DOI: 10.24996/ijs.2023.64.1.42

ISSN: 0067-2904

Assessment of Shatt Al-Arab Water Quality Using CCME/WQI Analysis in Basrah City of South Iraq

Farah Mahdi [1]*, Ban Abdul Razzaq[1], Maytham Sultan[2]

[1]*Department of Remote sensing and GIS, College of Science, University of Baghdad, Baghdad, Iraq.*

[2]*Environmental researches Center, Ministry of Sciences & Technology, Baghdad, Iraq.*

Received: 12/4/2022 Accepted: 3/7/2022 Published: 30/1/2023

Abstract

The Water Quality Index (WQI) is an important parameter in describing the water resources' suitability for human uses and is one of the most effective methods of describing water quality and indicative of assessing water quality and suitability for human utilization and the health of ecosystems. WQI of the Canadian Council of Ministers of the Environment (CCME) was used in the study to describe the Shatt al-Arab water quality in Basrah Southern Iraq, and its suitability for drinking use. The data for analyzing river water samples were adopted from five stations along the river every month during the years from 2014 to 2018 by the Iraqi Ministry of Environment, as it included the measurement of acidity function PH, Dissolved Oxygen DO, phosphorous PO4, nitrate NO3, Calcium Ca, potassium K, magnesium Mg, sodium Na, Total Hardness TH, sulfates SO4, chlorides Cl, Electrical Conductivity EC, Total Soluble Salts TDS, and Alkalinity ALK. The distributions of water quality index values along the river were mapped by GIS techniques. Study results were referring to illustrate the poor level of the water quality status of Shatt al-Arab in all study periods at all monitoring stations. The reason for this is due to the deterioration of fresh water quality drained from the Tigris and Euphrates, and the provision of salt wedges from the Arabian Gulf. However, with the continuous discharge of sewage water, industrial and oil effluents and sewage discharged from urban areas, the water quality of Shatt al-Arab was declined during the study period.

Keywords: Shatt al-Arab; WQI; CCME; Water quality; Water parameters; Drinking use.

تقييم مياه شط العرب باستخدام تحليل معامل جودة المياه(الموديل الكندي) في مدينة البصرة/جنوب العراق

فرح مهدي*[1] ، بان عبد الرزاق[1] ، ميثم سلطان[2]

[1]وحدة الاستشعار عن بعد، كلية العلوم، جامعة بغداد، بغداد، العراق

[2]مركز البحوث البيئية، وزارة العلوم و التكنولوجيا، بغداد، العراق

الخلاصه

*Email: farehasalah1@yahoo.com

يعد مؤشر جودة المياه مهم في وصف مصادر المياه ومدى ملائمتها للاستخدام البشري وهو احد اكثر الطرق فعالية لوصف جودة المياه وموشرا لتقييم جودة المياه ومدى ملائمتها للاستخدام البشري وصحة النظم البيئية.في هذه الدراسة ,تم استخدام موشر جودة المياه لمجلس وزراء البيئة الكندي لوصف جودة مياه شط العرب في مدينة البصرة (جنوب العراق),ومدى ملائمتها للشرب.تم اعتماد بينانات تحليل عينات مياه النهر من خمس محطات على طول النهر كل شهر خلال السنوات من 2014 الى 2018 من قبل وزارة البيئة العراقية ,حيث تضمنت قياس بعض الخائص الفيزيائية والكيميائية لجودة المياه.تم تعيين توزيعات قيم مؤشر جودة المياه على طول النهر بواسطة تقنيات نظم المعلوات الجغرافية.تشير النتائج الى سوء حالة جودة مياه شط العرب في جميع فترات الدراسة وفي جميع محطات الرصد.ويعود السبب في ذلك الى تدهور نوعية المياه العذبة التي يتم تصريفها من نهري دجلة والفرات,وتوفير اسافين ملحية من الخليج العربي.لكن مع استمرار الصرف الصحي المتدفقة من المناطق الحضرية فان جودة مياه شط العرب تدهورت خلال فترة الدراسة.

1. Introduction

Water is the most valuable resource that natural world supplies to humanity. It is the most vital aspect of our existence for the preservation of life, and it is necessary in all human activities, including agriculture, trade, industry, energy generation, and everyday drinking. Nonetheless, growing human activity has worsened the quality of water in many big rivers throughout the world in the last decades [1].

A multitude of natural and human causes have an impact on water quality. The most important natural influences are geological, hydrological, and climatic because they affect the quantity and quality of water available. As a result, even if sufficient quantities of water are available, the low quality of that water limits the uses that may be from it. Even though the natural ecosystem is in tune with fresh water quality, any important changes in its quality will typically disrupt the ecosystem [2].

