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Water quality assessment using A Novel Iraqi water quality index for Euphrates River between Karbala and Babylon provinces as a case study

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Abstract

Many parts of the world are facing water scarcity problems due to the limitation of water resources coinciding with the increasing population. Rivers are vital freshwater systems that are critical for the sustenance of life. This work deals with the monitoring and assessment of water quality of the Euphrates River between Karbala and Babylon provinces from ten sites near the discharge of industrial facilities, drainage of agricultural lands, wastewater and other facilities, samples were taken monthly and the results were converted into four seasons, it's divided into two seasons (dry- wet). Various physico-chemical and microbial analyses were performed based on standard methods. The following parameters were measured (pH, EC,BOD, DO,WATERTEM, TDS, TOTAL COLIFORM, TH, SO4, NO3, CL, Na, PO4, RSC, SAR, SSP, MH, B,NO2 and Mg). By using A Novel Iraqi water quality index that fits the Iraqi aquatic systems and reflects the environmental reality of Iraqi water, the developed IWQI includes above components, The results showed that the water quality of the Euphrates River in the studied sites are ranged from (poor - very poor) for fresh water. As for the suitability of the water for agriculture and living for aquatic organisms, and its suitability for drinking, the results for the sites ranged from (good - unsuitable) during the wet and dry seasons. Based on these indices, it is concluded that industrial facilities, city wastewater and intensive communities that live along the river bank are negatively affecting the water quality of rivers.

Keywords: Euphrates River, Novel Iraqi Water Quality Index (NIWQI), Physico-Chemical and biological Parameters, surface water quality, water pollution.

Introduction

Many parts of the world are facing water scarcity problems due to the limitation of water resources coinciding with a growing population [1]. Fresh water is a finite resource, essential for agriculture, industry and even human existence, without fresh water of adequate quantity and quality, sustainable development will not be possible [2] .Rivers play a major role in the assimilation or carrying off of municipal and industrial wastewater and runoff from agricultural land; the former constitutes the constant polluting source, whereas the latter is a seasonal phenomenon [3]. With the rapid development in agriculture, mining, urbanization, and industrialization activities, river water contamination with hazardous waste and wastewater is becoming a common phenomenon [4,5]. In Iraq, the Euphrates and

Tigris rivers constitute the most important riverine system; these resources are polluted by increased human activities, illegal sewage, and industrial waste disposal, which affect the physicochemical and microbiological quality of the water [6]. This may cause a decline in river water quality and thus it is necessary to monitor the water quality to assess its problem and cause [7]. Due to its excellent characteristics, the Euphrates River basin has been a significant source of water supplies for numerous uses and offers fertile soil that permits the development of densely inhabited residential areas where, along rivers and estuaries, human communities and enterprises have historically been concentrated [8]. The improper management of water systems may cause serious problems with the availability and quality of water. since water quality and human health are closely related [9]. Therefore; evaluation of surface water quality is crucial because it can be one of the main channels for the spread of hazardous substances and pathogenic microbes [10].

The most official method of maintaining surface water in Iraq is to assess the concentration of impurities in a river's flow; this process produces high-quality water that may satiate the requirements for drinking, agriculture, aquatic life, and industrial use by eliminating or decreasing pollutants as much as feasible [11,12]. The assessment of water quality can be conducted through the use of the water quality index (WQI) model, which primarily depends on the physicochemical and biological parameters of water, to monitor and control the quality of water intended for human consumption [13,14]. There are many international and Iraqi indices to assess water quality and its suitability for use [12]. However, the novel IWQI was used because it includes several uses at the same time, measures the environmental risk index of water if it exceeds the permissible limit of Iraqi standards, and reflects the environmental reality of Iraqi water [15].

A novel WQI was developed in 2020 by a team of Iraqi experts to assess the suitability of rivers for different uses, which included both the quality and the degree of pollution. The second index is called the Environmental Risk Index (ERI), where only the variables that exceed the permissible environmental limits are included. Therefore; it is essential to regularly evaluate the river's water quality in order to determine its suitability for various uses and to detect pollution as soon as possible so that the appropriate authorities can take the necessary action [16]. The study aims to assess water quality by using A Novel WQI for ten sites located on the Euphrates River between the Babylon and Karbala governorates near the discharge of different facilities to determine the suitability of water for the uses of the novel index.

Materials and Methods

Hydrology and climate of the study area

The average annual flow of the river is variable, reaching its peak in April and May as the winter mountain precipitation melts. The typical decreasing water season occurs from July to December, reaching its lowest in August and September when water is most needed to irrigate the region's winter crops and the occurrence of summer evaporation [17]. In general, the climate in the study regions has been a typical desert in the last few years. Some areas are characterized by arid to semi-arid climates. The summer months are hot and dry while moderately cold and wet in winter. The spring and autumn seasons are relatively short and characterized by a moderate temperature. Rainfall is very limited and concentrated in winter months [18].Euphrates River passes through many towns and villages along the river study region and most industrial institutions and factories are located on both banks of the river. Thus, it represents the main source for different uses such as water supply systems, irrigation, and industrial purposes. The nature of land surrounding the river is a farming area, with some buildings and factories [19].

