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An Assessment of the Water Quality of Some Areas of Shatt Al-Arab and the East Hammar Marsh Using the Water Quality Index WQI

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ABSTRACT
The Canadian Model Water Quality Index was used to evaluate the water quality in some areas of Shatt Al-Arab and the East Hammar Marsh (CCME WQI) during the period from October 2020 to September 2021. The variables used in calculating the index were water temperature, pH value, biological oxygen demand, salinity, and dissolved oxygen. The analysis at Shatt Al-Arab's was categorized as marginal, as stated during the analysis conducted by the CCME-WQI. On the other hand, the East Hammar Marsh's water quality recorded poor rank. This indicates that the environmental factors studied are usually outside the permissible levels. The statistical analysis's findings indicated that there were no significant differences between the first stations (Al-Dair) and the second (Al-Haritha), and there were significant differences found in the third station (Al-Mashab).

INTRODUCTION

Most Iraq's aquatic habitats are rapidly becoming more and more plagued by modern issues and obstacles. To establish competent and manage specialized institutions based on contemporary artistic and technological foundations that ensure the best sustainability as a wealth for future generations, they must urgently and modernly manage their crises through scientific planning based on thorough consultations (**Moyel *et al*., 2023)**.

Water is an essential natural resource for the continuation of life on the surface of the earth. However, with the increase in the population and the increase in human and biological activities, there is a threat to the quality of water and the aquatic environment in general **(Al-Saboonchi *et al*., 2011)**. The world is currently experiencing an environmental catastrophe because of careless planning and irresponsible, harmful environmental use. The root cause of this dilemma is contamination of the environment in general, and water pollution specifically **(Al-Darraji *et al*., 2023)**. Due to a multitude of interrelated factors such as the population growth and the corresponding industrial and agricultural development to accommodate the expanding demands of millions of people, pollution has emerged as a threat to the natural environment that affects life processes and future life development **(Ahmed & Majeed, 2022)**.

Traditional water quality reports are typically overly technical and detailed, focusing only on monitoring data for a small number of water quality indicators rather than providing a thorough evaluation of the water quality. Various water quality indices (WQIs) have been developed to combine water quality indicators to close this gap **(Liou *et al*., 2004)**.

The Canadian Water Quality Index is an efficient mathematical model in evaluating water quality, for its ability to summarize many water quality data and convert them into information that can be easily understood and interpreted by decision makers, administrators and the public **(Rosemo *et al*., 2009)**. The concept of the guide is based on a comparison between a set of water quality variables and the permissible limits according to the permissible standards and specifications, which results in a single number ranging from 0-100, which represents a certain level of water quality **(Akhtar *et al*., 2021)**. Numerous studies have evaluated the water quality in the Marshes and the Shatt Al-Arab, including the study of **Moyil (2010)**, **Al-Saboonchi *et al.* (2011)**, **Essa and Mahmood (2012)**, and **Radi (2014)**. The current study aimed to apply the Canadian Water Quality Manual to assess the water quality of some areas of Shatt Al-Arab and East Hammar Marsh.

MATERIALS AND METHODS

Description of the study area

Located at the point where the Tigris and Euphrates rivers converge near Qurna, north of Basrah, the Shatt Al-Arab is among the most renowned significant rivers in Iraq. It flows southeast for about 195 km until it empties into the Arabian Gulf south of Faw. The river's width varies from 400 meters to approximately 1500 meters, and its depth is between 8 and 15 meters; in rare places, the depths may be greater **(Al-Mahmood *et al.*, 2011)**. Three stations were chosen from the Shatt Al-Arab and East Hammar marshes for this study to gather samples and use the Water Quality Index.

First station (Al-Deir): It is located north of Basrah city within coordinates47°96'37'20'81"E 30.23'18'89'51"N. This area is characterized by the speed of water currents and the presence of the movement of boats used by the population for fishing, Agricultural lands are another feature of the region that defines it on both sides.

Second station (Al Hartha): It is situated inside the latitude and longitude to the north of the Shatt Al-Arab 30.2318895"E 47.9637208"N. The depth of the water ranges from 10-15 m. The area is affected by the tidal movement. There are agricultural lands on both sides of the area and fish are raised in cages.

Third station (Al-Mashab): It is located east of the Hammar Marsh between longitudes and latitudes of 47°42'27.18"E and 30°37'16.68"N. The depth of the water in the islands range between 2.5 to 4.5m constituting many types of aquatic plants (Fig. 1).