There is an index that is environmentally justifiable and gives a relative number in relation to the minimal acceptable level for various substances. As a result, the Water Pollution Index (WPI) has been proposed, which is easier to understand, widely utilized for all water-related reasons, and simple to use for water pollution prevention and management, as well as recommendations values for certain chemicals and pesticides [3].

Water Quality Index (WQI) is used all over the world, though it is a slightly modified version of the original. WQI does not take into account some of the most important parameters, such as heavy metals and pesticides. WQI is a method of summarizing enormous amounts of water quality data into simple phrases for uniform reporting to management and the public. WQI also allows for the comparison of different rivers. This index allows for a broad assessment of water quality on a range of levels that influence the ability of a stream to support life. The CCME is made up of two parts: The number of variables that do not fulfill water quality objectives, and the frequency with which these objectives are not met [4].

WQI was described by scientists as one of the most powerful instruments for providing water quality information to relevant citizens and policymakers. It became a crucial metric in the evaluation and management of surface water. The WQI idea was based on comparing a water quality metric to applicable regulatory standards and generating a single value that expressed total water quality at a specific place based on many water quality factors [5]. The CCME WQI provided water quality information to decision-makers and policymakers. With minor modifications, it has been used by a variety of agencies in a number of nations [6].

Shatt al-Arab is one of Iraq's most important rivers and the city of Basrah's primary source of fresh surface water, which is utilized for drinking, irrigation, navigation, fisheries, and industry [7].The water quality of Shatt al-Arab has deteriorated in recent years as a result of the low rate of water drainage in the Tigris and Euphrates rivers as a result of the construction of several dams in the headwaters of Turkey and Iran major rivers [8].
The Tigris River's water quality was investigated using (CCME WQI). According to the index's findings, the water quality of the Tigris River ranged from 37 to 42, indicating that the river had the lowest quality due to the influence of multiple urban polluting sources [9]. WQI for all study stations was rated within the third (Fair) and fourth (Marginal) categories [10].The lowest water quality values for all three uses of the river were scored during the dry season in this study, and the reduced freshwater discharges from the Tigris and Euphrates, low annual precipitation, and an encroaching salt wedge from the Arabian Gulf have all been blamed for the worsening of the Shatt al-Arab water quality [11]. CCME-WQI was used to assess the water quality of Al-Gharraf River. The index had a low value, indicating that the river's water quality was poor due to numerous forms of contaminants entering the river, untreated residential sewage discharge, and runoff water from agricultural fields near the river's banks [12].

WQI was investigated for Shatt al-Arab and its tributaries. The research employed the WQI to define the river's pollution level and created a WQI map using Geographic Information System (GIS). Water quality was found to be poor towards the governorate's center, along the river forks. Furthermore, it was determined that high sewage water discharged into the river, particularly river branches, as well as illegal industrial effluent and sewage discharges, were the primary causes of river pollution [13]. WQI and GIS software were used to water quality assessment along Tigris River in Iraq. The results of this study showed that the state of water quality for the Tigris River was degraded downstream of the River during the rainy and dry seasons, which led to a visible increase in deterioration at Qurnah [14]. The results of a study of water quality evaluation of Shatt al-Arab, using NSF-WQI from October 2019 to September 2020, revealed that the water quality index values ranged from 110 to 221, indicating that the water quality of Shatt al-Arab River was generally classified as poor. The index's maximum value (122) was recorded at the second station, while the lowest value was reported at the first station (110) [15].

The aims of the current study are to present information about contribution in assessing and controlling the water quality of Shatt al-Arab in Basra city by determining the state of the river for different uses and benefiting from it for decision-makers and sectors benefiting from the river, as well as the citizens in the governorate and specialized researchers. Thus, the research diagnosis the environmental problems that the river suffers from and finds solutions and treatments through new information and the results obtained that can be employed in the interest of society, in addition to the knowledge field in clarifying the gap in the literature as an extension of the efforts of researchers who dealt with the quality of the waters of the Shatt al-Arab.

2. Study area

The study region is related to Shatt al-Arab River which lies in Basra city, south of Iraq. The waterway structures from the conjunction of Tigris and Euphrates rivers in Al Qurna city until it streams into the Arabian Gulf. Its length has a place with 195 km while its width changes from 250 m at Qurna to 750 m at the mouth. Shatt al-Arab is considered the main wellspring of water in Basra and it experiences breakdown in its quality because of the sewage networks decrease, pesticide items, low release from feeders, and the flowing impact from the Arabian Gulf [16].The map of the study area is shown in Figure 1.