Study Area

When the Euphrates River enters the province of Babylon in the city of Musayyib and after flowing for a distance, al-Hussayinia and western stream branch out from it, and it's considered the two main feeders of the Karbala province, then the river continues to flow until it branches into two main rivers, Shatt al-Hilla and al-Hindiya River. Al-Hindiya River contains al-Hindiya dam. Ten sites were chosen for conducting the study within two governorates near factories, hospitals, and fish

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breeding sites, as well as sewage waste and agricultural irregularities, all of which are thrown into Euphrates River, which is the lifeblood of these governorates. Then it continues to flow until it enters the Najaf province in al-Kifil region [11,20,21] table.1 illustrate the sites studied during two seasons wet and dry.

Global Positioning System (GPS)

The Global Positioning System (GPS), originally NAVSTAR GPS, is a satellite-based radio navigation system It is one of the global navigation Satellite Systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites [22]. The GPS does not need the user to transmit any data, and it operates independently of any mobile or internet reception; it is freely accessible to anyone [23]. Table 1 represents the Global Positioning System for the sites.

Table 1. The Geographical Positions System (GPS) of the study site

Site no.	Site name	Province	Distance between provinces km2	longitude	Latitude
S1	Cement factory discharge	Babylon	-	44.267365	32.739251
S2	Electrical Power station	Babylon	17	44.269642	32.842315
S3	Silk factory discharge	Babylon	14	44.272600	32.752490
S4	Beginning Hussaynia river	Karbala	8	44.270216	32.746007
S5	Beginning western stream	Karbala	7.41	44.265201	32.735884
S6	Trocar drainage collection	Karbala	9.3	44.235705	32.643055
S7	Al-Hindyia hospital	Karbala	8.1	44.217486	32.551447
S8	Old al-Hindyia bridge	Karbala	5.3	44.222340	32.547172
S9	Karbala refinery station	Karbala	15	44.23609	32.529428
S10	Modern al-Hindyia bridge	Karbala	5.9	44.250024	32.509011

A Geographic Information System (GIS)

Is a system of computer software, hardware and data, as well as personnel that makes it possible to enter, manipulate, analyze, and present data, and the information that is tied to a location on the earth's surface. This system comprises of Software, Hardware, Data, and Personnel that make it possible to enter, manipulate, analyze and present information that is tied to a location on the earth's surface. This software was used to locate selected sites on the Euphrates River [24]. Fig. 1 shows the location map for the study area.

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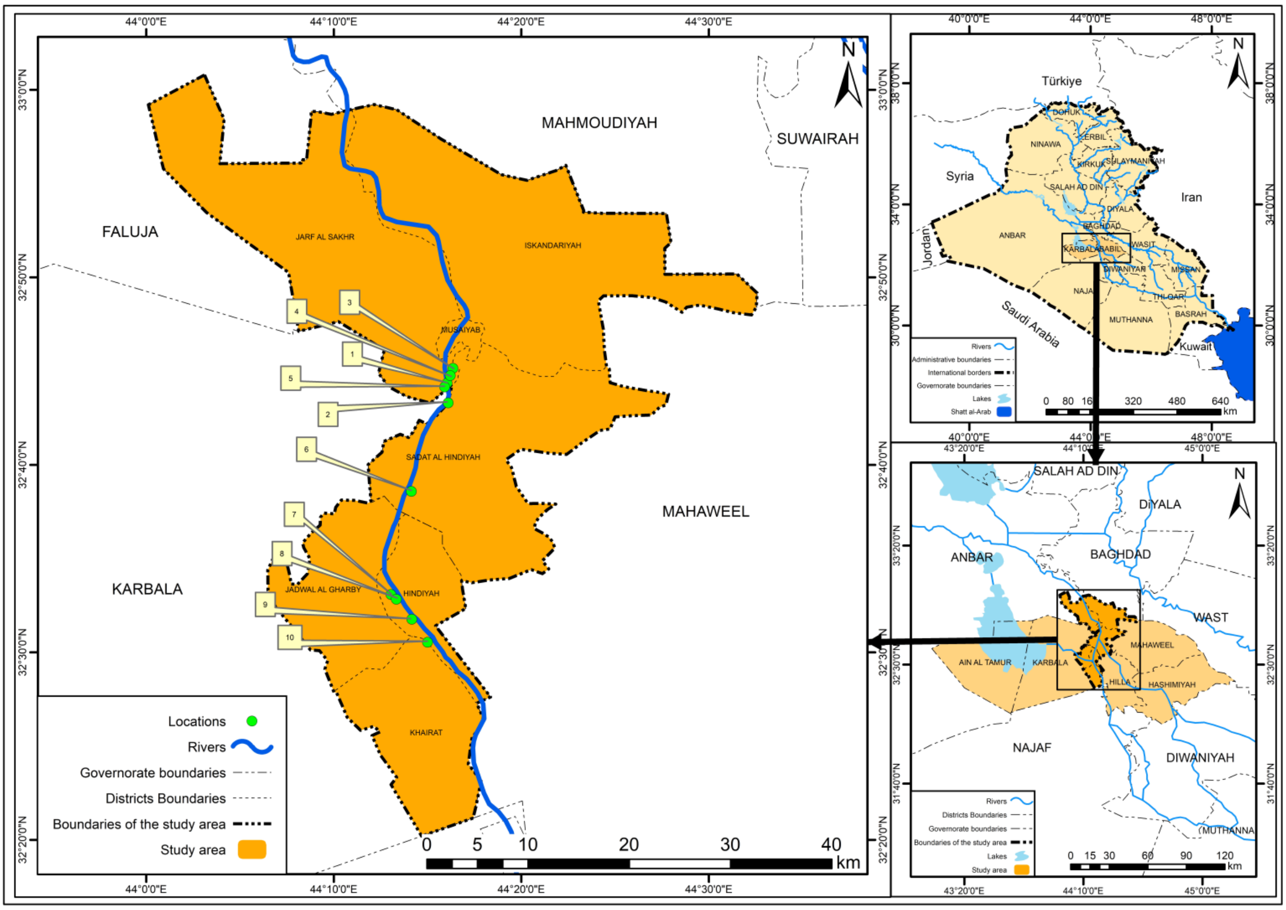

