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Spatial variations of water quality in Al-Hilla River, Babil Province, Iraq

iD **Sajad A. Abdullah**
College of Education, Qurna University of Basrah, Basrah, Iraq
*Corresponding Author: e-mail *sajadabd1964@gamil.com*

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Abstract -The study was conducted to explain the variations of ten variables of WQI in four stations at Al-Hilla River which is the major branch of the Euphrates River, and located in the middle of Babylon Province. It extends for 101 km long. Water samples were collected from the river from June 2016 to May 2017. Ten of the physicochemical parameters were analyzed; dissolved oxygen, total dissolved solids, electrical conductivity, the potential of hydrogen, calcium, magnesium, nitrates, phosphates, turbidity and total alkalinity. The range of water quality index values of Al-Hilla River is 48.63 was recorded at station 1, the values indicate good water quality to very poor (85.67) at station 4, according to weighted arithmetic. The results indicated that there were significant differences between the first and fourth stations. The results values of WQI were 56.61 and 82.81 at stations 2 and 3 which indicate poor at station 2 and very poor status at station 3, respectively. The values of water quality index within turbidity ranged from 133.7 at station 1 to 192.04 at station 4 and the results values of WQI were 206.39 and 156.30 at stations 2 and 3. Significant ($P<0.05$) relationships were noted in the water quality index among the stations.

التغيرات المكانية لنوعية المياه في نـهر الحلة بمحافظة بابل- العراق

سجاد عبد الغني عبد الله
كلية تربية القرنة، جامعة البصرة، البصرة - العراق

المستخلص - أجريت دراسة الاختلافات الشهرية لعشرة عوامل فيزيائية وكيميائية وذلك لتقييم نوعية المياه لأربع محطات في نهر الحلة، الفرع الرئيس لنهر الفرات والذي يمتد بطول 101 كم وسط محافظة بابل. جُمعت عينات المياه بواقع عينة شهرياً من حزيران 2016 إلى آيار 2017 ، إذ قيست عشرة متغيرات بيئية وهي الأوكسجين الذائب والمواد الصلبة الذائبة الكلية والتوصيلية الكهربائية والأس الهيدروجيني والكالسيوم والمغنسيوم والنترات والفوسفات والعكارة فضلاً عن القاعدية الكلية. تراوحت قيمة دليل نوعية المياه بدون قيم العكارة بين 48.63 والتي تشير إلى مستوى جيد في المحطة الأولى وفقير جدا 85.76 في المحطة الرابعة، بينما تراوحت القيم 56.61 و 82.81 أذ بينت أنها فقيرة في المحطة الثانية وفقيرة جداً في المحطة الثالثة على التوالي. وكان مدى قيم دليل نوعية المياه مع قيم العكارة المستحصلة في الدراسة هي 133.7 في المحطة الأولى و 192.04 في المحطة الرابعة بينما أُشرت القيم في المحطتين الثانية والثالثة 206.39 و 156.30 حسب الترتيب. أشارت قيم دليل نوعية المياه إلى تأثير العوامل البيئية وتغاير قيمها والتي من خلاها يمكن مراقبة المسطحات المائية.

الكلمات المفتاحية: تغيرات مكانية، نوعية مياه، نهر الحلة.

Introduction

Rivers are one of the most disturbing ecosystems that caused by different human activities, such as drinking, cooking, industry, agriculture and recreation, these have significant effects in the river fauna activities (Jayalakshmi *et al.,* 2011). River water usually is of the highest quality in its headwater reaches, becoming dirtier along its length as it passes through different land uses and used for a diversity of purposes (Kotti *et al.,* 2005).

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Deterioration of river water quality is caused by various points and unknown sources (Carpenter *et al.,* 1998). For a long time, as a result of regard to watercourses as a mere physical way of taking water and not a biological system, only river structure was restored and not the river function (Swanson and Sparks, 1990). Nowadays this situation seems to be changing with an increasing interest in river restoration studies (Oscoz *et al.,* 2005).