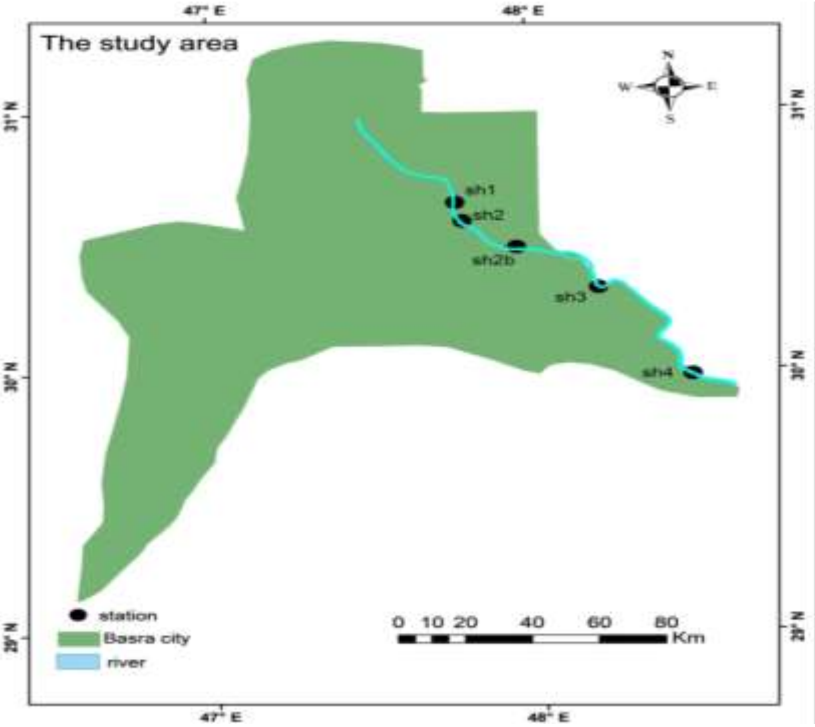

Figure 1: The map of study area of Shatt al-Arab River and monitoring stations

3. Material and method

The water samples were taken from five stations on Shat al-Arab consistently during the years 2014-2018 and were investigated for various water quality features by the Iraqi Ministry of Environment. These features were hydrogen particle focus (PH), broke up oxygen (DO), Phosphate (Po4), complete hardness (TH), absolute disintegrated solids (TDS), chloride (Cl), magnesium (Mg), calcium (Ca), sulfate (So4), nitrate (No3), potassium (K), sodium (Na), alkalinity (ALK.), and electrical conductivity (EC). All stations that used to monitor Shatt al-Arab lied in Basra city, their portrayal and directions are displayed in Table 1.

Table 1: Monitoring stations on Shatt al-Arab River

Station code	Location	Station coordinates	
		Longitude (E)	Latitude (N)
SH1	Before Karmat Ali river	47º 45′ 56″	30º 39′ 01″
SH2	Al Meqal/near Khalid bridge	47º 46′ 70″	30º 34′ 45″
SH2B	Abo Al Khasib Al Snaker	47º 56′ 67″	30º 27′ 95″
SH3	Al Seibah/ near seihan water project	48º 11′ 66″	30º 19′ 60″
SH4	Al-Fao	48 º 29 ′ 04 ″	29 º 58′ 51″

The annual mean values for each parameter in each station were calculated as shown in Tables 2-6, these values were used in the WQI calculation procedure.

Table 2: The annual mean values of parameters 2014

Stations Parameter	SH1	SH2	SH2B	SH3	SH4	S_n
pH	8.195	7.994	7.969	7.903	7.991	8.5
DO	7.796	8.284	7.300	7.443	6.926	5
PO_4	0.293	0.339	0.314	0.295	0.293	0.3
NO_3	7.923	9.961	9.431	10.329	9.566	50
Ca	146.813	185	203.625	217.56	343.125	200
Mg	84.938	147.375	149.250	288.625	603.438	50
TH	663.875	1004.125	1040.000	1407.875	2845.250	300
K	5.614	10.664	14.264	32.979	108.186	12
Na	436.429	865.714	1007.857	1846.000	1767.200	200
SO_4	317.500	450.833	508.333	350.000	745.833	250
Cl	446.571	811.714	1000.86	2301.9	2088.25	250
TDS	1628.000	2935.571	3390.286	3113.000	3410.667	1000
EC	2746.714	4539.286	5084.286	4638.000	5100.000	2000
Alk.	180.200	188.000	187.700	172.600	173.200	200
Failed var.	8.000	9.000	11.000	10.000	10.000	
Failed test	8.000	9.000	11.000	10.000	10.000	
Total var.	14	14	14	14	14	