Figure 1. showing the Location of the study area and sampling sites by using GIS.

The study methodology

Fig. 2: illustrates the study methodology; it explains the work from selecting sites to extracting the final water quality result.

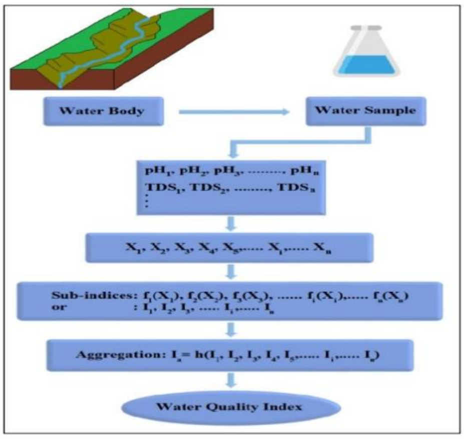

Figure 2. The schematic diagram for research methodology

Sampling of Surface Water

Water samples were taken from each site, Each sample was collected from the subsurface (about 30 cm below the surface) in clean stopper-fitted polyethylene bottles. Before filling the bottles with the required sample, they were rinsed in river water several times. Temperature, pH, EC and TDS measurements by PH meter were taken at the site, and the samples were preserved in an ice-cool box until they were taken to the laboratory and subjected to physicochemical and biological analyses. Laboratory measurements were conducted 24 hours after sampling at the Karbala Environment Directorate -Iraq. Field and laboratory measurements were carried out according to [16,25]

Water Quality Index (WQI)

In this study, one equation was used to evaluate the quality of surface water intended for consumption and irrigation, this is classified into five different

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suitability classes Fig. 3-6 illustrate it. Equation abides by the parameters proposed by the World Health Organization Iraqi Ministry of Environment.

In the present research, the WQI was calculated using 20 hydrochemical parameters: PH, EC, TDS, TEM, DO, BOD, NO3,PO4, CL, TH, Mg, Na, NO2, B, SO4, RSC, SAR, MH, SSP and Total Coliform. There were three processes involved in calculating WQI. Table 2 shows the use of Iraqi classification.

First, each hydrochemical measure was allocated a weight based on its relative relevance to the overall quality of drinking and irrigation water. Where each parameter was given its own weight, so that the weight of all parameters does not exceed 1[26] . Steps two involves calculating:

$$\text{final Wi} = \frac{\text{tW}}{\sum \text{tW}} \qquad 1$$

Where tW= temporary weight. It should be considered that the total final weight (the summation of all weights of parameters) is 1.0 for WQIs.

$$\text{SIi} = \text{finalwight} \times \text{Qi} \qquad 2$$

$$\text{Qi} = \frac{\text{Ci}-\text{Cidea}}{\text{si}-\text{Cideal}} \times 100 \text{ for pH and DO} \qquad 3$$

$$\text{Qi} = \frac{\text{Ci}}{\text{Si}} \times 100 \text{ for other parameter} \qquad 4$$

SIi= the sub-index of ith parameter; Qi= quality rating based on the concentration of ith parameter; Ci= is the observed value of the nth parameter; Si= is the standard value of the nth parameter; Ci deal for DO= 14.6; Ci deal for pH=7; Wi= final Wight.

