavy Metals
Standard Specifications
Tigris River
Water Quality Index.

A B S T R A C T

The Tigris River is considered as one of the two major rivers in Iraq. Many factories are located on both bank of the river such as the public company for soft drinks, Al-Dura oil refinery, chemical, plastic, and leather factories, Dura electricity station, and others. It is well known that most discharge effluents into the river do not match national standard specifications. In addition, the major aim of the presented work is to assess the Water Quality Index (WQI) for the Tigris River starting from The University of Baghdad to 0.5 km downflow the confluence of the Diyala River. The samples were collected during a six months period; one sample each month for fifteen locations along the Tigris River. Different parameters were studied to calculate the water quality index: Total Dissolved Solids (TDS), NO_3, Heavy Metals (Cadmium, Chromium, Lead, Zinc), and pH. The water quality index with regard to such samples is ranging between (58.24 and 160.66) and classified between poor to unfit.

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1. Introduction

Worldwide, there is a growing focus that water is going to be the major essential natural resources in the upcoming years. Also, the scarcity of water is growing globally, where the pressure on current water recourses is increased because of the growing requirements in many sectors including hydropower generation, agriculture, industrial, and so on. Thus, the evaluation regarding the quality of water in many nations is essential recently **[1]**.

The water quality is specified with regard to its biological, chemical, as well as physical parameters, also determining that its quality was significant prior to usage for different tasks including recreational, agricultural, potable, industrial water usage, and so on. **[2]**. In addition, it has been evaluated by means of various parameters for indicating their levels of pollution. There is a possibility that any water sample is going to show different contamination levels in terms of many tested parameters **[3]**.

WQI is considered one of the arithmetical tools utilized for performing large quantity of water quality data in a single cumulatively derived number. Also, it is representing specific water quality levels, whereas removing the quality's subjective assessments **[4-5]**. It provides a major idea regarding water quality in specific regions.

The benefit related to WQI, along with getting required data as well as information is to determine the status or general health related to a system. WQI is one of the efficient tools to assess spatial and temporal changes in water quality and communicate information about water quality with concerned citizens and policymakers **[6-7]**.

WQI was described by many researchers, Khalid, **[8]** presented the index for evaluating the groundwater's quality for drinking purposes in Samarra and Tikrit Cities. Sirajudeen, **[9]** used WQI for the same purpose to assess Tamil Nadu and Pondicherry, India, Sunita, **[10]** assessment regarding WQI of groundwater in Smalkhan, Haryana. Mohend, **[11]** studied WQI to evaluate groundwater quality in Green- Belt Area North of Najaf AL-Ashraf City. Abdul Hameed **[12]** evaluated raw as well as treated water quality of the Tigris River within Baghdad through index analysis. WQI is utilized in various nations for assessing the water such as the USA **[13]**, UK **[14]**, Canada **[15]**, India **[16]**, and Egypt as well **[17]**.

The goal of the presented work is an assessment of the Tigris River starting from the University of Baghdad to 0.5 km downflow the confluence of Diyala River using WQI.

2. Materials and Methods

I. Study Area

The case study extends from Jadiriyah to the confluence of Tigris-Diyala Rivers, having latitudes 33°16'-33°12' N and longitudes 44°22'-44°30' E, as shown in Figure 1, and Table I.

II. Field Work

For the purpose of research, the study area was divided into 15 sites. Water samples were collected using a manual pump and a clean polyethylene container for the period between January and June. Also, the samples have been analyzed as soon as possible for physical and chemical parameters.
Different parameters were studied: Total Dissolved Solids (TDS), NO_3, Heavy Metals (Cadmium, Chromium, Lead, Zinc), pH, and Temperature. The analysis was accomplished according to the standard method **[19]**. Detailed of the methods are listed in Table II. The average results of physio-chemical parameters for six months are shown in Table III.

Figure 1: Site location within the study area

Table I: Numbers of studied sites

Site Number	Site Location
1	Baghdad university
2	Wastewater Treatment plant
3	Dura electricity Plant
4	before Oil Refinery
5	After Oil Refinery
6	Oils factory
7	South Baghdad gas station
8	Leather factory
9	Before the industrial region
10	Pepsi Factory
11	Chemical and plastics Factory
12	After the industrial Region
13	End of Tigris River
14	the confluence of the Diyala River
15	After confluence of the Diyala River

Table II: Methods of analysis

Parameter	Methods
pH	4500-H+B
EC	2510-B
TDS	2540-C
Temperature	2550 B
NO_3	4500
Cd, Cr,Pb, Zn	4500-P E

Table III: Average results of laboratory tests for six months.