The nature and level of water pollution are characterized by several physicals, chemical and biological parameters (Chitmanat and Traichaiyaporn, 2010). Human discharges represent a constant polluting source, whereas surface runoff is a seasonal phenomenon, largely affected by different climatic conditions (Divya Raj and Mophin Kani, 2018). The information on water quality is an important target for the implementation of sustainable water usage for management strategies (Bu *et al*., 2010). The problem of particular in the case of water quality monitoring is the complexity associated with analyzing a large number of measured variables and high variability due to anthropogenic and natural influences in ecology (Simeonov *et al.,* 2002).

In some cases, water quality index values allow for identifying pollution variables, consequently for recommending preventive action in the aquatic ecosystem (Srivastava *et al*., 2011). Many of researchers have studied the water bodies of Iraq, such as Abdullah *et al.* (2019a) in their study on the Euphrates River, Al-Janabi *et al.* (2012) during the evaluation of the water in the Tigris River and Iraqi southern marshes by Al-Saad *et al.* (2010), as well as the study of Abdullah *et al.* (2019b) on the Al-Kahlaa River. The objective of the study is to assess the water quality based on physiochemical parameters as well as monitoring it during 12 months for the year 2016 to 2017.

Materials and Methods

The study was conducted at Al-Hilla River, the main branch of the Euphrates River in the middle of Al-Hilla province, which is 101 km in length (Al-Hasnawi and Maitham, 2018). Four stations were selected to evaluate the suitability of the water for drinking purposes according to the Standard Specification of Iraq (2001), Standard Specification of Iraq (2009) and WHO (2008). A GPS manufactured in Taiwan was used to define the study area in Al-Hilla River (Table 1, Fig. 1).

Table 1. Sampling stations coordinates at Al-Hilla River.

Sampling station code	Latitude (N)	Longitude (E)
St. 1	32˚35'13"	44˚22'02"
St. 2	32˚33'59"	44˚23'47"
St. 3	32˚28'31"	44˚26'23"
St. 4	32˚23'19"	44˚32'36"

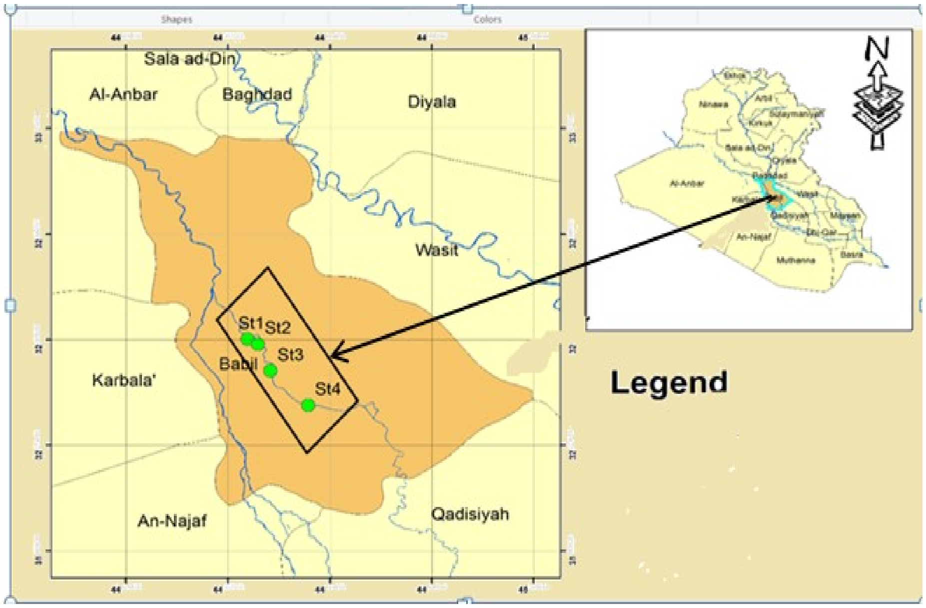

Figure 1. Map of the sampling stations location in Al-Hilla River.