Fig. 1. A map displaying the locations of sampling

Canadian water quality index (CCME-WQI)

In this study, the Canadian water quality index (CCME WQI) was used, for its suitability to the local habitats in addition to being approved internationally. Five parameters (Water Temperature, salinity, pH, DO, BOD_5) were selected in the WQI calculation at three stations. The Iraqi standard for the protection of general water resources No. (25) for year 1967 was employed to evaluate the Shatt Al-Arab and East Hammar Marsh's water quality **(MPDC, 1967)**.

The Canadian Water Quality Index 1.0-technical report **(CCME, 2001)** details the WQI's formulation. It consists of the following three factors:

Factor 1 (Scope): It represents, in relation to the total number of variables tested, the percentage of failed variables—variables that fail to accomplish their objectives at least once during the time period under consideration:

F1= (Number of failed variables / Total number of variables) ×100

Factor 2 (Frequency): It shows the proportion of individual tests that are unsuccessful (do not achieve the objectives):

F2 = (Number of failed tests / Total number of tests) ×100

Factor 3 (Amplitude): It indicates the degree to which test values fell short to the desired results. F3 was computed in three phases.

First step: The term "excursion" refers to the frequency with which a single concentration exceeds or falls short of the goal and is defined as follows: where test value cannot be more than the goal:

excursion = (Failed Test Value / Objective value)-1

In the following situations, the test value cannot be less than the goal: excursion =(Objective value /Failed Test Value)-1

When the guideline number is 0

Excursion 3 = failed test result

Second step: The total amount that each test failed to meet compliance requirements. This is computed by adding up each test's deviation from its goal and dividing the result by the total number of tests. The normalized sum of excursion, or nse, is the name of this quantity. It is computed as:

nse = $\sum_{i=1}^{n} \text{excursion} / \text{number ofspecies}$

Third step : The F3 (Amplitude) is determined by scaling the normalized sum of the excursion from objectives (nse) using an asymptotic function, which produces a range from 0 to 100.

F3 = nse / (0.01 nse + 0.01)

Finally, the water quality index was calculated by using this equation:

$$\text{CWQI} = 100 - \left(\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732}\right)$$

Where, the resulting values are normalized to a range between zero and 100, where zero denotes the lowest water quality and 100 the highest water quality, using the divisor 1.732. The following categories were used to rank the quality of the water (Table 1).

Table 1. CWQI ranks water quality according to **CCME (2001)**

Category	Index value
Excellent	95 – 100
Good	80 – 94
Fair	65 – 79
Marginal	45 – 64
Poor	0 – 44

The Excel software was used to design CWQI which is simple and powerful tool to detect water quality problems **(CCME, 2001; UNEP, 2007)**.

RESULTS

During the current study, five variables were measured in three stations during the period from October 2020 to September 2021 in order to apply the Canadian model water quality index (Water temperature, salinity, dissolved oxygen, pH, and biological oxygen demand) (Tables 2, 3, 4).

Table 2. Water's physical and chemical characteristics at the first station

Date	water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	26	1	8.24	4	4
November	21	1.1	8.03	5.6	1.6
December	19	1.2	7.84	4.4	-2.8
January	12	1.3	8.51	5.6	0.2
Febraury	16	1.3	8.14	10	1.6
March	20	1.7	8.13	5.6	-0.4
April	22	2.5	8.03	5.2	1.4
May	26	1.7	8	6.6	2
Juny	18	1.8	7.72	11	5
July	30	2	7.19	14.6	4.1
August	33	1.1	7.52	10.4	5
September	29	1.3	7.32	5	1

Table 3. Water's physical and chemical characteristics at the second station

Date	water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	25	3	8.32	5	1.6
November	22	7.1	7.62	11.2	9.6
December	16	2.3	7.45	6.1	1
January	17	1.6	8	6.2	0.3
Febraury	16	3.12	8.1	10	2.4
March	20	1.8	8.14	6.6	-0.2
April	26	2.5	7.99	6.4	2.2
May	29	1.7	8.02	7.8	4.4
Juny	30	2.2	8.03	7	0.6
July	29	2.1	6.77	15.8	4
August	23	1.5	7.03	10	3.8
September	30	1.2	7.24	7.6	4.4

Table 4. Water's chemical and physical characteristics at the third station.

Date	water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	26	5	8.08	3	0.8
November	28	13.5	8.1	13	10.2
December	20	8.6	7.65	6.3	2.2
January	22	5.9	8.53	5.6	1
Febraury	19	5.9	7.99	8.2	2.2
March	18	5.7	7.94	6.8	6.8
April	30	2.7	7.55	3	2
May	33	4.2	7.81	2.4	0.6
Juny	26	9	7.65	4	0.4
July	33	11.2	6.58	13.2	5.2
August	30	3.5	7.03	10.8	7.2
September	33	2.9	7.12	5.4	1.2

Tables (5, 6 and 7) represent the variables that are within the mean and represented by the symbol (-) and the values of variables that deviate from the mean for the five variables under study.