Table 3: The annual mean values of parameters 2015

Stations Parameter	SH1	SH2	SH2B	SH3	SH4	S_n
pH	7.933	7.931	7.732	7.913	7.960	8.5
DO	9.304	9.094	8.771	9.102	8.560	5
PO_4	0.403	0.488	0.358	0.348	0.398	0.3
NO_3	4.027	4.056	3.923	4.064	3.647	50
Ca	188.714	214.667	219.083	172.4	432.333	200
Mg	131.500	170.444	153.875	78.100	643.500	50
TH	1056.400	1286.143	1243.400	763.333	4104.500	300
K	15.350	34.711	34.233	7.670	158.567	12
Na	874.286	1578.889	1447.917	645.000	5107.000	200
SO_4	375.000	525.000	425.000	375.000	825.000	250
Cl	1004.14	1817.22	1641	729.8	5515.8	250
TDS	3234.000	5063.667	4502.417	2362.200	8449.000	1000
EC	4359.000	5305.000	5256.000	3553.000	24496.250	2000
Alk.	190.000	187.125	187.273	171.600	177.000	200
Failed var.	10.000	11.000	11.000	9.000	10.000	
Failed test	10.000	11.000	11.000	9.000	10.000	
Total var.	14	14	14	14	14	

Table 4: The annual mean values of parameters 2016

Stations Parameter	SH1	SH2	SH2B	SH3	SH4	S_n
pH	7.771	7.550	7.763	7.800	7.983	8.5
DO	7.999	6.863	8.885	8.370	9.807	5
PO_4	0.370	0.416	0.270	0.450	0.437	0.3
NO_3	4.033	4.731	3.918	4.135	4.947	50
Ca	177.429	198.667	245	168.25	293	200
Mg	97.429	106.444	136.750	108.500	435.667	50
TH	848.429	942.333	1186.500	873.000	2553.000	300
K	8.543	12.956	15.875	20.500	169.833	12
Na	553.571	775.000	1247.500	1007.500	5193.333	200
SO_4	394.286	392.778	512.500	305.000	750.000	250
Cl	639.286	832.111	1309.25	1083	3251	250
TDS	2294.429	2601.333	3783.500	3035.250	4244.000	1000
EC	3422.143	4003.778	5471.250	4515.500	6400.000	2000
Alk.	189.429	789.222	172.125	179.500	189.000	200
Failed var.	9.000	11.000	10.000	10.000	11.000	
Failed test	9.000	11.000	10.000	10.000	11.000	
Total var.	14	14	14	14	14	

Table 5: The annual mean values of parameters 2017

Stations Parameter	SH1	SH2	SH2B	SH3	SH4	S_n
pH	8.242	8.150	8.350	7.992	8.000	8.5
DO	9.328	8.026	9.041	8.828	9.426	5
PO_4	0.518	0.578	0.686	0.582	0.587	0.3
NO_3	2.693	2.778	2.968	2.762	2.688	50
Ca	129.022	153.25	166.833	190.25	496.778	200
Mg	100.636	112.917	122.417	146.083	908.556	50
TH	604.500	855.917	929.583	1086.500	5035.333	300
K	59.775	79.017	59.358	68.225	66.594	12
Na	596.350	804.283	819.767	1397.067	904.367	200
SO_4	350.508	371.667	454.167	446.667	1533.333	250
Cl	696.75	975.25	1064.58	1828.8	13250.33	250
TDS	2145.000	2780.167	2913.350	4493.500	26412.667	1000
EC	3232.833	4082.583	4552.500	6310.833	4544.687	2000
Alk.	332.667	205.500	202.167	200.417	235.188	200
Failed var.	11.000	11.000	11.000	11.000	12.000	
Failed test	11.000	11.000	11.000	11.000	12.000	
Total var.	14	14	14	14	14	

Table 6: The annual mean values of parameters 2018

Stations Parameter	SH1	SH2	SH2B	SH3	SH4	S_n
pH	7.833	7.583	7.733	7.694	7.942	8.5
DO	7.983	8.093	7.748	7.203	7.229	5
PO_4	0.499	0.692	0.486	0.503	0.558	0.3
NO_3	3.424	3.392	3.493	3.086	3.006	50
Ca	186.250	308.333	282.667	431.333	613.750	200
Mg	169.250	390.167	338.250	674.917	1601.750	50
TH	1220.333	2393.583	2116.417	3896.500	8216.083	300
K	29.883	72.000	70.525	166.542	384.167	12
Na	1620.833	4021.667	3897.500	6745.000	13483.333	200
SO_4	470.833	689.167	650.000	962.500	2158.333	250
Cl	1973.000	5000.750	4548.250	9614.833	19864.417	250
TDS	4977.333	10917.500	10174.917	19250.583	38724.500	1000
EC	7365.833	14768.333	13721.667	31549.167	50397.500	2000
Alk.	196.833	210.167	206.000	217.667	193.667	200
Failed var.	10	12.000	12.000	12.000	11.000	
Failed test	10	12.000	12.000	12.000	11.000	
Total var.	14	14	14	14	14	

The CCME has been used to analyze water quality in several locations throughout the world. The CCME was calculated with all of the water quality parameters provided. CCME model calculation depends on three factors, it is given by: [9]

$$CCME = 100 - \frac{\sqrt{F1^2+F2^2+F3^2}}{1.732} \quad ....(1)$$

Where;

F1: scope, F2: frequency and F3: amplitude.