Water samples were collected from the middle of the river from June 2016 to May 2017, one sample per station. Ten parameters were measured; dissolved oxygen (DO) was determined according to Welch (1964) and the results are expressed in (mg/l), total dissolved solids (TDS) in (mg/l) and electrical conductivity (EC) in (µS/cm) and potential of hydrogen (pH) are reported in pH units were measured with a Hanna instrument (a waterproof HI-9146 pH/EC/TDS and temperature). The values of calcium (Ca^{+2}) and magnesium (Mg^{+2}) were estimated by Ethylenediaminetetraacetic acid (EDTA) titration and the results are expressed in (mg/l) (Lind, 1979). Nitrates (NO_3) and phosphates (PO_4) were measured according to Parsons *et al*. (1984) and are reported in (mg/l). Turbidity was estimated with a turbidity meter HI-93703C and reported in nephelometric turbidity units (NTU). Total alkalinity was determined according to APHA (2005), and the results are expressed in (mg/l).

Calculation of the WQI:

The water quality index for Al-Hilla River was calculated according to the following Equation (Horton, 1965 ; Cude, 2001):

$$WQI = \sum_{i=1}^{n} \frac{Wi * Qi}{\sum_{i=1}^{n} Wi}$$

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

$$Qi = \frac{(Mi - l\ )}{(Si - l\ )} \ *100$$

Where the weightage unit (Wi) of each variable was calculated as a value inversely proportional to the water quality limit of the WHO, and (Qi) is the sub index of the variables, and (li) is the ideal value and (Si) is the standard limit of the parameter. The ideal value of pH = 7, dissolved oxygen (DO)=14.6 mg/l and for other parameters, it is equal to zero (Chowdhury *et al.,* 2012; Ewaid and Abed, 2017). The values of WQI were listed in Table (2).

Table 2. WQ status level according to Horton (1965) and Cude (2001).

The range of water quality	Water quality status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
>100	Unsuitable

Results

Physicochemical Properties:

The monthly and seasonal variations of the parameters features for WQI were examined in the four stations during the duration of the study are shown in Tables (3, 4 and 5). The range values of dissolved oxygen (DO) was from 5.7 mg/l in July at station 4 to 10.5 mg/l in December at station 1, with annual mean of 7.7 mg/l, the results showed that there were no significant differences ($P>0.05$) in the DO rates of the stations but it differed between seasons. The dissolved oxygen (DO) was negatively correlated with TDS and EC (r = - 0.623, r = - 0.900) at the levels of 0.05 and 0.01, respectively. The total dissolved solids (TDS) values varied from 401 mg/l in February at station 1 to 998 mg/l in August at station 4 with an average 554.95 mg/l during the study period, the results indicated that there were significant differences ($P<0.05$) between station 4 and the rest of stations. In the seasons, the rate of values ranged from 505.17 in Winter to the 614.17 in summer, on the other hand, there was a difference in the values between the seasons at three stations.

The lowest values of electrical conductivity (EC) and hydrogen ion (pH) (690 µS/cm, 6.8) occurred in March and July at station 1, whereas the highest (1700 µS/cm, 8.9) was recorded in August and February at stations 4 and 3 with a mean value of 929.5 and 7.87 µS/cm, respectively. The seasonal values of EC varied from 890 µS/cm in Winter to 990 µS/cm in Summer, on the other hand, the values of pH ranged from 7.60 in summer to 8.30 in Spring. Significant differences ($P<0.05$) in the values were observed between the seasons both for EC and the pH.

Hydrogen ion was weakly positively correlated with DO (r = 0.356) and negatively with TDS and EC (r = -0.702, r = -0.700). The minimum values of Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) (98 mg/l, 10.4 mg/l) were recorded at station 1 during January and November. The present results showed high concentrations of Ca^{+2} and Mg^{+2} (210 mg/l, 142 mg/l) at stations 4 and 1 in August and April with average values of 198.9 mg/l and 108.9 mg/l, respectively, Ca^{+2} and Mg^{+2} were negatively correlated with DO (r = -0.634, r = -0.418), whereas positively correlations were observed with TDS (r = 0.848, r = 0.442) and EC (r = 0.378, r = 465) at the level 0.05 and 0.01, respectively. Seasonally, the lowest Ca^{+2} and Mg^{+2} values (101.33 mg/l, 27.24 mg/l) were recorded in Winter and Autumn at station 1 and the highest (206.67 mg/l, 116.93 mg/l) in Summer and Spring at station 4, respectively. The values of Ca^{+2} in the study area varied from 153.88 mg/l in Spring to 184.42 mg/l in Summer. The range of Mg^{+2} from 73.31 mg/l in Winter to 112.88 mg/l in Spring (Table 4), there were significant differences ($P<0.05$) in the values at different seasons among stations 1, 2 and the other stations.

