



## 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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### ARTICLE INFO

#### Article History:

Received: Aug. 14, 2024

Accepted: Nov. 29, 2024

Online: Dec. 31, 2024

#### Keywords:

Water Quality,

WQI,

East Hammar Marsh,

Shatt Al-Arab

### 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 are water temperature, pH value, biological oxygen demand, salinity, and dissolved oxygen. The analysis of the water's quality, as assessed by CCME WQI, showed that the Shatt Al-Arab's water quality was categorized as Marginal, while the East Hammar Marsh's water quality was assigned the rank of Poor, which means that the environmental factors studied are usually outside the permissible normal 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 with the third station (Al-Mashab).

### INTRODUCTION

The majority of Iraq's aquatic habitats are rapidly becoming more and more plagued by modern issues and obstacles. In order to establish competent and managed specialized institutions based on contemporary artistic and technological foundations that ensure the best sustainability as a wealth for future generations, they must, therefore, 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, but 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 as a result 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, chief among them 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 in order 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 a large number of water quality data and convert them into information that can be easily understood and interpreted by decision makers, administrators and the general 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 Al-Saboonchi *et al.* (2011), Essa and Mahmood (2012), Radi (2014), Hamdan, *et al.* (2018), Aldoghachi and Altamimi (2021) and Moyel *et al.* (2023).

The current study aims to present information about the role that has been played in evaluating and controlling the water quality of the Shatt al-Arab and East Hammar Marsh in Basrah city by assessing the river's state for various purposes and benefiting from it for decision-makers, sectors that benefit from the river, residents of the governorate, and specialized researchers. As an extension of the work of researchers who studied the quality of the East Hammar Marsh and Shatt al-Arab water, the research thus diagnoses the environmental issues the river faces and discovers remedies and solutions through new data and the results obtained that can be used in the interest of society.

## MATERIALS AND METHODS

### Description of the Study Area

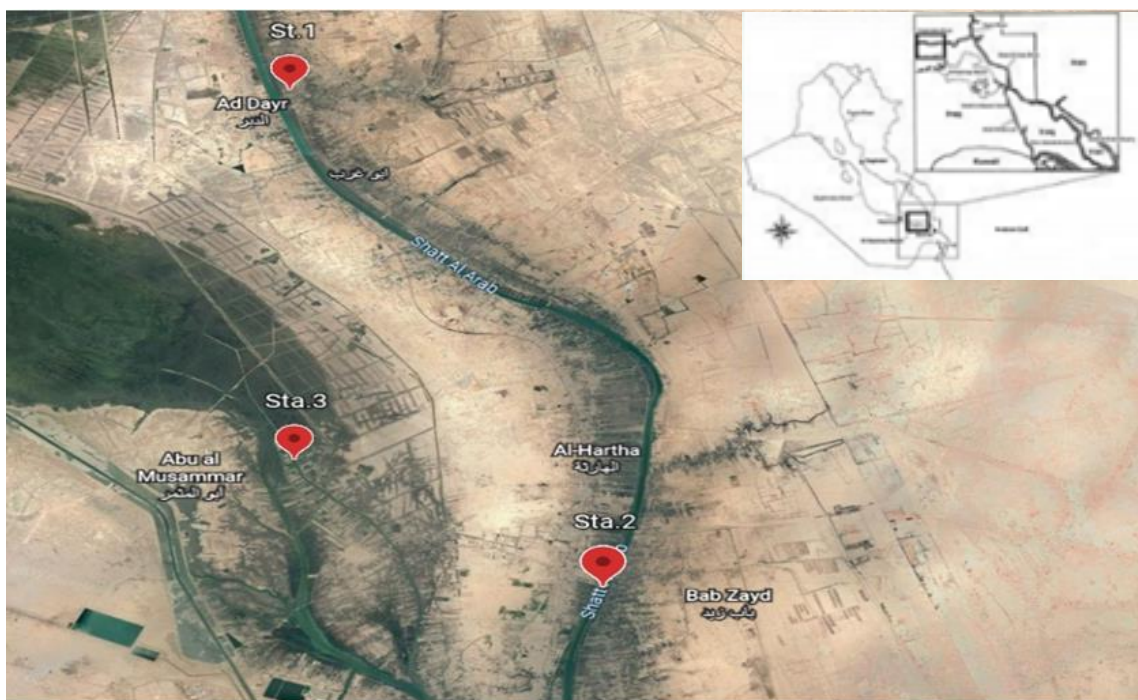
The Shatt Al-Arab is one of the most well-known and important rivers in Iraq. It is situated north of Basrah, close to Qurna, at the confluence of the Tigris and Euphrates rivers. It flows southeast for about 195 km until it empties into the Arabian Gulf south of Faw. The river's width varies from 400 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 in order to gather samples and use the Water Quality Index.