Table 5. Values of the excursion for the parameters used in the WQI to the first station

Date	water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	0.35	-	-	0.25	-
November	0.67	-	-	-	-
December	0.84	-	-	0.14	-
January	1.92	-	-	-	-
Febraury	1.19	-	-	-	-
March	0.75	-	-	-	-
April	0.59	0.47	-	-	-
May	0.35	-	-	-	-
Juny	0.94	0.06	-	-	-
July	0.17	0.18	-	-	-
August	0.06	-	-	-	-
September	0.21	-	-	-	-

Table 6. Values of the excursion for the parameters used in the WQI to the second station

Date	water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	0.40	0.76	-	-	-
November	0.59	3.18	-	-	0.92
December	1.19	0.35	-	-	-
January	1.06	-	-	-	-
Febraury	1.19	0.84	-	-	-
March	0.75	0.06	-	-	-
April	0.35	0.47	-	-	-
May	0.21	-	-	-	-
Juny	0.17	0.29	-	-	-
July	0.21	0.24	-	-	-
August	0.52	-	-	-	-
September	0.17	-		-	-

Table 7. Values of the excursion for the parameters used in the WQI to the third station

Date	Water temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg/L)	Biological oxygen demand (mg/L)
October	0.35	1.94	-	0.67	-
November	0.25	6.94	-	-	1.04
December	0.75	4.06	-	-	-
January	0.59	2.47	-	-	-
Febraury	0.84	2.47	-	-	-
March	0.94	2.35	-	-	0.36
April	0.17	0.59	-	0.67	-
May	0.06	1.47	-	1.08	-
Juny	0.35	4.29	-	0.25	-
July	0.06	5.59	-	-	0.04
August	0.17	1.06	-	-	0.44
September	0.06	0.71		-	-

Table (8) represents the Canadian model and the values of F1, F2 and F3 for the three stations under study, where the value of the guide in the first station was 60, for the second station was 58, and for the third station was 44.

Table 8. F1, F2, and F3 in the three stations as well as the WQI value

Station	WQI	F1	F2	F3
St.1	60	60	28.33	13.19
St.2	58	60	35	18.81
St.3	44	80	40	35

DISCUSSION

The computation of the water quality index is important to be able to determine the specifications of this water and the degree of its suitability for aquatic organisms and for human and agricultural uses. WQI is a mathematical method for measuring the general condition of surface waters and determining water quality at specific times and places **(Simoes *et al.*, 2008)**. The current study's findings demonstrated distinct regional variations in the water quality index values over the course of the investigation, as the first stations (Al-Dair) and the second (Al-Haritha) were similar, as they were classified under the “Marginal” category, but with different values. All three research stations had low water quality index values, although Al-Mashab, the third station, had the lowest readings.

With an index value of 44, the situation was categorized as "Poor." This could be the result of the study variables' values declining, dissolved oxygen, salinity, biological oxygen demand, water temperature, and pH **(Al-Hejuje, 2014)**. This explains the severe impact of the region on organic pollutants due to the low levels of incoming water and its impact on untreated sewage and agricultural waste. It is also affected by the liquid waste of livestock near the river, as well as the impact of fish farming waste in floating cages located in the area **(Ahmed *et al.*, 2022)**. This finding is in line with a study by **Mahdi *et al.* (2023)** that examined the quality of the Shatt Al-Arab water in Basrah City, South Iraq, using CCME/WQI analysis. He clarified that the river's water quality was poor at all stations and that the reason for this decline in the index values during all study years was that the study stations were close to residential areas, making them susceptible to pollution from the discharge of agricultural waste and wastewater into the river. Therefore, among the most important steps to restore the ecosystem of the Shatt Al-Arab and the Marshes are enhancing the water flow, sustainable management, a firm and unwavering policy, and the prohibition of untreated wastewater discharge into the water.

Water users, planners, and decision-makers can depend on these results to evaluate the Shatt Al-Arab and Marshes' water quality and identify acceptable ways to reduce pollution. These solutions will surely take additional time and effort in addition to sound judgment

CONCLUSION

The quality of the water and its suitability for various uses were assessed using the WQI. The results showed that population density, agricultural practices, and sewage had an overall effect on the water quality of the Shatt Al-Arab. Based on WQI measurements, the Shatt Al-Arab water can be rated as Marginal, whereas the East Hammar Marsh is rated as Poor, due to its effects on sewage water and agricultural activities.

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