The concentrations of nitrates (NO_3) and phosphate (PO_4) varied from the lowest values (0.68 mg/l, 0.029 mg/l) at station 3 and 2 during October and August to the highest values (17.8 mg/l, 1.98 mg/l) were recorded at station 4 in February and December with mean value of all the stations (5.87 mg/l, 0.58 mg/l) (Table 3), on the other hand, the seasonal values of NO_3 and PO_4 varied from 1.7 mg/l, 0.08 mg/l in Summer at stations 3 and 2 to 14.7 mg/l, 2.95 mg/l in Winter and Spring at station 4, respectively. Moreover, the values of NO_3 ranged from 2 mg/l in Summer to 14 mg/l in Winter and the values of PO_4 varied from 0.11 mg/l in Summer to 1.25 mg/l in winter (Table 4). There were significant differences in the values of all stations, while the results of total nitrate (NO_3) and phosphate (PO_4) were exhibited a strong positive correlation with dissolved oxygen (r = 0.784, r = 0.937) and negatively correlated with TDS and EC (Table 5) at the level 0.05 and 0.01, respectively.

Alkalinity values were always within the alkaline direction ranged from 96 mg/l at station 2 in February to 197 mg/l at station 4 in March with an annual mean value of 129.88 mg/l. The seasonal values of alkalinity was ranging from 123.16 mg/l in Winter to 159.20 mg/l in Summer. The results showed significant negative correlations (r= -0.779, r = -0.633, r = -0.779, r = -0.504, r = -0.689) among alkalinity and turbidity, phosphates, nitrate, hydrogen ion and dissolved oxygen, whereas positive correlations with Calcium and total dissolved solids (r = 0.772, r = 0.657), respectively were obtained in Table (5).

Table 3. Statistical analysis of ten parameters at Al-Hilla River from June 2016 to May 2017.

	St. 1		St. 2		St. 3		St. 4		Annual
Variables	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Mean
DO	7-10.5	8.6	6.2-8.7	7.5	6-9.5	7.6	5.7-9.3	7.4	7.7
TDS	401-595	486.8	422-568	521	525-657	575	558-998	637	554.95
EC	690-860	751	740-890	811	830-970	898	1000-1700	1258	929.5
pH	6.8-8.3	7.4	7.4-8.9	8	7.5-8.8	8	7.2-8.7	8	7.85
Ca^{+2}	98-180	137.33	110-190	149.83	170-201	190.16	185-210	198.9	169.05
Mg^{+2}	10.4-142	63.7	61.9-134.9	86.31	54.7-133.7	103	59.20-130	108.93	90.48
NO_3	1.1-15.11	5.2	1.3-14.8	5.88	0.68-16.9	5.86	0.99-17.8	6.55	5.87
PO_4	0.06-1.32	0.506	0.029-0.84	0.327	0.059-1.85	0.65	0.03-1.98	0.873	0.58
Turbidity	3.24-43.5	19	4.1-75.7	32	3.44-57.87	18.53	6.5-31.5	25	23.62
Alkalinity	110-182	138	96-175	131	100-170	135.54	153-197	115	129.88

Table 4. Seasonal variations of parameters at Al-Hilla River from 2016 to 2017.

Variables	Summer	Autumn	Winter	Spring
DO	6.28	7.94	9.10	7.49
TDS	614.17	579.67	505.17	522.58
EC	990.00	920.00	890.00	920.00
pH	7.60	7.80	8.10	8.30
Ca^{+2}	184.42	181.50	153.08	156.30
Mg^{+2}	94.40	81.84	73.31	112.88
NO_3	2.00	7.00	14.00	4.00
PO_4	0.11	0.71	1.28	1.22
Turbidity	11.38	17.14	21.90	15.65
Alkalinity	159.20	141.66	123.16	136.58

Table 5. Correlation coefficients of the physicochemical parameters at Al-Hilla River from June 2016 to May 2017.

