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Monitoring Lotic Ecosystem by the Application of Water Quality Index (CCMEWQI)

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Abstract:

Water Quality Index (WQI) as a tool to assess the water quality status provides advice related to the use of water quality monitoring data and it is a way for combining the complex water quality data into a single value or single statement. The present study was conducted on Al- Hilla river in the middle of Iraq from August 2012 to July 2013 at five selected stations in the river, from Al- Musaib city to Al- Hashimya at the south of Hilla to determine its suitability for aquatic environment (GWQI), drinking water (PWSI) and irrigation (IWQI). This index offers a useful representation of the overall quality of water for public or any intended use as well as indicating pollution, water quality management, and decision making. According to the obtained results, it can be concluded that the EC, TSS, Total hardness, Ca, Mg, DO, BOD₅, and NO₃ moved away from the desired standards when the temperature rises. The variable of value of this index may be due to increasing the ration of organic matters and converting the carbonate to bicarbonate. The results recorded high value of calcium and magnesium more than the standard value of WHO and IQS (50 mg/l and high value of total hardness more than 500 mg/l). Irrigation water quality index (IWQI) in the study sites were ranged between 66-83 ranged between fair and good.

Keywords: Hilla river, Lotic ecosystem, River monitoring, Water quality index.

Introduction:

A water quality Index is a good statistical tool for assessment, simplifying and reporting complex information obtained from any aquatic system(1).

It is difficult to evaluate water quality from a large number of samples (2,3). Water quality indices goal for giving a single value to the water quality of a sources reducing great amount of parameters into a simpler expression and enabling easy interpretation of monitoring data(4).

The particulate problem in case of water quality monitoring is the complexity associated with analysing a large number of measured variables (5). WQI can be used as a tool in comparing the water quality of different sources and summarizing large amounts of data in simple terms (e.g. poor, good etc.) for reporting to management and the public in a consistent manner(6).

Numerous water quality indices have been formulated all over the world which can easily judge out the overall water quality within a particular area promptly and efficiently, such as

Canadian, Council of Ministry of the Environment Water Quality Index (CCME WQI), British Columbia Water Quality Index (BC WQI), National Sanitation foundation water quality index (NSF WQI) and Oregon water quality index (OWQI)(4)

Horton(1) was the first author who suggested the advantages of using the WQI and since, then many studies concerning water index have been reported elsewhere for different aquatic systems(4,7,8,9,10).

The decline in water quality of the main Iraqi water resources is one of the important reasons to use the water quality index in Iraq in order to simplify the results of many data of water quality(11). Some studies used the WQI to assess of water quality in Iraq(12,13,14,15). The WQI illustrates physical and chemical properties of an aquatic system by simple decision whether an aquatic system is valid for different human use or for lives of aquatic organisms (16).

The present paper was the CCME WQI to assess of water quality in Hilla River, middle of Iraq for aquatic environment (GWQI), drinking water (PWSI), and irrigation (IWQI) to fill the gap of information on water quality of the river area.

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Materials and Methods:

-Water Sampling:

Hilla River is one of two major branches of Euphrates River in AL- Hindiya barrage, middle of Iraq. The water of the river is used for multipurpose such as drinking, irrigation, etc. Water samples were collected in polyethylene bottles from five sites from August 2012 to July 2013.

-Water Quality Parameters:

A total of 16 parameters were detected in this study, all the following parameter were considered in calculating the WQI {air and water temperature, pH, EC, TDS, TSS, water current velocity, dissolved oxygen, BOD₅, total alkalinity according to (17); total hardness, calcium, magnesium (18); salinity (19); Nitrite, Nitrate (20) (Parson *et al.*, 1984), and reactive phosphorous (21).

Calculation of CCME WQI:-

The water quality was assessed using the Canadian model (CCME WQI) (22). The data analysis involve two steps, the first step include dividing the study period to four periods; first period (Aug., Spt., Oct.) second period (Nov., Dec., Jan.); third period (Feb., March, May), and fourth period (April, Jun , July).

In the second step, included three measures were selected to calculate WQI (scope, frequency and amplitude).