The divisor 1.732 converts the output values to a range of 0 to 100, subsequently, they are categorized into five classes as evidenced by Table 7.

Table 7: CCME WQI water quality classification

Rank	WQI Value
Excellent	95-100
Good	80-94
Fair	65-79
Marginal	45-64
Poor	0-44

F1 (Scope) reflects the proportion of parameters that failed to fulfill their guidelines at least once during the time period under consideration ("failed parameters"), as a percentage of the total number of parameters measured, given by the equation: [17]

$$F1 = \frac{No.of\ failed\ variables}{Total\ no.of\ variabls} \times 100 \qquad ......(2)$$

F2 (Frequency) reflects the percentage of tests that fail to fulfill the standards ("failed tests"), it is given by: [17]

$$F2 = \frac{No.of\ failed\ tests}{total\ no.of\ tests} \times 100 \qquad .....(3)$$

F3 (amplitude) indicates the percentage of failed tests that fail to satisfy their objectives. It is calculated by: [17]

$$F3 = \frac{nse}{0.01*nse+0.01} \qquad ......(4)$$

Where:

nse is the normalized sum of excursions. It represents the total amount of time that individual tests have been found to be out of compliance, given by: [18]

$$nse = \frac{\sum \text{excursions}}{total\ no.of\ tests} \qquad ......(5)$$

The excursion is the number of times an individual's concentration exceeds (or falls short of) the target.

When the test value must not be higher than the goal: [18]

$$\text{excursions} = \frac{\text{failed test value}}{\text{objective}} - 1 \qquad .....(6)$$

When the test value must not fall below the objective: [18]

$$\text{excursions} = \frac{\text{objective}}{\text{failed test value}} - 1 \qquad .....(7)$$

4. Geographic information systems (GIS)

GIS is a logical device for handling geographic information. They are answerable for coordinating a few parts of certifiable geographic information and gathering and working and examining the information. GISs fill numerous needs since they can work with a wide range of genuine geographic information, including those connected with the earth, like geographical and topographical information, and human-related measurable and epidemiological information, like the spread of illness across a district of land [19]. However, Scientists and specialists give GIS a few different definitions, some of them characterized GIS as a coordinated assortment of PC equipment, programming, topographical information, and work force intended to productively catch, store, update, control, examine, and show all types of geologically referred to data, while others made sense of GIS as a framework for catching, putting away, checking, incorporating, controlling, breaking down, and showing information that are spatially referred to the earth. GIS permits clients to see, get, question, decipher, and imagine information in manners that uncover connections, examples, and patterns as guides, globes, reports, and graphs [20].

5. Inverse Square Distance Method(IDW)

This approach is defined as a local deterministic interpolation technique that is precise. The un-sampled location value, according to IDW, is a distance-weighted average of values at sampled sites within a defined neighborhood surrounding the un-sampled point [21].The IDW insertion of the worth Y ̃j for a given area j is processed as: [22]

$$\hat{Y}_j^{IDW} = \sum_{i=1}^{n} w_{i,j}\ y_i \qquad ...... (2.1)$$

Where;
y_i: is a data point available at a location *i*.
i=1……n
$w_{i,j}$: represent the weight
The weights $w_{i,j}$ for each data point are given as: [23]

$$w_{i,j} = \frac{d_{i,j}^{-\alpha}}{\sum_{k=1}^{n} d_{k,j}^{-\alpha}} \quad \text{……… (2.2)}$$

Where;
$d_{i,j}$: is the Euclidian distance between the estimated and the known points.
α: is exponential power parameter.

6. Results and discussion

Tests were gathered and dissected for various physical and compound boundaries consistently during the years 2016-2018 by Iraqi service of Environment. The mean yearly upsides of every boundary were determined by analyst and utilized in WQI estimation.

After determination of the failed parameters and failed tests that did not meet guidelines (S_n) recommended by World Health Organization(WHO) which were pointed in red color as shown before in Tables 2-6, F1, F2 and F3 were computed utilizing equations (2, 3 and 4) separately. CCME WQI was assessed utilizing equation (1) for consistently in five stations along Shatt al-Arab stream, the aftereffects of CCME WQI were displayed in Table 8 and broke down utilizing a dominate program, as displayed in Figure 2, knowing that all calculations were made by Microsoft Excel program.