Variables	DO	TDS	EC	pH	Ca^{+2}	Mg^{+2}	NO_3	PO_4	Turbidity	Alkalinity
DO	1									
TDS	-0.623	1								
EC	-0.900**	0.987**	1							
pH	0.356	-0.702	-0.700**	1						
Ca^{+2}	-0.634*	0.848**	0.378	-0.637*	1					
Mg^{+2}	-0.418	0.442	0.465	-0.390	0.281	1				
NO_3	0.784**	-0.667*	-0.286	0.464	-0.730*	-0.641*	1			
PO_4	0.937**	-0.469	-0.251	0.253	-0.528	-0.541	0.831**	1		
Turbidity	0.557	1.000	-0.246	0.573	-0.581	-0.482	0.736	0.648	1	
Alkalinity	-0.689*	0.657	0.241	-0.504	0.722	0.214	-0.779**	-0.633*	-0.779**	1

* Correlation is significant at the level of 0.05.

** Correlation is significant at the level of 0.01

Water Quality Index (WQI):

Water quality properties at the four stations were shown in Table (6). According to the classification of water quality of weighted arithmetic (Table 2). The range of water quality index values of Al-Hilla River is 48.63, was recorded at station 1, the values indicates good water quality to very poor (85.67) at station 4, accordingly weighted arithmetic were applied to assess water quality in Al-Hilla River.

Table 6. Water Quality Index values and related factors at Al-Hilla River stations from June 2016 to May 2017.

Station	Variables	Stand. value (Si)	Ideal Value (li)	Monitored values (Mi)	Sub-Index (Qi)	Weigh. Unit (Wi)	Wi * Qi	WQI value
St. 1	DO	5	14.6	8.6	62.50	0.2	12.50	
	TDS	1000	0	486.8	48.68	0.	0.05	
	EC	250	0	751	300.4	0.004	1.20	133.70**
	pH	7.5	7	7.4	80	0.133	10.64	48.63*
	Ca^{+2}	150	0	137.33	91.55	0.006	0.55	
	Mg^{+2}	100	0	63.7	63.70	0.01	0.64	
	NO_3	50	0	5.2	10.40	0.02	0.21	
	PO_4	5	0	0.506	10.12	0.2	2.02	
	Turbidity	5	0	19	380.00	0.2	76.00	
	Alkalinity	200	0	138	69.00	0.005	0.35	
	Total					0.779	79.34	
St. 2	DO	5	14.6	7.5	73.96	0.2	14.79	
	TDS	1000	0	521	52.10	0.001	0.05	
	EC	250	0	811	324.40	0.004	1.30	
	pH	7.5	7	8	100.00	0.133	13.30	206.39**
	Ca^{+2}	150	0	149.83	99.89	0.006	0.60	56.61*
	Mg^{+2}	100	0	86.31	86.31	0.01	0.86	
	NO_3	50	0	5.88	11.76	0.02	0.24	
	PO_4	5	0	0.327	6.54	0.2	1.31	
	Turbidity	5	0	32	640	0.2	128	
	Alkalinity	200	0	131	65.50	0.005	0.33	
	Total					0.779	114.01	
St. 3	DO	5	14.6	7.6	72.91	0.2	14.58	
	TDS	1000	0	575	57.5	0.001	0.06	
	EC	250	0	898	359.2	0.004	1.44	156.30**
	pH	7.5	7	8	200	0.133	26.60	
	Ca^{+2}	150	0	190.16	126.77	0.006	0.76	82.28*
	Mg^{+2}	100	0	103	103	0.01	1.03	
	NO_3	50	0	5.86	11.72	0.02	0.23	
	PO_4	5	0	0.65	13	0.2	2.60	
	Turbidity	5	0	18.53	370.6	0.2	74.12	
	Alkalinity	200	0	135.54	67.77	0.005	0.34	
	Total					0.779	121.76	
St. 4	DO	5	14.6	7.4	75	0.2	15.00	
	TDS	1000	0	637	63.7	0.001	0.06	
	EC	250	0	1258	503.2	0.004	2.01	
	pH	7.5	7	8	200	0.133	26.60	192.04**
	Ca^{+2}	150	0	198.9	132.6	0.006	0.80	
	Mg^{+2}	100	0	108.93	108.93	0.01	1.09	85.67*
	NO_3	50	0	6.55	13.1	0.02	0.26	
	PO_4	5	0	0.873	17.46	0.2	3.49	
	Turbidity	5	0	25	500	0.2	100	
	Alkalinity	200	0	115	57.5	0.005	0.29	
	Total					0.779	149.6	