The values of these three measures were used in the following formula to calculate WQI:

F1: number of failed variables total number of variables x 100

F2 (Range): This factor represents the percentage of individual tests that do not meet the objectives (failed tests) and the formulation is as follows: F2 number of failed tests Total number of tests

F3 (Range): This factor represents the number of failed tests that do not meet their objectives.

The Canadian water quality index is then calculated as:

$$\sum WQI = 100 - f1^2 + f2 + f3^2 / 1.732$$

F1 : number of failed variables/total number of variables x 100

F2: number of failed tests / total number of tests

F3: (nes/ (nes + 0.01)

The calculated WQI could be classified according to the following ranges 0 - 44 poor, 45 - 64 Marginal, 65 - 79 Fair, 80 - 94 Good and 95 - 100 Excellent (22,23).

Results and Discussion:

The environmental parameters of the river water in the study area are shown in Table (1). WHO and IQS standers are listed in Table (2).

Water quality of Hilla River was studied to different purpose as general water quality index (GWQI), potable water supply index (PWSI); Irrigation water quality index (IWQI).

Table (3) shows the water quality of the Hilla River ranged between 48 (marginal) at site 2 in 4th period (Aug- Oct. 2012) as lowest value and 74 (Fair) at site 5 in 2nd period (Nov., Dec., 2012 – Jan., 2013).

Bad quality of water may be due to the discharge of sewage and industrial waste water on the study sites (24), or because of the increase in temperature and decrease of dissolved oxygen (25).

The study recorded high values of BOD₅ and TSS compared with standard limited values (22). The result of this study agrees with many other studies (26, 27, 15).

On the other hand, the result showed low value of drinking water quality index in all study sites (Table 4) may be due to non compatible the values with global limited values related with community public health (28). The values of this index (PWSI) ranged between 39 (poor) in 4th period at st.2 and 68 (fair) at st.5 in 2nd periods as highest value. The variable of value of this index may be due to increasing the organic matters and converting of the carbonate to bicarbonate. The results recorded high value of calcium and magnesium more than the standard value of WHO and IQS (50 mg/l and high value of total hardness more than 500 mg/l).

The results agree with many other studies such as (29, 30, 31). The spatial and temporal variations in the index value may be due to the increase of pollutants discharged in the river that lead to increasing many environmental parameters such as hardness, turbidity, TDS, BOD₅, etc. (15, 23). The river water quality within Babylon province is generally categorized as good and suitable for drinking uses and human consumption, but the results of current research disagree with previous studies and it is recommended to treat the river water before using for drinking and the study is compatible with Khudair (31) (2013) on Tigris River.

Water quality indices used to assess the Rivers water FOR irrigation purpose by many environmental parameters such as EC, salinity, alkalinity, TDS, TSS, Nitrite, Nitrate, reactive phosphate, BOD₅, DO, etc. (32, 13). Irrigation water quality index (IWQI) in the study sites ranged between 66-83 as fair to good because most of the sites are agriculture land and have low population density (30), but the decline in value of water quality index may be due to the increase of temperature; acidity or increase in dissolved heavy metals

concentration(14). Canadian model is put to give a clear picture of the changes and represents a reflection of the different aquatic systems (4).

According to the obtained results,it can be concluded that the EC, TSS, Total hardness, Ca, Mg, DO, BOD5 and No₃, moved away from the desired standards when the temperature rises.

Table 1. Variation of physical and chemical parameters in study sites in Hilla River between 2012-2013 (first line: range, second line: mean ± SD).