$$\textit{Novel}\ \text{IraqiWQI} = \sum \frac{\text{SIi}}{\text{Wi}} \qquad 5$$

Table 2. showing the Categorization of (Novel IWQI)

Novel Iraqi Water Quality Rating		
WQI value	**Rating**	
0-25	**Excellent**	**Blue**
26-50	**Good**	**Green**
51-75	**Poor**	**Yellow**
76-100	**very poor**	**Orange**
Above 100	**Unsuitable**	**Red**

Parameters	Mean Rating Returned by Respondents	Temporary Wights	Final Weight	observed value	Iraqi rivers maintaini	Qi=[Ci/Si]*100	SIi=RW*Qi	IWQI=∑SIi/Final Weight
DO	4.170	5.000	0.352	11.2	5.00	35.417	12.452	83.13
(BOD)	3.880	1.075	0.076	3.7	5.000	74.000	5.592	
pH (6.5-8.5)	3.880	1.075	0.076	6.15	7.50	-170.000	-12.848	
PO4	3.700	1.127	0.079	0.023	0.40	5.750	0.456	
NO_3^-	3.650	1.142	0.080	2.1595	15.00	14.397	1.157	
Cl^-	3.460	1.205	0.085	460.6225	200.00	230.311	19.518	
SO_4^{-2}	3.260	1.279	0.090	334.8415	200.00	167.421	15.059	
B	3.450	1.209	0.085	1.4975	1.00	149.750	12.728	
TDS	3.760	1.109	0.0780	1860	500.00	372.000	29.011	
		14.2211	1.000					

Water Quality Rating		
WQI value	Rating	
0-25	Excellent	Blue
26-50	Good	Green
51-75	poor	Yellow
76-100	very poor	Orange
Above 100	unsutabil	Red

Figure 3. showing NIWQI for fresh water

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Parameters	Mean Rating Returned by Respondents	Temporary Wights	final weight	Qi=[Ci/Si]*100	Sii=RW*QI	observed value	CCMEaquatic standard	IWQI=∑SIi/Final Weight
DO	4.69	5	0.366311	46.259	16.945	11.2	7.250	168.796
pH	4.15	1.130120482	0.0827951	-113.333	-9.383	6.15	7.75	
WT	4.04	1.160891089	0.0850494	53.5714	4.556	28	15	
PO4	3.81	1.230971129	0.0901837	23	2.074	0.023	0.1	
NO3	3.77	1.24403183	0.0911405	16.6115	1.514	2.1595	13	
Cl-	3.65	1.284931507	0.0941369	104.249	9.814	260.623	250	
NO_2^-	3.65	1.284931507	0.0941369	1141.67	107.473	0.685	0.06	
TDS	3.57	1.31372549	0.0962464	372	35.804	1860	500	
sum		13.64960303	1.00000		168.796			

Water Quality Rating		
WQI value	Rating	
0-25	Excellent	Blue
26-50	Good	Green
51-75	poor	Yellow
76-100	very poor	Orange
Above 100	unsutabil	Red

Figure 4. showing NIWQI for aquatic life

Parameters	Mean Rating Returned by Respondents	Temporary Wights	final weight	Qi=[Ci/Si]*100	Sii=RW*QI	observed value	Agricultural guideline	IWQI=∑SIi/Final Weight
SAR	4.42	5	0.3665	37.72	13.82	6.79	18	-156.305
pH (6.5-8.4)	3.86	1.14507772	0.0839	-188.89	-15.85	6.15	7.45	
RSC	3.75	1.178666667	0.0864	-2420.00	-209.06	-60.5	2.5	
SSP	3.75	1.178666667	0.0864	41.80	3.61	16.71922	40	
Cl^-	3.7	1.194594595	0.0876	260.62	22.82	260.6225	100	
TDS	3.62	1.220994475	0.0895	82.67	7.40	1860	2250	
MH	3.33	1.327327327	0.0973	74.24	7.22	37.12	50	
SO4	3.16	1.398734177	0.1025	133.94	13.73	334.8415	250	
		13.64406163	1.0000					

Water Quality Rating		
WQI value	Rating	
0-25	Excellent	Blue
26-50	Good	Green
51-75	poor	Yellow
76-100	very poor	Orange
Above 100	unsutabil	Red