With turbidity (**), without turbidity (*)

Significant ($P<0.05$) relationships were found in the water quality index between the stations. Values of WQI were 56.61 and 82.81 at stations 2 and 3, respectively. The turbidity values of water quality index ranged from 133.7 at station 1 to 192.04 at station 4. The values of WQI were 206.39 and 156.30 at stations 2 and 3, respectively. Significant ($P<0.05$) relationships were found in the water quality index between the stations.

Discussion

Physicochemical Properties:

Spatial variations within an aquatic system occur, during the use of water for different purposes and this impact on the aquatic environment. The values of dissolved oxygen were above that of the quality standard >5 mg/l, and within the permissible levels of the WHO and

Standard Specification for drinking water of Iraq at all the stations and all seasons. DO was negatively correlated with TDS and EC at the levels of 0.05 and 0.01, respectively, this is coincided with finding of Hussein *et al.* (2015). TDS values at stations 3 and 4 were more than that of the WHO (2008), but the rate of values of total dissolved solids (TDS) and EC at all stations were within the limit of the Standard Specification (2009). On the other hand, the TDS which was positively correlated with electric conductivity, agreed well with the finding of Rubio-Arias *et al*. (2013).

The seasonal pH values of the water at the study stations were in the direction of average values of the Iraqi inland water (Abdullah *et al.,* 2019a). The Calcium (Ca^{+2}) and Magnesium (Mg^{+2}) were negatively correlated with DO and positively correlated with TDS at the levels 0.05 and 0.01, respectively. Calcium and Magnesium ions refer to the state of equilibrium of water bodies. In some times, the monthly and seasonal values of Calcium and Magnesium were above the levels of WHO for drinking waters, this is may be due to effect of the activities of drainage water of agriculture land (Amteghy, 2014). The rates of NO_3 and PO_4 in Al-Hilla River confirmed by Ewaid and Abed (2017), when studying Al-Gharraf river, while the results of total nitrate (NO_3) and phosphate (PO_4) exhibited strong positive correlation with dissolved oxygen and negatively so with TDS and EC at the levels 0.05 and 0.01, respectively.

The runoff and organic matter decomposition in surface water bodies also produced inorganic nutrients such as ammonia, nitrate and phosphates with resultant effects of eutrophication and other serious ecological impairments of such water body (Adesuyi *et al.,* 2015). The rates of turbidity values were found above than 5 NTU at all the stations, this result of turbidity rates indicated higher values than the guidelines of WHO (2011). Total alkalinity is affected by the bicarbonates and these values are within the level of the Iraqi inland waters of all months and seasons (Hussein *et al.,* 2008; Abdullah, 2017). These values were found within the range of natural waters (APHA, 2005) as the range was from 20 to 200 mg/l.

Water Quality Index (WQI):

The range of water quality values of Al-Hilla River which was good at station 1 and very poor at station 4 because some of parameters such as electric conductivity, calcium and magnesium were above the upper limit of Standard Specification (2009) according to the standard of the Iraqi drinking water and World Health Origination (2011), this could be attributed to the presence of human activates, agriculture waste, and organic matter pollution (Chauhan and Singh, 2010), and is in accordance with the findings of Ewaid and abed (2017) in some parameters. The results showed that the turbidity values obtained at the four stations were above the standard limits of CCME (2001), in addition, the EC, Ca^{+2} and Mg^{+2} concentrations swerved off the standard specification of the river maintenance system, and this is may be attributed to domestic effluent discharges anthropogenic activities, run-off with high suspended matter contents and lower water levels (UNESCO/WHO/ UNEP, 2001).

Conclusions

In the light of the present study, and by comparing it with studies conducted on the lower approaches of Iraqi rivers as an example of which the Euphrates River, a clear difference is observed in the values of environments variables in the present study compared with the previous results.

