Available online at https://bajas.edu.iq
https://doi.org/10.37077/25200860.2023.36.2.19
College of Agriculture, University of Basrah

Basrah Journal of Agricultural Sciences

ISSN 1814 – 5868 **Basrah J. Agric. Sci., 36(2), 243-255, 2023** **E-ISSN: 2520-0860**

Assessment of Water Quality of East Hammar Marsh Using Water Quality Index (WQI) Following the Cessation of Saline Tide in 2018

Naeem S. Hammadi[1*], Mujtaba A.T. Ankush[1], Sajad A. Abdullah[2], Adel K. Jassim[1], & Alaa A. Maytham[1,3]

[1] Department of Fisheries & Marine Resources, College of Agriculture, University of Basrah, Iraq
[2] Department of Biology College of Education-Qurna University of Basrah, Iraq
[3]Marine Science Center, University of Basrah, Iraq

* **Corresponding author email**: **N.S.H.**: naeem.hammadi@uobasrah.edu.iq; **M.A.T.A.**: mujtaba.tahir@uobasrah.edu.iq; **S.A.A.**: sajadabd1964@gamil.com; **A.K.J.**: adel.jassim@uobasrah.edu.iq; **A.A.M.**: alaa.msc92@gmail.com

Received 15th February 2023; Accepted 19th October 2023; Available online 30th December 2023

Abstract: The water quality index (WQI) was studied monthly, from November 2018 to October 2019, at three stations (Al-Saddah, Al-Burgah, and Al-Marsa) in the Basrah Governorate's East Hammar Marsh. This study measured various environmental factors, including water temperature, pH, dissolved oxygen, biological oxygen demand, light penetration, salinity, total dissolved salts, total hardness, nitrates, nitrites, phosphate, sulfate, calcium, and magnesium. After the end of the salty tide in 2018, the first station showed poor seasonal evidence 43.7 (low WQI score) in the winter, fair 67.6 and 64.9 (third category) in the spring and summer respectively, and marginal 55.9 (fourth category) in the summer and fall. The second and third stations had poor WQI score in the Winter and marginal in the rest of the seasons. The results indicate that the water quality is polluted and deviates from its optimal state. The WQI values varied significantly across all sites. The lack of freshwater drainage and ongoing marine water impacts are the reasons for the deterioration of water quality. Treatment is recommended to address this issue.

Keywords: CCME, East Hammar marsh, Inland water, Southern Iraq.

Introduction

Freshwater is a vital and limited resource necessary for life, as well as for various agricultural and industrial uses. Thus, ensuring an adequate quantity and quality of freshwater is required to develop renewable sources of water (Dunea *et al*., 2020). Scientific studies support the importance of water treatment for maintaining its quality (Borchardt *et al*., 2016).

Deterioration of water quality can occur due to human activities, including the discharge of harmful chemicals and an uptick in pollutants. These factors may contribute to elevated nutrient concentrations in surface waters. (Stoner & Albrey Arrington, 2017). These impacts on nature can have dire consequences and upset the balance of natural resources due to society's increasing use of them (Galal *et al*., 2022). Therefore, ongoing efforts are being made to develop technologies and approaches to prevent these negative consequences and safeguard and optimize natural resources (Dunea *et al*., 2020). These approaches are based on scientific research to enhance our understanding of the processes and phenomena that occur in the Earth's water (López-Felices *et al*., 2020).

It is essential to develop comprehensive solutions to control contamination, water use, and land management to ensure effective management of water resources, particularly water quality (Syed & Jodoin, 2006).

However, surface water monitoring should be conducted through a well-planned approach that involves collecting samples, measuring and recording water parameters, and meeting quality criteria and goals in the short and long term. Water quality monitoring should be carried out at level and number of water basins, using models that provide a wide range of monitoring results over space and time while considering conditions of water body, hydrology and geomorphology (Uddin *et al*., 2021). Appropriate techniques should be used to account for various processes, such as pollutant transport capacity, dilution, decomposition, dispersion and photosynthesis (Echeverría *et al*., 2019).