Figure 5. showing NIWQI for agricultural

Parameters	Mean Rating Returned by Respondents	Temporary Wights	final weight	Qi=[Ci/Si]*100	Sii=RW*QI	observed value	Raw Drinking guideline	IWQI=∑SIi/Final Weight
BOD	4.6	5	0.3267	61.67	20.15	3.7	6.00	49.139
TDS	4.4	1.045454545	0.0683	124.00	8.47	1860	1500.00	
pH (5.5-9)	4.3	1.069767442	0.0699	-340.00	-23.77	6.15	7.25	
Total Coliforms (MPN/100 ml)	4.1	1.12195122	0.0733	16.48	1.21	824	5000.00	
TH	4.1	1.12195122	0.0733	112.60	8.25	563	500.00	
NO_3^-	4.1	1.12195122	0.0733	4.88	0.36	2.1595	44.27	
Cl^-	4	1.15	0.0751	104.25	7.83	260.62	250.00	
Mg^{2+}	3.9	1.179487179	0.0771	139.33	10.74	209	150.00	
Na+	3.9	1.179487179	0.0771	57.00	4.39	114	200.00	
SO4	3.5	1.314285714	0.0859	133.94	11.50	334.84	250.00	
		15.30433572	1.0000					

Water Quality Rating		
WQI value	Rating	
0-25	Excellent	Blue
26-50	Good	Green
51-75	poor	Yellow
76-100	very poor	Orange
Above 100	unsutabil	Red

Figure 6. showing NIWQI for raw drinking water

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Results and Discussion

Site no.	1	2	3	4	5	6	7	8	9	10
PH	7.75	7	7.1	7.35	7.65	7.4	7.9	7.25	7.4	7.7
EC (㎲/cm	2435	2440	2645	2545	2530	2650	2465	2500	2570	2575
TDS (mg/l)	1190	1215	1320	1265	1300	1315	1230	1300	1365	1435
TEM W ©	21.25	19.85	18.95	19.3	19.45	19	20.05	20.15	19.9	18.7
DO mg/l	11.6	10.8	12.1	10.3	10.1	11	10.65	10.9	11.35	8.75
BOD mg/l	5.3	3.4	4.8	5.5	3.4	5.9	4.35	3.6	5.25	2.3
NO3 mg/l	1.3865	1.994	0.9675	2.1585	2.0525	2.5485	1.4175	1.7865	1.8945	1.4045
PO4 mg/l	0.02115	0.0225	0.085	0.119	0.157	0.18	0.035	0.0635	0.292	0.021
CL mg/l	99.003	135.1055	90.697	130.387	116.6945	125.927	120.803	147.6255	123.9835	118.997
TH mg/l	682.5	683.5	548	582	581.5	952.5	640	679	686.5	677
Mg mg/l	202	264	243.5	227.5	209.5	375.5	235.5	297	267	254
Na mg/l	80.905	83.4	87.7	92.23	100.75	124.5	95.4	105.9	98.3	110.6
NO2 mg/l	0.07	0.011	0.066	0.062	0.087	0.126	0.0335	0.079	0.0567	0.0395
B mg/l	0.875	1.204	2.0155	1.423	1.3515	2.0345	1.7475	1.425	1.11	0.7535
SO4 mg/l	474.575	438.415	467.53	446.03	467.745	528.415	465.735	496.93	478.555	516.47
RSC (MEQ/L	-31.93	-33.36	-25.32	-25.21	-25.4	-48.94	-30.08	-31.5	-30.22	-31.28
SAR meq/l	0.78	0.79	0.91	0.94	1.04	0.99	0.93	0.99	0.92	1.05
MH (meq/l)	40.94	50.93	56.87	51.42	48.15	51.77	48.98	56.18	51.21	49.75
SSP	10.53512	10.81151	13.6935	13.58661	14.66414	11.50328	12.88058	13.40676	12.44383	13.9488
T.Coliform MPN/100ml	250	205	320	485	445	1600	1600	1600	1260	730

Figure 7. the results for wet season (2022-2023)

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Site no.	1	2	3	4	5	6	7	8	9	10
PH	6.3	6.95	6.8	6.25	6.35	6.45	6.2	6	6.6	6.15
EC (ms/cm	2580	2575	2550	2515	2505	2525	2370	2325	2675	2425
TDS (mg/l)	1290	1280	1275	1260	1255	1260	1160	1230	1320	1860
TEM W ©	28.15	28.35	28.85	27.35	27.1	28.3	29.05	30.25	28	28
DO mg/l	6.45	9.25	10.25	7.3	7.15	11.25	10.1	9.65	9.5	11.2
BOD mg/l	1.5	2	5.1	1.55	1.7	5.85	4.9	2	1.9	3.7
NO3 mg/l	2.1745	2.322	2.2785	2.074	2.0305	3.547	2.5575	4.0545	2.2835	2.1595
PO4 mg/l	0.027	0.19115	0.15865	0.471	0.243	1.978	0.0915	1.39795	1.571	0.023
CL mg/l	74.4445	79.408	90.3265	105.215	228.504	70.5615	103.2995	82.016	170.6615	260.6225
TH mg/l	606	758	590	602	658	755	721	599.5	683.5	563
Mg mg/l	134	383.5	130	184	272	232	274	209.5	190	209
Na mg/l	101.9	116.35	102.6	100.95	102.4	86.95	104.9	88.5	101	114
NO2 mg/l	0.0735	0.099	0.269	0.147	0.297	0.482	0.563	0.5145	0.5615	0.685
B mg/l	1.573	1.519	1.212	2.7225	1.5155	3.863	1.4775	1.989	1.903	1.4975
SO4 mg/l	715.34	355.32	359.08	438.04	410.76	326.63	386.005	414.005	421.214	334.8415
RSC (MEQ/L	-22.71	-37.58	-21.85	-7.27	-28.58	-30.66	-30.14	-24.29	-55	-60.5
SAR meq/l	1.07	1.01	0.03	1.48	0.98	0.8	0.96	0.9	5.46	6.79
MH (meq/l)	31.89	62.81	31.79	86.34	53.75	42.25	50.33	46.97	27.8	37.12
SSP	14.29574	13.22084	14.70757	14.26049	13.37863	10.27231	12.64846	12.78809	12.79048	16.71922
T.Coliform MPN/100ml	910	545	910	1260	975	1600	1600	1600	865	824