N.	PH	T.D.S mg/l	EC µm/cm	NO_3 mg/l	Cd µg/l	Cr µg/l	Pb µg/l	Zn µg/l
1	7.18	302	472	22.27	4.9	9.85	35	5.88
2	7.12	314	489	10.5	0.68	3.55	25.4	9.05
3	7.15	315	493	13.73	3.56	16.4	19.4	4.4
4	7.16	314	491	19	4.21	6.9	26.8	4
5	7.15	314	491	13.38	2.98	28.9	27.8	2.86
6	7.06	345	539	31.8	3.16	0	12.9	3.7
7	7.09	327	511	28	3.08	0	13.9	3

8	7.15	314	490	27	3.28	0	12.9	2.55
9	7.2	311	486	22	2.21	0	9.94	2.55
10	7.2	311	469	7.06	5.56	0	8.95	2.2
11	7.13	311	484	8.27	4.22	0	8.95	2.1
12	7.18	313	484	10	2.15	0	13.9	1.5
13	7.14	318	497	8.47	2.72	0	7.95	2.11
14	7.11	334	522	19.86	2	0	10.9	2.36
15	7.13	309	483	21.6	2.3	7.6	15.4	2.3

3. Calculation of Water Quality Index (WQI)

Weighted arithmetic index approach was used to calculate WQI.

1- Unit weight (wi) for each parameter was estimated through the next formula suggested by **[16]**:

$$wi = \frac{K}{Si} \qquad (1)$$

Where:

K= constant of proportionality:

$$\mathrm{K} = \frac{1}{\sum_{j=0}^{n} \frac{1}{\mathrm{Si}}}$$

Si=permissible limit for each one of the parameters.

n=number of the parameter.

2- Quality rating (Qi) was calculated as,

$$Qi = \frac{100Vi}{Si} \qquad (2)$$

Where:

Vi= value related to water quality parameter acquired from laboratory analysis.

The quality rating for pH(QpH) was calculated based on:

$$QpH = 100\left[\frac{Vi - S}{Si - S}\right] \ if\ pH>7$$

$$QpH = 100\left[\frac{S - Vi}{Si - S}\right] \ if\ pH<7$$

Where

S: represents the ideal value regarding pH which is equal to (7.00).

Si: represents the value regarding water quality parameter which is equal to (8.5).

3- Water Quality Index (WQI):

$$WQI=\sum Wi\ Qi \qquad (3)$$

Based on WQI, water quality has been classified into five types according to **[16]** as shown in Table IV.

Table IV: Water quality index scale [16]

WQI Value	0-25	26-50	51-75	76-100	> 100
Water Quality	Excellent	Good	Poor	Very Poor	Unsuitable

According to Iraqi standard limits for drinking water **[18]**, WQI and relative weights (Wi) for each one of the parameters have been calculated as shown in Tables V and VI.

Table V: Relative weight (Wi) for the WQI parameters

Parameters	Limits (Si) (ICOSQ, 2009)	1/Si	K	Relative Weight (Wi)
pH	8.5	0.117647	1.68737	0.19851
TDS (mg/l)	1000	0.001		0.00168
EC (µmohs/cm)	1500	0.00066		0.00112
NO_3 (mg/l)	50	0.02		0.03375
Cd (µg/l)	3	0.333		0.56246
Cr (µg/l)	50	0.02		0.03375
Pb (µg/l)	10	0.1		0.168737
Zn (µg/l)	3000	0.00033		0.000562
		∑= 0.592637		∑ = 1.000569