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References

Abdullah, S.A. 2017. Diversity of fishes in the lower reaches of Tigris River, north east of Basrah province, Southern Iraq. Basrah J. Agric. Sci., 30(1): 85-96.https://doi.org/10.37077/25200860.2017.25

Abdullah, S.A., Abdullah, A.H.J. and Ankush, M.A. 2019a. Assessment of water quality in the Euphrates River, southern Iraqi. J. Agric. Sci., 50(1): 221-228.https://doi.org/10.36103/ijas.v50i1.297

Abdullah, S.A., Abdullah, A.H.J. and Ouda, Y.W. 2019b. Diversity and status of fish fauna in the Al-Kahlaa River, in Missan Province-Iraq, with notes on environmental variables. Eurasia J. Biosci., 13: 1817-1824.http://un.uobasrah.edu.iq/papers/18049.pdf

Adesuyi, A.A., Nnoduu, V.C., Njoku, K.L. and Jolaoso, A. 2015. Nitrate and Phosphate Pollution in Surface Water of Nwaja Creek, Port Harcourt, Niger Delta, Nigeria. Intern. J. Geo. Agric. and Environ. Sci., 3(5): 14-20.https://www.woarjournals.org/IJGAES/vol_issue.php?abc1=14

Al-Hasnawi, J.K and Maitham, K.H. 2018. Spatial variation of Shatt Al-Hillah water pollution. Journal of Babylon Center for Humanities Studies, 8(4): 185-206.https://www.iasj.net/iasj/article/149616

Al-Janabi, Z., Al-kubaisi, A. and Al-Obaidy, A. 2012. Assessment of water quality of Tigris River by using Water Quality Index (CCME) (WQI). J. Al-Narhrain Univ., 15(1): 119-126. https://www.iasj.net/iasj/download/470a159c38c2ab39

Al-Saad, H.T., Hello, M.A., Al-Taein, S.M. and Douable, A.Z. 2010. Water Quality of the Iraqi southern marshes. Mesopot. J. Mar. Sci., 25(2): 188-204.URL

Amteghy, A.H. 2014. Enhancement of Quality for Shatt Al-Arab River and NW Arabian Gulf BY Granular Activated Carbon and local Sand. Journal of Thi Qar Science, 4(3): 108-118.https://www.iasj.net/iasj/download/b061c6739f288886

APHA (American Public Health Association) 2005. Standard methods for the examination of water and waste water. 21^{th} ed. Washington D.C., 1193p.URL

Bu, H., Tan, X., Li, S. and Zhang, Q. 2010. Temporal and spatial variations of water quality in the Jinshui River of the South Qinling Mts., China. Mts. Ecotoxicol. Environm. Saf., 73(5): 907-913.https://doi.org/10.1016/j.ecoenv.2009.11.007

Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Shawley, A.N. and Smith, V.H. 1998. Non point pollution of surface waters with phosphorus and nitrogen. Ecol. Appl., 8(3): 559-568.https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2

CCME (Canadian Council Ministers of the Environment) 2001. Canadian water quality guidelines for the protection of aquatic life CCME Water Quality Index 1.0 user's manual, 1999. Winnipeg: Canadian Council of Ministers of the Environment, 5p.URL

Chauhan, A. and Singh, S. 2010. Evaluation of Ganga water for drinking purpose by quality index at Rishikesh, Uttarakhand, India. Repo. and Opini., 2(9): 53-61.URL

Chitmanat, C and Traichaiyaporn, S. 2010. Spatial and temporal variations of physical chemical water quality and some heavy metals in water, sediments and fish of the Mae Kuang River, Northern Thailand. Intern. J. Agric. and Bio., 12(6): 816-820.URL

Chowdhury, R.M., Muntasir, S.Y. and Monowar, H.M. 2012. Water Quality Index of water bodies along Faridpur-Barisal rod in Bangladesh. Global Eng. Techno. Rev., 2(3): 1-8.URL

Cude, C. 2001. Oregon water quality index; A tool evaluating water quality management effectiveness. J. Am. Water Res. Assoc., 37: 125-137.https://doi.org/10.1111/j.1752-1688.2001.tb05480.x

Divya Raj, S. and Mophin, K.K. 2018. Water Quality Assessment of Sasthamcotta Lake, Kollam, Kerala. International Journal of Engineering and Advanced Technology (IJEAT), 7(3): 119-129.URL