Figure 8. the results for dry season (2022)

Table 3. describe NIWQI of fresh water for wet season (2022-2023)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	83.03178	75.19568	82.71318	90.27494	93.39846	99.98239	96.19914	85.97788	90.18432	93.70617
Rating	v.poor	Poor	v.poor	v.poor	v.poor	v.poor	v.poor	v.poor	v.poor	v.poor

Table 4. describe NIWQI of aquatic life for wet season (2022-2023)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	69.73113	58.99362	67.81884	83.13693	84.86005	96.91501	73.61593	77.48792	94.52554	84.88446
Rating	Poor	Poor	Poor	v.poor	v.poor	v.poor	Poor	v.poor	v.poor	v.poor

Table 5. describe NIWQI of agricultural for wet season (2022-2023)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	51.65528	66.4774	37.38999	30.99514	26.42578	109.1543	38.38366	49.87024	46.53212	42.89772
Rating	Poor	Poor	Good	Good	Good	Unsuitable	Good	good	Good	Good

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Table 6. describe NIWQI of raw drinking water for wet season (2022-2023)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	98.62495	70.5972	78.28418	89.57979	86.3468	112.0587	101.821	85.95715	95.88483	88.48965
Rating	v.poor	Poor	v.poor	v.poor	v.poor	Unsuitable	Unsuitable	v.poor	v.poor	v.poor

Table 7. describe NIWQI of fresh water for dry season (2022)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	92.0507	79.11159	75.14482	95.13526	86.54292	124.0522	67.36554	94.08996	110.7904	83.12522
Rating	v.poor	v.poor	Poor	v.poor	v.poor	Unsuitable	Poor	v.poor	Unsuitable	v.poor

Table 8. describe NIWQI of aquatic life for dry season (2022)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	80.54856	92.63974	109.9476	127.9769	137.3595	298.5365	142.5828	254.25	288.7692	168.7963
Rating	v.poor	v.poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable

Table 9. describe NIWQI of agricultural for dry season (2022)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	39.07613	87.04317	42.10533	15.9687	53.69574	79.55144	75.10273	59.80082	140.7841	156.3048
Rating	Good	v.poor	Good	Excellent	Poor	v.poor	Poor	Poor	Unsuitable	Unsuitable

Table 10. describe NIWQI of raw drinking water for dry season (2022)

Site no.	1	2	3	4	5	6	7	8	9	10
Result	42.67134	66.3983	64.02892	35.77863	47.11044	64.82827	57.42091	31.19965	50.09342	49.13856
Rating	Good	Poor	Poor	Good	Good	Poor	Poor	good	Good	Good

Variation the parameters of water

Seasonal variations of water quality characteristics for the 10 studied sites on the Euphrates River between Babylon and Karbala governorates are illustrated in Table1.

Figs. 7 and 8 show the descriptions of water parameter values. The pH values at all stations and seasons ranged between 8.7 the maximum value for site 1 in winter, and 5.7 in sites 8 and 10 in the summer season and the site 2 in the autumn season. the high temperatures in summer cause high decomposition by organisms present in the water; however, lower solubility of CO2 in higher temperatures can neutralize it [7,27] and increase the percentage of pollutants disposed from nearby sites. Rising temperatures influence the chemical, biological, and physical reactions that occur in the water. Furthermore, the low temperature reduces the solubility of gases in water, such as oxygen [13]. During the study period, the maximum temperatures were 36℃, as the temperature for summer season exceeded the limits of the Iraqi standard, while the rest of the season was within the requirements of the Iraqi standard.