Abdel-Satar *et al*. (2017) studies water quality index (WQI), heavy metal pollution index (HPI) and contamination index (Cd) at 24 stations in the Nile river. Othman *et al*. (2021) performed an assessment of the surface water quality along the Rodetta branch of the Nile river, Egypt using the Nile Chemical Pollution Index (NCPI) and microbiological pollution.

Iraq is include different water bodies, the two famous rivers, Tigris and Euphrates, with their tributaries, the Shatt Al-Arab river, reservoirs, lakes, and marshes. Wetlands are among the most productive ecosystems and support human life in various fields (Al-Gburi *et al*., 2017).

The southern marshes of Iraq are one of the largest wetland areas in the Middle East and are characterized by their high primary productivity of aquatic plants and plankton. They are food base, shelter, spawning and nursery areas that support countless species of fish, birds, shellfish, mammals, reptiles and amphibians. (Hussain, 2014). Among the southern marshes, the Hammar Marsh is important as water storage, control floods, reducing greenhouse gas emissions that contribute to climate change, moreover, provide critical habitat to native and endangered species (Al-Saboonchi *et al*., 2014).

Some studies have been addressed the water quality and environmental status of Hammar marsh. Al-Gburi *et al*. (2017) focused on water quality at various sites in the Hammar marsh, measuring various parameters of the water. Al-Saad *et al*. (2010) conducted a water quality survey in six stations, including two in the Hammar marsh.

Quality of water at the East Hammar Marsh was evaluated by several studies using different methods. Al-Saboonchi *et al*. (2011) used the Canadian WQI (CCME) to assess water quality and found it to be poor to marginal. Al-Musawi *et al*. (2018) used GIS to evaluate water quality, while Al-Nagar *et al*. (2020) studied the WQI in the East Hammar during a severe increase in salinity in 2018. Moyel (2010) found WQI values for general purposes, irrigation, and drinking to be within the third and fifth categories, in the fifth category of water consumption, also in the poor and good category for irrigated water from the northern part of the Shatt Al-Arab river. Abdullah *et al*. (2018) found that the Tigris river waters were generally agreeable, with the best quality in winter and spring. Maytham *et al*. (2019) recorded the highest water quality value (61.46) in the fourth category in summer and the lowest (33.11) in the fifth category in winter for the second station in the middle part of the Shatt Al-Arab river. Given the ongoing environmental changes affecting the East Hammar Marsh and other bodies of water in Basrah governorate, this study aims to assess water quality in three sites using physical and chemical measurements and the Canadian model, following the resolution of the salty tide problem in 2018.

Materials & Methods

The East Hammar Marsh, located in southern Iraq, is part of the wetlands of the Tigris and Euphrates rivers. It is divided into two sections. The western section is in the south of Thi-Qar Governorate and receives water from several rivers. The eastern section is in the north of Basrah Governorate and currently receives most of its water from the Shatt Al-Arab river, which is continuously affected by environmental changes and tides (AL-Musawi *et al*., 2018). Three study stations, namely Al-Saddah (30º 36′ 29″ N, 47º 40′ 16″ E), Al-Marsa (30º 37′ 23″ N, 47º 40′ 02″ E), and Al-Burga (30º 41′ 07″ N, 47º 35′ 56″ E), were chosen in the East Hammar Marsh (Fig. 1)