Ewaid, S.H. and Abed, S.A. 2017. Water quality index for Al-Gharraf River, southern Iraq. Egyptian Journal of Aquatic Research, 43: 117-122.https://doi.org/10.1016/j.ejar.2017.03.001

Horton, R.K. 1965. An index number system for rating water quality. J. Water Pollut. Cont. Fed., 37(3): 300-305.URL

Hussein, S.A., Abdallah, A.M. and Abdallah, S.A. 2015. Ecology and fish stricture in the southern sector of Euphrates River, Iraq. Basrah J. Agric. Sci., 28(1): 82-94.https://doi.org/10.36103/ijas.v50i1.297

Hussein, S.A., Al-Sabochi, A.A. and Fahad, K.K. 2008. Ecological characteristics of the southern sector of Euphrates river at Al-Nasiryia city. II. Seasonal variations in nutrients. J. Thi Qar Univ., 4(3): 121-126.URL

Jayalakshmi, V., Lakshmi, N. and Singara Charya, M.A. 2011. Assessment of physicochemical parameters of water and waste waters in and around Vijayawada. Intern. J. Res. Pharm. and Biom. Sci., 2(3): 1040-1046.http://www.ijrpbsonline.com/files/RS00010.pdf

Kotti, M.E., Vlessidis, A., Thanasoulias, N.C. and Evmiridis, N.P. 2005. Assessment of River Water Quality in Northwestern Greece. Water Reso. Mana., 19: 77-94.https://doi.org/10.1007/s11269-005-0294-z

Lind, O.I. 1979. Handbook of common methods in limnology. C.V. Mosby Louis, 199p.URL

Oscoz, J., Leunda, P.M., Miranda, R., Fresca, C.G., Campos, F. and Escala, M.C. 2005. River channelization effects on fish population structure in the Larraun river (Northern Spain). Hydrobi., 543: 191-198.https://doi.org/10.1007/s10750-004-7422-2

Parsons, T.R., Maita, Y. and Lalli, C.M. 1984. A manual of chemical and biological methods for sea water analysis. Pergamum Press Oxford, 60p.URL

Rubio-Arias, H., Ochoa-Rivero, J.M., Quintana, R.M., Saucedo-Teran, R., Ortiz-Delgado, R.C., Rey-Burciaga, N.I. and Espinoza-Preito J.R. 2013. Development of water index (WQI) of artificial aquatic ecosystem in Mexico. J. Environ. Protec., 4: 1296-1306.URL

Simeonov, V., Einax, J., Stanimirova, I. and Kraft, J. 2002. Environmetric modeling and interpretation of water river monitoring data. Analytical and Bioanalytical Chemistry, 374: 898-905.https://doi.org/10.1007/s00216-002-1559-5

Srivastava, P.K., Mukherjee, S., Gupta, M. and Singh, S.K. 2011. Characterizing Monsoonal Variation on Water Quality Index of River Mahi in India Using Geographical Information

System. Water Quality Exposure and Health, 2(3-4): 193-203.https://doi.org/10.1007/s12403-011-0038-7

Standard Specification 2001. Drinking water, Iraq. First Modernization, No. 417, the Council of Ministers, Central Apparatus for Assessment and Quality Control, 5p. (In Arabic).

Standard Specification 2009. Drinking water, Iraq. Second Modernization, No. 417, the Council of Ministers, Central Apparatus for Assessment and Quality Control, 7p. (In Arabic).

Swanson, F.J. and Sparks, R.E. 1990. Long-term ecological research and the invisible place. BioScience, 40(7): 502-508.https://doi.org/10.2307/1311318

UNESCO/WHO/UNEP. 2001. Water Quality Assessment A guide to Us Biota, Sediment and Water in Environment Monitoring. 2nd Edition, PP: 10-14.

Welch, P.S. 1952. Limnology. 2nd ed., McGraw-Hill Book Co., New York, 538p. URL

WHO 2008. Guidelines for drinking water quality [electronic resource]: Incorporating 1st and 2nd addenda, Vol. 1, Recommendations, 3rd ed. World Health Organization, Geneva, 515p.URL

WHO 2011. Guidelines for Drinking Water Quality, 4th ed., Avai E.T. lable: http://www.W.int/water.URL