Table 8: CCME WQI calculation results

Station	2014	2015	2016	2017	2018
sh1	50.43369	34.07359	42.54373	29.56671	29.69525
sh2	39.76935	24.93307	29.06127	27.57931	14.6219
sh2B	28.3931	25.7378	32.14498	27.42209	15.02915
sh3	29.39243	42.33552	34.11255	24.80223	12.40306
sh4	26.29345	23.67692	19.50223	12.77439	15.35767

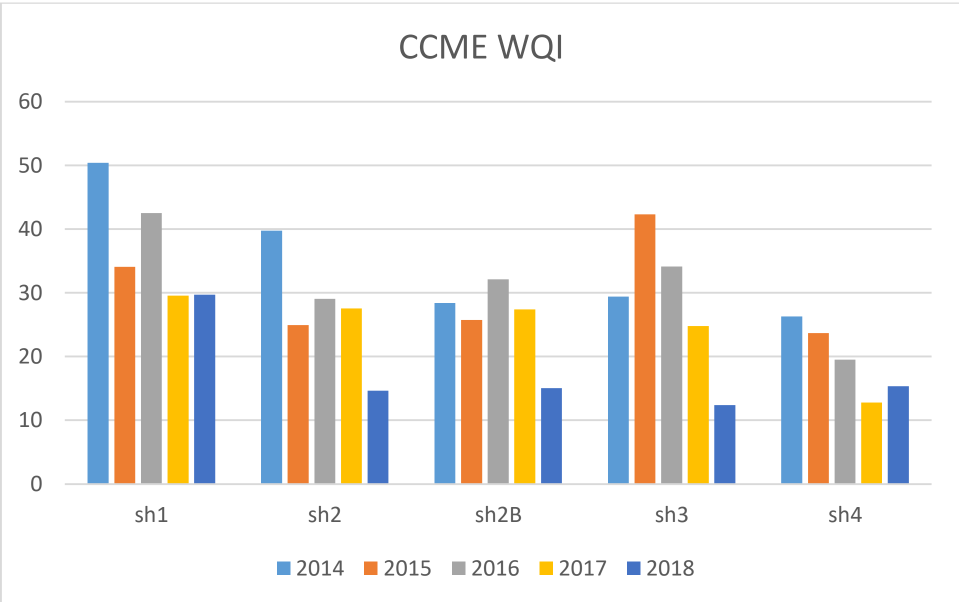

Figure 2: WQI analysis along monitoring stations in study period

The WQI results were ordered into various classes as per CCME WQI arrangement as displayed in Table 9 to delineate the situation with water quality along the surface water. The results of this index showed that all sampling stations had low water quality and for all study periods, except for the sh1site in 2014 that the river class was marginal because water quality of the river was frequently threatened or impaired; or water properties were often exceeding the natural levels.

Table 9: Status of study area water quality

Station	2014	2015	2016	2017	2018
sh1	Marginal	poor	poor	poor	poor
sh2	poor	poor	poor	poor	poor
sh2B	poor	poor	poor	poor	poor
sh3	poor	poor	poor	poor	poor
sh4	poor	poor	poor	poor	poor

Geographic Information System (GIS) was used for mapping the CCME-WQI of Shatt al-Arab using Inverse Distance Weighted (IDW) interpolation techniques, and the results showed that GIS was a good and efficient technique for creating maps and giving a clear picture to take the appropriate solutions to improve the river water quality, Figure 3.