With higher DO concentrations, BOD5 at 20°C is between high and low due to the high oxygen demand by microorganisms. The BOD5 concentrations of the collected water samples at all stations were within the range of 1mg/l at site 5 in the wet season and at site 1 in the dry season and the maximum range was 7.8 in the site 7 in the dry season mg/L. The high BOD5 level indicates the

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presence of excessive bacteria/microorganisms in the water, which might come from industrial and domestic wastewater that consumed the dissolved oxygen and increased biochemical oxygen demand in the river water [14]

Dissolved Solids in natural water are usually composed of sulfate, bicarbonate and chloride of calcium, magnesium and sodium. The result showed that TDS value was in the permissible level recommended by the IWQI for drinking water, but higher than the permissible level recommended at site 10 in the dry season. Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage [9].

Total coliform (TC) bacteria were determined using LURYL Briefly, 500 µL of a 1:10 diluted sample was put in the tube and incubated at 37 °C for 24 h. The average colony counts were expressed as CFU/1 mL [10]. Is 150 MPN/100 ml in site 1 in the winter, and the maximum value is >1600 in most sites. The reason for the presence of coliforms is due to the pollution of the river water from the sewage and from the neighboring agricultural lands [28].

The high values of total hardness were recorded in January which ranged between 464 mg.CaCO3.l-1 in the site 3 in the wet season and 990 mg/l in the site 6 in the dry season .Increased hardness may be due to increased water discharge from nearby areas [29], as well as the impact of human activity and sewage on the river and soil texture, and hardness is attributed to the consumption of carbon by the photosynthetic organisms [30]. As well as increasing the growth of aquatic plants, which in turn draw magnesium and calcium ions and some important salts, thereby reducing the hardness value [31]. Magnesium recorded high values in site 6 in wet season which range 480 mg/l this was being directly affected by excreta from land near the river, especially waste containing magnesium ions and the decomposition of organisms containing magnesium [30]. And low value 52 mg/l in site 1 in wet season.

Chloride occurs naturally in all types of freshwater, usually in low concentration. The value of chloride in the river in all sites and seasons within the range allowed in Iraqi waters, where it was less than 250 mg/l , which is quite low in comparison to the permissible level for aquatic organisms [32]. In the current study, we observed spatial changes in sulfate ion concentration and all ranged outside the permissible range of Iraqi water. The reason for this rise is due to the chemical content of Iraq's groundwater, which is mainly determined by four positive ions – calcium, magnesium, sodium, and potassium – and four negative ions – bicarbonate, carbonate, chloride, and sulfate and the reason for the high concentration of sulphates is also attributed to the discharge of factories, agricultural lands and sewage water [33,34]. the problem of boron pollution of the surface water by the changes in the boron content in environmental objects (surface) from wastewater discharges from enterprises of the chemical, industries and agricultural. . As a result of the study, the maximum concentration of boron in dry season, where all sites exceeded the permissible limit of 1 mg/l. but in wet season all site the wet season, all sites fall within the allowable concentration [35].

Nutrients (nitrate and phosphate and nitrite) are important, as living microorganisms need them for physiological processes. However, they are considered contaminants when their concentrations exceed the allowed limit. In this study, nitrate and phosphate values were well below the permissible limit of Iraqi water ranged [36].

The results of Na values are within the permissible limits of the Iraqi standards for drinking water (not exceeding 200 mg/L) and not classified as parameters responsible for water quality deterioration [37]. Predicting the effects of SAR, RSC, SSP and MH is considered essential for river water quality, irrigation and agriculture. The concentration of SAR,RSC,SSP and MH in the river can be influenced by many physicochemical parameters, including the rate of discharge of water into the river and many other processes occurring, in addition, increased values in the water quality of irrigation lead to the undesirability of water, which directly affects crops [38].

Water quality index

Several water quality indices were developed to assess water situation in the world, in Iraq many international indices were used to determine the suitability of water for drinking, irrigation and other uses, they showed discrepancy in the WQI results due to the different variables used and the weights adopted in each index such as in the following studies [39] , the water quality index model (WQIM) was calculated after modifying the weighted arithmetic method to define as MWQI. The chosen parameters were comprised of Cl, SO4, HCO3, NO3, Na, K, Ca, Mg, T.H., TDS, and EC. And it is considered a new Iraqi index. and the study of Kareem SL, et al., [40] assesses Shatt Al-Kufa water quality as one branch of the Euphrates River by calculating three types of water quality indices in two cases, excluding and including the phosphate (PO4) concentration, as it was the parameter that most met the standard. The used water quality indices are the Weight Arithmetic Water Quality Index (WAWQI), the Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) and the Oregon Water Quality Index (OWQI) in this study using world indices were used and the study of Ewaid SH,et al., [12] was to create the Iraqi Water Quality Index (Iraq WQI) by applying the authors' experience, modified Delphi technique, and principal components analysis, taking into account the Iraqi water quality standards by constructing the curves of the water quality parameters. This index is to be used in monitoring and comparing the water quality of Iraqi rivers and lakes for drinking purposes, and to observe the changes for better management of water resources.