**First station (Al-Deir):** Located north of Basrah city within coordinates (47°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 47°42'27.18"E and 30°37'16.68"N. The depth of the water during the islands ranges between 2.5 to 4.5 m and there are 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 since it matches the local habitats and for its international approval. Five parameters (Water Temperature, salinity, pH, DO, BOD<sub>5</sub>) 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): 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:

$$F1 = (\text{Number of failed variables} / \text{Total number of variables}) \times 100$$

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

$$F2 = (\text{Number of failed tests} / \text{Total number of tests}) \times 100$$

Factor 3 (Amplitude): Indicates the degree to which test values that failed fall short of the desired results. F3 is 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:

$$\text{Excursion} = (\text{Failed Test Value} / \text{Objective value}) - 1$$

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

$$\text{Excursion} = \text{failed test result}$$

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:

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

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:

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

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 to detect water quality problems, according to the method of **CCME (2001)** and **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	-	-	-	-
February	1.19	-	-	-	-
March	0.75	-	-	-	-
April	0.59	0.47	-	-	-
May	0.35	-	-	-	-
June	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	-	-	-	-
February	1.19	0.84	-	-	-
March	0.75	0.06	-	-	-
April	0.35	0.47	-	-	-
May	0.21	-	-	-	-
June	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) shows the Water Quality Index values representing 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 58 and for the third station 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). Although the first station (Al-Dair) and the second station (Al-

Haritha) were comparable in that they were categorized under the "Marginal" category, the results of the current study showed clear geographical changes in the water quality index values over the course of the examination. Although Al-Mashab, the third research site, had the lowest readings, all three had low water quality index scores. 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)** 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 is in line with a study of **Mahdi et al. (2023)** that examined the quality of the Shatt Al-Arab water in Basrah City, South Iraq, using CCME/WQI analysis. They clarified that the river's water quality was poor at all stations and that the reason for his 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.

The results of this investigation are consistent with those of **Moyel et al. (2023)**. The results of the study show that most water quality variables have declined, particularly those that deal with dissolved salts and organic and bacterial contaminants. On the WQI scale, the water quality at every station during the study period was graded as low. The middle half of the water's quality has decreased, particularly during the dry season, according to the WQI data. Elevated salinity and organic pollution are the two main reasons why the waters in the Shatt al-Arab River's middle portion are deteriorating. In general, strict supervision is needed, especially in the middle section of the Shatt al-Arab River. Therefore, improved water flow, sustainable management, a strict and steadfast policy, and the ban on untreated wastewater discharge into the river are among the most crucial elements to restore the ecosystem of the Shatt Al-Arab and the Marshes.

These findings can be used by water users, planners, and decision-makers to assess the water quality of the Shatt Al-Arab and Marshes and find workable solutions for pollution reduction. These alternatives will undoubtedly need more time, energy, and good judgment.

## CONCLUSION

The quality of the water and its suitability for various uses are assessed using the Water Quality Index. The results showed that population density, agricultural practices, and sewage all 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, agricultural activities, and sewage water.