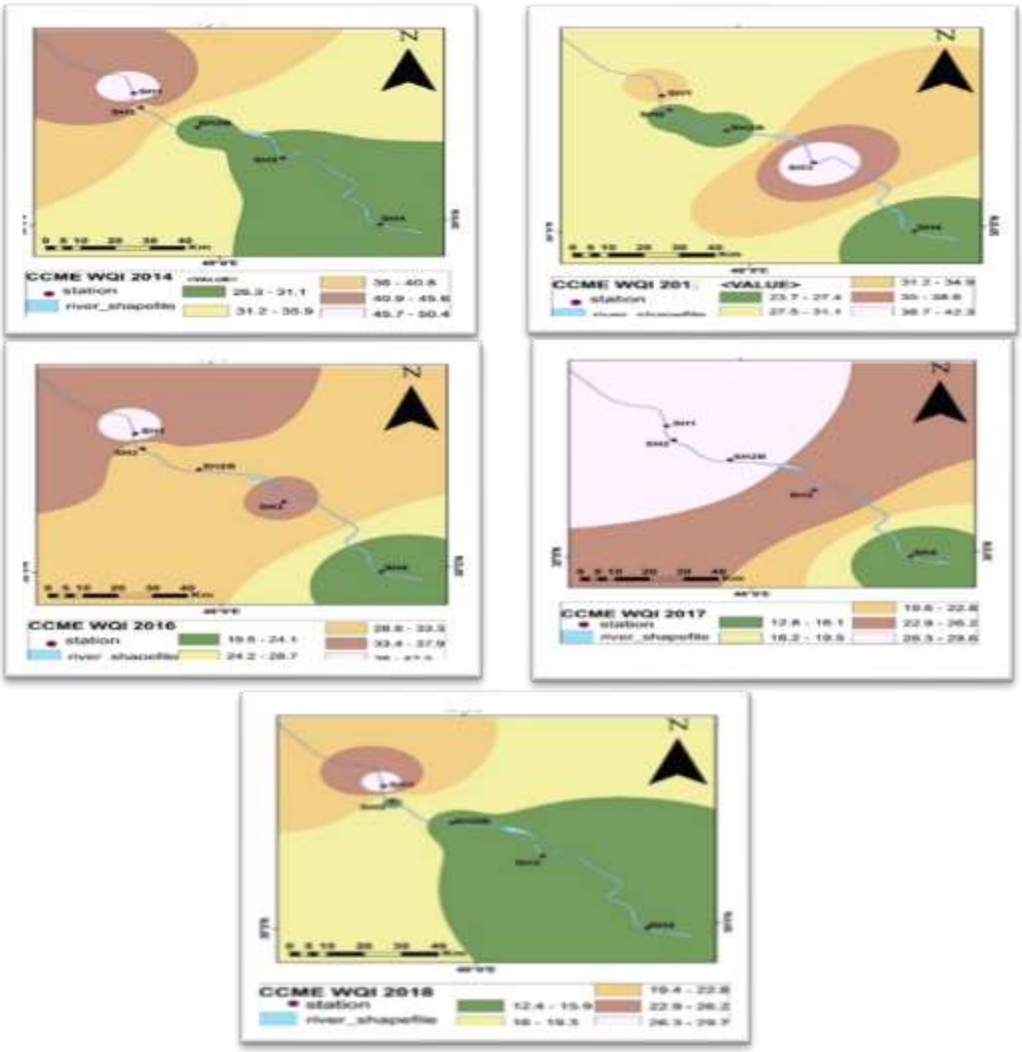

Figure 3: The distribution maps of CCME WQI

The CCME-WQI distribution map shows that the river water was poor in most study stations, except for one site in 2014 where the river class was marginal. The deterioration of the water quality of the river was due to the discharge of municipal and industrial wastes, as well as agricultural operations, deterioration of the quality of freshwater drained from the Tigris and Euphrates, and the provision of salt wedges from the Arabian Gulf.

From Figure 3, the results also showed clear changes in the index values between the study stations and during the period 2014-2018 which classified as poor as the quality of Shatt al-Arab water which was classified within the fifth and last category (0-44). This decline in CCME-WQI had a close relationship with the characteristics of the river water during the study period, which was ascribed to the high water temperature and low oxygen dissolved as a result of an increase in the concentration of organic waste in addition to an increase in the values of other variables, and this indicated the effect of environmental variables on the value of the water quality index. This decrease in the index values may also be attributed to the proximity of study stations to the residential areas, and consequently, they were vulnerable to pollution due to the dumping of household and agricultural waste into the water, especially the second and third stations.

7. Conclusion

CCME- is a valuable indication for presenting water quality information, as well as analyzing changes in water quality over time. It was accepted as a technique to assess the state of Shatt al-Arab over a period of time and for multiple sites. The study results concluded that the status of water quality of the river in each station was collapsed during the study period, and the first station recorded the maximum value of WQI in all study years, i.e. the first station was the best in quality than the other stations. Generally, the water quality of the river was poor at all stations, and in all study years, or indicated threatened or impaired river water quality conditions that usually depart from natural or desirable levels. This decrease in the index values may be attributed to the proximity of study stations to the residential areas, and consequently, they were vulnerable to pollution because of wastewater and agricultural waste discharge into the river, especially the second and third stations. Also, the effect of environmental variables on the water quality index value was clear because of high water temperature and decrease of DO2 values dissolved as a result of an increase in the concentration of organic waste in addition to an increase in the values of other variables.

8. Acknowledgements

The researchers would like to thank the Ministry of Environment for providing the necessary data to complete the research.

References

[1] A. A. Muthanna F. Allawai, "Using GIS and Remote Sensing Techniquesto Study Water Quality Changes and Spectral Analysis of Tigris River within Mosul City, North of Iraq," *Iraqi Journalof Science*, vol. 60, no. 10, pp. 2300-2307, 2019.

[2] J. a. B. R. Bartram, "Water Quality Monitoring - A Practical Guide to the Design," behalf of United Nations Environment Programme and the World Health Organization,, 1996.

[3] W. H. Organization, "Guidelines for Drinking Water Quality," WHO, Geneva, 2004.