But in our study we used A Novel IWQI showed high efficiency with the possibility of relying on a specific number of parameters that were chosen by water quality experts. Also, the index merges the quality and pollution indices, where Novel IQWQI is linked with ERI to eliminate the eclipse effect in WQI [26]. Finally, the proposed model allowed the Iraqi Water Quality Index (IQWQI) user to eliminate any parameter from the index only in case the final weight did not fall below 0.7. Sensitivity analysis using artificial neural network regression (ANNR), can produce a more reliable and accurate output of prediction of the Novel IWQI than backward linear regression (BLR) [16]. And it's shown in table 2: the table describes each color and number of the suitability of water for any of its uses, Twenty water quality parameters were measured during the study period and used for calculating the Novel IWQI that is used for protecting Euphrates River, Variations of parameters have the results (excellent-unsuitable) rating for raw drinking water, agricultural water, aquatic life and fresh water). TDS, EC and sulphates are the most parameters that exceed the limit and have an effect on the rating for NIWQI. Although all sites obtained varying extent ratings but most of them were very poor, which follows the water parameters distribution and their concentration during the two seasons dry and wet, Figs. 3, 4, 5 and, 6: represent some examples to illustrate how to use A Novel IWQI. Tables 3 -10: shows the description of water quality parameters values that used for assessment the studied sites in Euphrates River.

Conclusion

Using water quality indices for particular consumption is considered a simple method for the primary recognition of river water quality. The use of the index of water quality will not only allow the assessment of changes in water quality over time and space but also evaluate the successes and shortcomings of domestic policy and international treaties designed to protect aquatic resources.

The discharge of pollutant water into the river can pose an environmental risk to the organisms living in surface water and effect the water's chemical composition. Notwithstanding, this impact is strongly connected to the river water flow rate and the volume of the discharged pollutant water. One of the methods which provide the possibility to assess this impact is to compare the results of physico-chemical analyses of water samples collected near water discharge points in two seasons. The results obtained in both locations can be easily compared. However, this comparison may prove when many different parameters are measured. Thus, the calculation of appropriate indices can be a good alternative. Ecological indices are also useful to indicate long-term changes in water chemical status

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and to assess the impact of hazardous objects on water quality. The application of Novel IWQI allows for merging the quality and pollution indices, so we can know the suitability of water for any of the following uses (raw drinking water, agricultural water, aquatic life, and freshwater).

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Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at University of Baghdad.

Author's Contribution

B.M. K. and J.S. A. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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تقييم نوعية المياه باستخدام مؤشر جودة المياه العراقي الجديد لنهر الفرات بين محافظتي كربلاء وبابل كدراسة حالة

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الخلاصة

تواجه أجزاء كثيرة من العالم مشاكل ندرة المياه بسبب محدودية الموارد المائية تزامنا مع تزايد عدد السكان. الأنهار هي أنظمة حيوية للمياه العذبة والتي تعتبر بالغة الأهمية لاستمرار الحياة. يتناول هذا العمل مراقبة وتقييم نوعية مياه نهر الفرات بين محافظتي كربلاء وبابل لعشرة مواقع بالقرب من تصريف المنشآت الصناعية وتصريف الأراضي الزراعية ومياه الصرف الصحي ومرافق اخرى ، وتم أخذ العينات شهرياً ومن ثم تحويل النتائج إلى موسمين (جاف – رطب). تم إجراء العديد من التحاليل الفيزيائية والكيميائية والميكروبية بناءً على الطرق القياسية. تم قياس المعلمات التالية (الدالة الحامضية, المتطلب البايلوجي للاوكسجين, الأوكسجين المذاب, درجة حرارة الماء,القولونيات الكلية, العسرة الكلية, الكبريتات, النترات, الكلورايد, الصوديوم, الفوسفات, كاربونات الصوديوم المتبقية, نسبة امتزاز الصوديوم, نسبة الصوديوم المذابة, خطورة المغنيسيوم, البورون, النتريت والمغنيسيوم). وباستخدام مؤشر جودة المياه العراقي الجديد الذي يتناسب مع النظم المائية العراقية ويعكس الواقع البيئي للمياه العراقية، يتضمن مؤشر IWQI الجديد المكونات المذكورة أعلاه، وأظهرت النتائج أن نوعية مياه نهر الفرات في المواقع المدروسة تراوحت بين (رديئة - سيئة للغاية) بالنسبة للمياه العذبة أما بالنسبة لملائمة المياه للزراعة والحياة المائية والشرب فقد تراوحت بين (جيد – غير صالح) خلال المواسم الرطبة والجافة. وبناء على هذه النتائج نستنتج أن المنشآت الصناعية ومياه الصرف الصحي في المدن والمجتمعات الكثيفة التي تعيش على طول ضفة النهر تؤثر سلبا على نوعية مياه النهر.

الكلمات المفتاحية: نهر الفرات، نوعية المياه السطحية، مؤشر جودة المياه العراقي الجديد، المعلمات الفيزيائية الكيميائية والبايلوجية، تلوث المياه.