## REFERENCES

- Ahmed, M.H., and Majeed, H.S.** (2022). AN Assessment of water quality of the north and south part of the Shatt AL-Arab using organic pollution index (OPI). *Annals of forest research*, 65(1): 4939-4945.
- Ahmed, M.H.; Abdullah, A.M. and Nasir, N.A.N.** (2022). Study of organic pollution indicators in two stations of the Garmat Ali River, Basrah, Iraq. *Iraqi Journal Aquacult.* Vol. (19) No.(1): 75-90
- Akhtar, N.; Ishak, M.I.S.; Ahmad, M.I.; Umar, K.; Md Yusuff, M.S.; Anees, M.T.; Qadir, A. and Ali Almanasir, Y.K.** (2021). Modification of the Water Quality Index (WQI) Process for Simple Calculation Using the Multi-Criteria Decision-Making (MCDM) Method: A Review. *Water* .905 ,13 <https://doi.org/10.3390/w13070905>
- Al-Darraji, J.L.K.; Alshami, I.J.J. and Ankush, M.A.T.** (2023). Effect of Some Heavy Metals in the Industrial Flows on Shatt al-Arab River . *Egyptian Journal of Aquatic Biology & Fisheries*, Vol. 72(3): 801 – 814.
- Aldoghachi, M.A. and Altamimi, D.E.** (2021). Assessment of water quality using heavy metals concentrations in several water resources of Shat Al-Arab River and tissues of Nile tilapia (*Oreochromis niloticus*) and shrimp (*Metapenaeus affinis*). *Egyptian Journal of Aquatic Biology and Fisheries*, 25 (2): 803-817.
- Al Hejuje, M.M.K.** (2014). Application of water quality and pollution indices to evaluate the water and sediments status of the middle part of Shatt Al Arab River. Unpublished Ph.D.Thesis, College of Science, University of Basrah, Iraq. pp. 239.
- Al-Mahmood, H.K.H.; Al-Sayaab, H.A.; Al-Miahi, D.S.B.; Mahmoud, A.B. and Mutasher, W.R.** (2011). One dimensional model to study hydrodynamics properties for north part of Shatt Al Arab River (south Iraq) *Basrah Journal of Science*, 28(1), 1-14.
- Al-Saboonchi, A.M.; Mohamed, A.M.; Jawad, H.S.A. and Maulood, B.K.** (2011). On the current and Restoration Conditions of the southern Marshes: Application of the CCME WQI on the East Hammar Marsh .*Journal. of Environmental protection* .Vol. 2, pp316-322.
- Canadian Council of Ministers of the Environment(CCME).**(2001). Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, Technical Report. In: Canadian environmental quality guidelines, 1999. Winnipeg: Canadian Council of Ministers of the Environment. 14pp.
- Essa, A.M. and Mahmood, A.A.** (2012). An Assessment of the treated water quality for some drinking water supplies at Basrah. *Journal of basrah researchers (sciences)* Vol. 38, No.3, pp95-105.

- Hamdan, A.; Dawood, A. and Naeem, D.** (2018). Assessment study of water quality index (WQI) for Shatt Al-arab River and its branches, Iraq," Arabian Journal of Geosciences, vol. 13, no. 654. <https://doi.org/10.1051/mateconf/201816205005>
- Liou, S.M.; Lo, S.L. and Wang, S.H.** (2004). A generalized waterquality index for Taiwan, Environmental Monitoring and Assessment. 96(1): 35-52. <http://dx.doi.org/10.1023/B:EMAS.0000031715.83752>.
- Mahdi, F.; Abdul Razzaq, B. and Sultan, M** (2023). Assessment of Shatt Al-Arab Water Quality Using CCME/WQI Analysis in Basrah City of South Iraq. Iraqi Journal of Science, 64(1), 480-491. <https://doi.org/10.24996/ijs.2023.64.1.42>
- Moyil, M.S.** (2010). Assessment water quality for North part from Shatt Al-Arab river to using water quality index Canadian spacemen" Thesis of Science college. pp 1-100.
- Moyel, M.S.; Akbar, M.M. and Hussain, N.A.** (2023). Evaluation of Spatio-Temporal Changes in Water Quality in the Middle Section of the Shatt Al-Arab River, Southern Iraq, Journal of Ecological Engineering 2023, 24(4), 297–311. <https://doi.org/10.12911/22998993/161014>
- MPDC (Ministry of Planning and Development Cooperation).** (1967). Maintenance of rivers and public water system from contamination No. (25) for the year 1967. Baghdad: Ministry of Planning and Development Cooperation; 1980. Arabic. Modelling, 193: 560-574.
- Radi, F.K.** (2014). Assessment of Al-Hamar marsh protectorate nature for uses ecology index Unpublished Msc. thesis Basrah University, Iraq ,pp113.
- Rosemo, S.; Duro, D.C. and Dube, M.** (2009). Comparative analysis of regional water qualityin Canada using the Water Quality Index. Environmental Monitoring and Assessment, Vol. 156,pp 223–240.
- Simoès, F.; Moreira, A.B.; Bisinot, M.C.; Gimenez, S.M. and Yaba, M.J.** (2008). Water quality index as a simple indicator of aquaculture effects on aquatic bodies. Ecol. Indic., 8: 476-484.
- United Nations Environment Programme (UNEP)** (2007). National Water. Global Environment Monitoring System/Water Programme, UNEP/GEMS. C/O.