[4] A. a. D. A. KUMAR, "Water Quality Index for Assessment of Water Quality of River Ravi At Madhopur (India)," *Global Journal of Environmental Sciences*, vol. 8, no. 1, p. 49 – 57, 2009.

[5] N. B. A. B. K. a. G. T. Tadesse, "Suitability of Groundwater Quality for Irrigation with Reference to Hand Dug Wells, Hantebet Catchment, Tigray, Northern Ethiopia," *Momona Ethiopian Journal of Science*, vol. 3, no. 2, 2011.

[6] M. T.Mustafa, "Assessment Of Water Quality For Al-Gharraf Stream Southeast of -Iraq Using Canadian Council of Ministers Of The Environment (CCME) Index.," *Multidisciplinary Engineering Science and Technology* (JMEST), vol. 4, no. 10, 2017.
[7] A. Abdullah, I. Masih, P. van der Zaag, U. Karim and I. &. A. S. Q. Popescu, "Shatt Al Arab River system under escalating pressure: A preliminary exploration of the issues and options for mitigation," *Int. J. River Basin Manage*., vol. 13, no. 2, pp. 215-227, 2015.
[8] H. Partow, "*The Mesopotamian marshlands: Demise of an ecosystem," UNEP/DEWA, Nairobi*, 2001.
[9] Z. Zahraw Al-Janabi, "Assessment of Water Quality of Tigris River by using Water Quality Index (CCME WQI)," *Al-Nahrain University*, vol. 15, no. 1, pp. 119-126, 2012.
[10] R. A.-H. J. a. R. A. Abbass, "Assessment of Water Quality of Shatt al Arab River in north of Basra.," *Iraqi. J. Aquacult*., vol. 11, no. 1, pp. 37-56, 2014.
[11] M. a. H. N. Moyel, "Water quality assessment of the Shatt al-Arab River,Southern Iraq," *Journal of Coastal Life Medicine*., vol. 3, no. 6, pp. 459-465, 2015.
[12] S. Ewaid, "Water quality evaluation of Al-Gharraf river by two water quality indices," *Applied Water Science*, vol. 7, no. 7, pp. 3759-3765, 2016.
[13] A. D. A. a. N. D. Hamdan, "Assessment study of water quality index (WQI) for Shatt Al-arab River and its branches, Iraq," *Arabian Journal of Geosciences* , vol. 13, no. 654, 2018.
[14] A. e. a. Chabuk, "Water quality assessment along Tigris River (Iraq) using water quality index (WQI) and GIS software," *Arabian Journal of Geosciences*, vol. 13, no. 654, 2020.
[15] A. a. R. A. Ali, "Water Quality Assessment of Shatt Al-Arab River, Southern Iraq Using NSF-WQI," *Biol. Appl. Environ. Res. Journal*., vol. 5, no. 2, pp. 194-202, 2021.
[16] S. Al-Asadi, "A study of pH values in the Shatt Al-Arab River (Southern Iraq).," *International Journal of Marine Science*, vol. 6, no. 29, pp. 1-8, 2016.
[17] A. Al-Saffawi, "Application of the CCME WQI to Evaluate Water Quality for Drinking Purpose: A Case Study for Groundwater Quality of Al-Mahalibiyah Sub District, Nineveh Province/ Iraq.," *Rafidain Journal of Science*, vol. 27, pp. 192-203, 2018.
[18] C. W. Q. G. f. t. P. o. A. Life, "CCME WATER QUALITY INDEX USER'S MANUAL," 2017. [Online]. Available: https://ccme.ca/en/res/wqimanualen.pdf. [Accessed 4 1 2022].
[19] E. K. P. a. F. M. H. A.-M. O. Mohamed, *Pollution Assessment for Sustainable Practices in Applied Sciences and Engineering, Elsevier Inc*., 2021.
[20] R. P. A. P. B. H. S. Sharma, R. P. A. P. B. Hari Shanker Sharma, *Mathematical Modelling in Geographic Information System, Global Positioning System and Digital Catography, New Delhi: Concept Publishing Company*, 2006.
[21] B. A. A. Tabarak S. Hashesh, "Using GIS and Remote Sensing to Study Water Quality Changes and Spectral Analysis forAL-Hawizah Marshes, South ofIraq," *Iraqi Journal of Science*, vol. 59, no. 3C, pp. 1757-1768, 2018.
[22] G. D. L. Emmendorfer, "A Novel Formulation for Inverse Distance Weighting from Weighted Linear Regression," *Computational Science – ICCS* , vol. 12138, p. 576–589, 2020.
[23] C. C. o. M. o. t. Environment, "CCME WATERQUALITY INDEXUSER'S MANUAL," Canadian Environmental Quality Guidelines, 2017 .