Parameters	Sites				
	Site 1	Site2	Site3	Site4	Site5
Air temp (C°)	13.6 - 41	13 - 43	13.3-41.5	12.9-42	15.6.9-42.4
	26 ± 9	23.8 ± 8.2	26.8 ±9.27	22.27±7.76	27.71±9.17
Water temp (C°)	10.43-29.5	10.1-29.9	10.6 – 31.4	10.23 – 29.7	13 – 31.4
	19.87±6.88	6.8 ± 20	20.79 ± 6.62	19.73± 6.69	21 ± 6.23
pH	7.5-8.7	7.4-8.9	7.6-8.7	7.7-8.8	7.5-8.7
	0.34 ± 8.25	0.57 ± 8.18	0.38 ± 8.29	0.34 ± 8.26	0.57 ± 8.18
Water Current(m/s)	0.29-0.68	0.26 - 0.63	0.31 – 0.61	0.33 – 0.68	0.26 – 0.63
	0.40 ± 0.16	0.43 ± 0.17	0.40 ± 0.16	0.48 ± 0.15	0.43 ± 0.17
E.C (µ.S/cm)	799-1168	811-1193	903 - 1144	798 - 1167	811 - 1168
	112.3 ±993.9	114.3 ±974.6	93.7 ± 1016.2	127.16 ± 961.17	114.36 ± 974.61
(‰) Salinity	0.51 - 0.74	0.51 - 0.76	0.57 - 0.73	0.51 - 0.75	0.51 - 0.75
	0.57 ± 0.05	0.62 ± 0.07	0.57 ± 0.05	0.57 ± 0.05	0.64 ± 0.06
TDS (mg/L)	567 - 739	575 - 804	527 -789	563 -747	567 -802
	682.5 ± 78.7	637.5 ± 53.7	651 ±67	620.8 ± 58.68	682.5 ± 78.71
TSS (mg/L)	9.2 -17.2	9.1 – 16.2	9.3 – 16.2	9.5 – 17.1	9.1 – 16.8
	14.1±2.1	14 ± 1.9	14 ± 2	14.1 ± 2.1	14.1 ± 2
DO (mg/L)	6.20-10.05	6.72-11.59	6.63 – 10.78	6.90 – 11.38	6.20 – 9.55
	7.8± 1.3	8.9 ± 1.5	8.4±1.3	8.69±1.4	7.81 ± 1.25
BOD ₅ (mg/L)	1.51- 4.5	1.94 – 5.1	1.05 – 4.86	0.96 – 4.83	1.51 – 4.1
	2.8 ± 1.3	2.9 ± 1	2.25±0.94	2.33±1.1	2.3±1.1
Total Alkalinity (mgCaCO ₃ /L)	136 - 204	112-243	102-208	119-203	132-230
	182.3 ± 29.9	163.8 ± 32.1	174.1±32.48	159.88±28.42	182.38±29.92
Total Hardness(mgCaCO ₃ /L)	307 - 700	446 - 775	423 - 650	423.3 - 775	307.6 - 775
	504 ± 112.2	529.6 ± 81.2	525.5 ± 82.4	548.9 ± 96.55	504 ± 112.27
Calcium(mg CaCO ₃ /L)	80.7- 143	80 – 180.3	87 - 175	76 - 173	84 – 145
	104.5±25.6	98.4 ± 24	114.8 ± 25.1	106.7 ± 36	104.5± 25.6
Magnesium(mg CaCO ₃ /L)	43 – 90.5	37.9 -97.2	35.5-78.9	36.8-96.2	44.5-90.5
	66 ± 12.1	64.8 ± 18.8	59.8± 17	65.9 ± 23	64.15 ± 13.4
Nitrite(mg/L)	0.8 – 2.4	0.93 - 1.85	0.9 – 1.85	0.8 – 1.9	0.62 – 2
	1.39 ± 0.42	1.4 ± 0.3	1.41 ± 0.31	1.41 ±0.39	1.4 ± 0.41
Nitrate(mg/L)	9.5-13.4	9.4-13.7	9.7- 13.4	9.4- 13	9.6- 13.2
	11.01 ± 1.23	12.07 ±1.31	11.87 ± 1.28	11 ±1.23	11 ± 1.23
Reactive phosphate(mg/L)	0.51-1.20	0.59 – 1.39	0.53-1.33	0.55-0.99	0.56-1.1
	0.73 ± 0.23	1 ± 0.4	1 ± 0.4	0.72 ± 0.21	0.73 ± 0.23

Table 2. Values of Water quality index (General water quality index GWQI, Potable water quality index PWQI, and Irrigation water quality index IWQI) on sites and periods study in Hilla River.