Table VI: WQI for all sites

parameter	Wi Qi P9	Wi Qi P10	Wi Qi P11	Wi Qi P12	Wi Qi P13	Wi Qi P14	Wi Qi P15
pH	2.6461	2.6461	1.72108	2.38212	1.8520	1.45507	1.72108
TDS (mg/l)	0.05224	0.052248	0.05258	0.05258	0.05342	0.056112	0.051912
EC (µm/cm)	0.03628	0.035022	0.03613	0.03613	0.037105	0.038976	0.03606
NO_3 (mg/l)	1.485	0.47655	0.55822	0.675	0.571725	1.34055	1.458
Cd (µg/l)	41.4364	105.928	79.1842	40.3115	144.737	37.4992	43.1238
Cr (µg/l)	0	0	0	0	0	0	0.513
Pb (µg/l)	16.755	15.1019	15.1019	23.4544	13.4145	18.3923	25.9854
Zn (µg/l)	0.00004	0.00004	0.00004	0.00002	0.00003	0.00004	0.00004
	∑62.41	∑124.23	∑96.65	∑66.91	∑160.66	∑58.78	∑72.88

Class	poor	unfit	very poor	poor	Unfit	poor	poor

parameter	Wi Qi P1	Wi Qi P2	Wi Qi P3	Wi Qi P4	Wi Qi P5	Wi Qi P6	Wi Qi P7	Wi Qi P8
pH	2.38	1.58808	1.9851	2.1181	1.9851	0.7940	1.19106	1.9851
TDS (mg/l)	0.050736	0.0527	0.05292	0.05275	0.05275	0.05796	0.05493	0.05275
EC (µm/cm)	0.035246	0.03651	0.03681	0.03666	0.03666	0.04024	0.03815	0.03659
NO_3 (mg/l)	1.503225	0.70875	0.926775	1.2825	0.9315	2.1465	1.89	1.8225
Cd (µg/l)	91.86659	12.7509	66.7471	78.9316	55.8691	59.2439	57.7477	61.49375
Cr (µg/l)	0.66487	0.2396	1.107	0.46575	0.20115	0	0	0
Pb (µg/l)	59.05795	42.8591	32.7349	45.2215	46.9088	21.7670	23.4544	21.7670
Zn (µg/l)	0.00011	0.000169	0.000082	0.00007	0.00005	0.000069	0.00005	0.00004
	∑155.55	∑58.24	∑103.59	∑128.11	∑105.98	∑84.05	∑84.37	∑87.16
Class	unfit	poor	unfit	unfit	unfit	very poor	very poor	very poor

4. RESULTS AND DISCUSSION

WQI has been plotted in Fig(2). The value of WQI for all sites ranged between (58.24-160.66) and classified as poor to unfit. The value of WQI for sites (2,9,12,14, and 15) was categorized as poor and should not be used without treatment. The remaining sites (1,3,4,5,6,7,8,10,11, and 13) ranged between very poor and unfit due to the increase of concentration of pollutants such as cadmium and lead, this is reflecting the impact of anthropogenic activities as well as urban wastes

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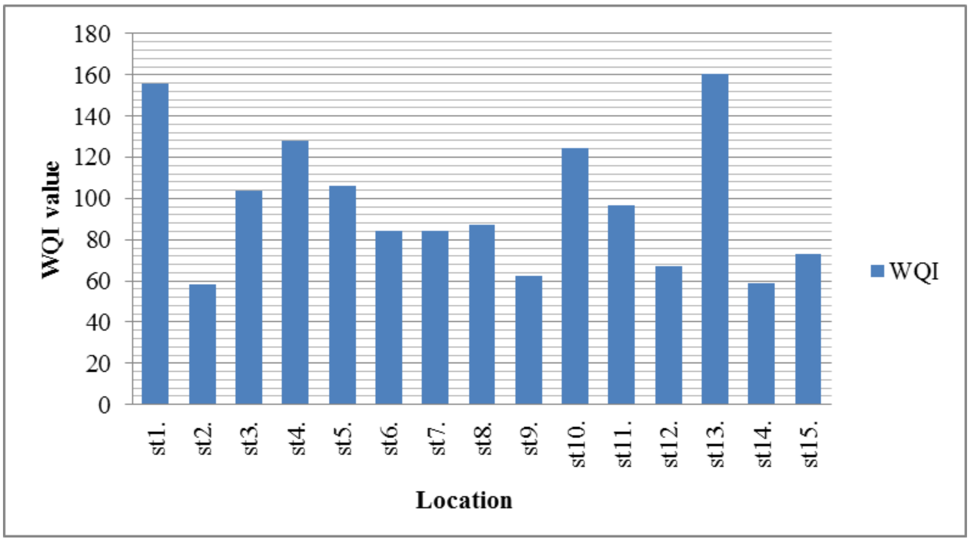

Figure 2: WQI for specified sites

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