Study Sites	Periods	Index value GWQI	Index range	Index value- PWQI	Index range	Index value - IWQI	Index range
		-					
St.1	1 St	66	Fair	61	Marginal	76	Fair
	2 nd	72	Fair	64	Marginal	83	Good
	3 th	70	Fair	62	Marginal	81	Good
	4 th	65	Fair	59	Marginal	74	Fair
St.2	1 St	48	Marginal	42	P00r	67	Fair
	2 nd	59	Marginal	45	Marginal	74	Fair
	3 th	64	Marginal	46	Marginal	78	Fair
	4 th	51	Marginal	39	P00r	66	Fair
St.3	1 St	63	Marginal	48	Marginal	71	Fair
	2 nd	69	Fair	52	Marginal	77	Fair
	3 th	70	Fair	59	Marginal	79	Fair
	4 th	61	Marginal	47	Marginal	69	Fair
St.4	1 St	50	Marginal	55	Marginal	69	Fair
	2 nd	57	Marginal	59	Marginal	72	Fair
	3 th	61	Marginal	62	Marginal	75	Fair
	4 th	49	Marginal	54	Marginal	68	Fair
St.5	1 St	65	Fair	61	Marginal	74	Fair
	2 nd	74	Fair	68	Fair	79	Fair
	3 th	73	Fair	65	Fair	81	Good
	4 th	65	Fair	51	Marginal	67	Fair

Table 3. International and Iraqi limited values used in calculated of water quality index.

Parameters	IWQI	GWQI	PWSI
Temperature		***15	
pH	6-8.56	***65-9	*6.5-8.5
EC	2250 [#]		
DO		***5.5-9	
BOD ₅		3>***	
TDS		***500	*1000
Total Alkalinity			**100
Ca			*50
Mg			*50
Total Hardness			*500
Reactive Phosphate		***0.1	
Nitrate		***13	*50
Nitrite		***0.06	*3

* Iraqi standardization for drinking water 2001

** WHO (2004)

*** CCME (2007)

[#]Ayers & Westcot (1985)*

[@]US Salinity Laboratory (1954)

Conclusion:

The results recorded high value of calcium and magnesium more than the standard value of WHO and IQS (50 mg/l and high value of total hardness more than 500 mg/l). Irrigation water quality index (IWQI) in the study sites were ranged between 66-83 ranged between fair and good. Bad quality of water may be due to the discharge of sewage and industrial waste water on the study sites .

Conflicts of Interest: None.

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مراقبة نظام مائي جاري بتطبيق دليل نوعية المياه (الموديل الكندي CCMEWQI)

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الخلاصة:

تعد موديلات وادلة نوعية المياه اداة جيدة تستخدم في مراقبة جودة نوعية المياه وهي احد الطرق لجمع بيانات متعددة والتعبير عنها من خلال قيمة واحدة. اجريت الدراسة الحالية على نهر الحلة وسط العراق من اب 2012 ولغاية تموز 2013 في خمس محطات مختاره من مدينة المسيب الى منطقة الهاشمية جنوب مدينة الحلة لتحديد مدى ملائمة مياه هذا النظام المائي للحياة المائية (GWQI) ولأغراض الشرب (PWSI) والري (IWQI) يقدم هذا الدليل تمثيلا مفيدا لنوعية لتقييم نوعية المياه ومدى امكانية استخدامها لأغراض متعددة اضافة الى انه قد يستخدم كمؤشر لحالة التلوث ويمكن ان يكون اداة جيدة في ادارة جودة المياه وصنع القرار المتعلق بذلك. ويمكن بواسطته تفسير المعلومات التي يقدمها من قائمة القيم العددية والتي تكون مفيدة في اتخاذ قرارات التحليل البيئي وبما يتوافق مع اللوائح والتشريعات البيئية. اظهرت النتائج ان هنالك العديد من خصائص المياه يمكن استخدامها لتحقيق هذا الموديل مثل المواد الصلبة الذائبة والاس الهيدروجيني والاكسجين الذائب والمتطلب الحيوي للاوكسجين والكالسيوم والمغنسيوم والنترت والنترات والفوسفات الفعالة. ومن نتائج الدليل يظهر زيادة تركيز الفضلات العضوية في النهر وتحول الكربونات الى بيكاربونات وان قيم الكالسيوم والمغنسيوم تفوق المحددات الدولية اضافة الى ارتفاع تراكيز العسرة في المياه وبالتالي فان مياه هذا النظام ممكن ان تكون صالحة للحياة المائية والري واستخدامها لاغراض الشرب قد يسبب مشاكل صحية وبيئية.

الكلمات المفتاحية: نهر الحلة، نظام مائي جاري، مراقبة الانهار، دليل نوعية المياه.