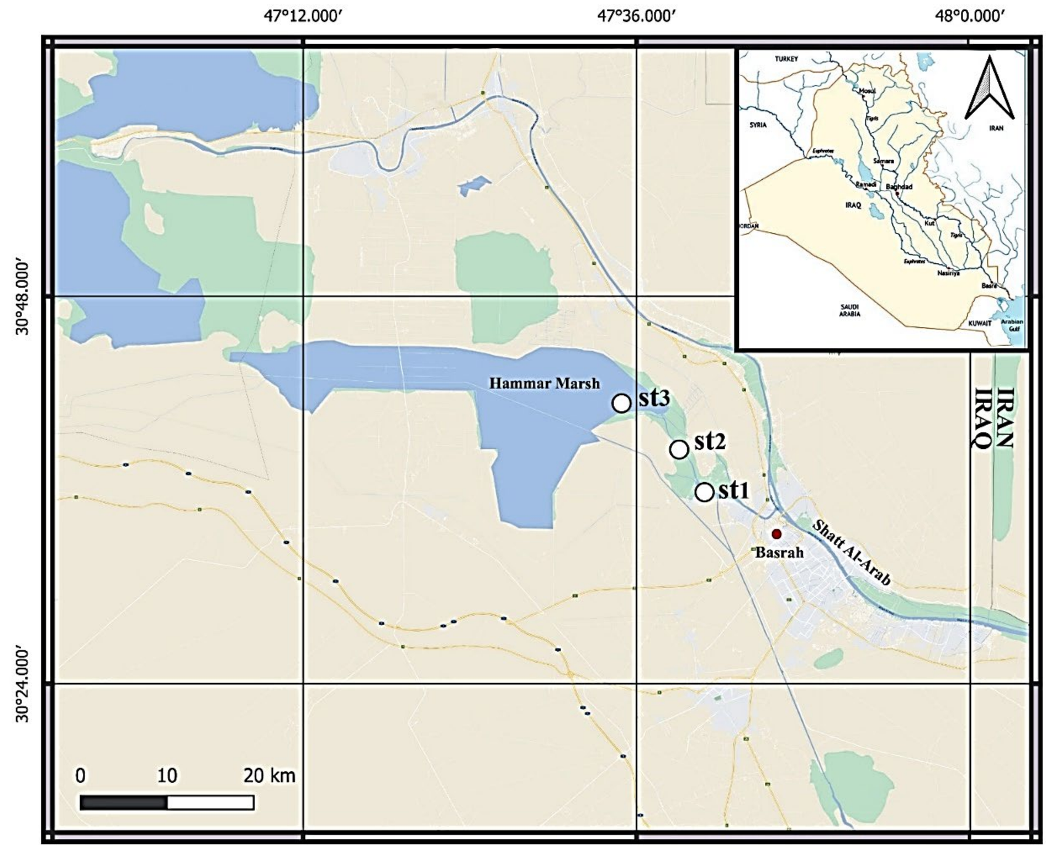

Fig. (1): Map of study area.

Samples were collected monthly from selected study sites between November 2018 and October 2019. The water quality index was calculated based on 14 environmental factors. Water temperature was measured in the field using a graduated mercury thermometer ranging from 0 to 100°C. Salinity, pH, DO, and TDS were measured using a YSI multi-meter. The determination of BOD_5, sulfate, total hardness, calcium, and magnesium followed the methods described in APHA (2005). The methods described by Parsons *et al*. (1984) were used to determine nitrites, nitrates, and phosphates. Light penetration was measured using a Secchi disk. The Canadian Water Quality Index (CCME WQI) was applied to estimate the quality of water at the East Hammar marsh. The application of this index depends on several basic steps, including determining the period. It is considered a challenging index for evaluating water quality, as it requires sufficient data to obtain a matrix of numbers that the mathematical model can easily interpret to produce acceptable results. The Iraqi standards and specifications for water No. 417, the second update of 2009, was used to calculate the Canadian Water Quality Index described by CCME (2001), which depends on the collection of three elements, namely: Scope, symbolized by (F1): It illustrates the percentage of variables whose values do not match the criteria set for the model (failed variables), and it is calculated using the following equation:

$$F_1 = \frac{Failed\ Variables\ Number}{Variables\ Total\ number} * 100$$

Frequency symbolized by F_2: It symbolizes percentage of tests whose values don't match the criteria set for the model (failed tests), and it is calculated from the following equation:

$$F_2 = \frac{Number\ of\ failed\ tests}{Total\ number\ of\ tests} * 100$$

Amplitude, symbolized by F_3: It represents the number of values of failed tests whose values do not match the established criteria. It is calculated in three steps:

1-The measure of excursion, which represents the number of times the test value moves away from the value of the established criterion, is calculated from the following equation:

Excursion= (Failed tests value/objective) -1

Or the test value is less than the value of the established standard, so it is calculated from the following equation:

Excursion = (objective/ Failed tests value) -1

2- Calculate the sum of the Normalized Sum of Excursion NSE, which represents the cumulative amount of individual tests whose values do not meet the established criteria and is calculated by dividing the sum of deviations by the total sum of the tests conforming and non-conforming to the established criteria, as follows:

$$NSE = \sum_{i=1}^{n} \frac{ecxcursion}{number\ of\ tests}$$

3- After that, the capacitance (F_3) is calculated from the following equation:

$$F_3 = \frac{nse}{0.01 * nse + 0.01}$$

The water quality index is calculated from the following equation:

$$WQI = 100 - [\frac{\sqrt{(F_1)^2 + (F_2)^2 + (F_3)^2}}{1.732}]$$

The division by the number 1.732 is to keep the resulting index value 0-100, then expresses the state of the water body by linking the value of the index with a numerical scale divided into five categories, each of which represents the level of quality of water and expresses the condition of the body of water as at table (1).

Table (1): Water quality rating based on the WQI values depending on CCME (2001).

WQI value	The state of water quality	Description
95-100	Excellent	The water is perfectly protected and far from sources of pollution, as it approaches the ideal condition.
80-94	Good	The water is well protected and the specifications are far from ideal.
60-79	Fair	Water is often protected, but is vulnerable to contamination and is away from the optimum state in some cases
45-59	Marginal	Water exposed to pollution and is predominatingly away from the optimum state
0-44	Poor	Water is always vulnerable to contamination and is away from the optimum state

Results & Discussion

Attention to the water quality index is critical in light of the ongoing water challenges in Iraq, especially in the study area, to evaluate the environmental effects caused by climate change and the continuous deterioration of water bodies (Al-Ansari *et al*., 2014).

The study focused on evaluating the environmental effects caused by climate change and the continuous deterioration of water bodies in the region. The results presented in table (2) indicate significant challenges and concerns regarding water quality in the East Hammar Marsh, Iraq.

Table (2 shows the calculated index values for the study stations, depending on the river conservation system for the year 1985. The evidence for the first, second, and third stations was low during the winter within the fifth category, and the index values were recorded in the spring within the third category, acceptable for the first station and marginal within the fourth category for the second and third stations. During the summer and fall seasons, the study stations were within the fourth category, marginal, and throughout the year within the fourth category, marginal for the first and second stations, indicating that the waters are vulnerable to contamination and mostly away from optimal conditions, and within the fifth category, poor for the third station, indicating that the water is always vulnerable to contamination and away from optimal conditions.

The index values calculated for the study stations revealed that the water quality was generally poor and fare away from optimal conditions. The first and second stations showed marginal water quality conditions, indicating vulnerability to contamination.

Nevertheless, the third station consistently displayed poor water quality throughout the study period, indicating a constant susceptibility to contamination . The decline in water quality was mostly related to some factors such as salinity, dissolved solids and total hardness. These variability were identified as the most effective factors control water quality index. The study also highlighted the impact of industrials and agricultural activities, in addition the effect of dams that constructed upstream in the Tigris and

Euphrates rivers, on the water quality in that region (Khalaf *et al*., 2021).

Results confirm that the water quality in East Hammar marsh has better since study of Al-Nagar *et al*. (2020), where they indicated that water quality in during high salinity period in Summer 2018 was poor category and did not provide protection for aquatic life, irrigation or drinking, with values range between 25 and 31.

Some environmental parameters were measured to determine who is responsible for the degradation in water quality at Hammar Marsh. The highest salinity values were recorded in November 2018 as a result of the sharp rise in salinity concentrations coming from the Gulf (Al-Nagar *et al*., 2020).

Table (2): The general water quality index values and their taxonomic denominations in the study sites

	Station 1		Station 2		Station 3	
	WQI value	Category	WQI value	Category	WQI value	Category
Winter	43.7	Poor	41.2	Poor	43.3	Poor
Spring	67.6	Fair	59.2	Marginal	57.4	Marginal
Summer	64.9	Fair	55.2	Marginal	61.0	Marginal
Autumn	55.9	Marginal	56.9	Marginal	57.4	Marginal
Full year	51.0	Marginal	46.8	Marginal	45.2	Marginal

Fig. (2) shows the monthly fluctuations in the values of the water temperature and pH, at three stations of the East Hammar Marsh from November 2018 to October 2019. The lower and higher values ranged between (10-31) ºC, (7.1-8.4) respectively.

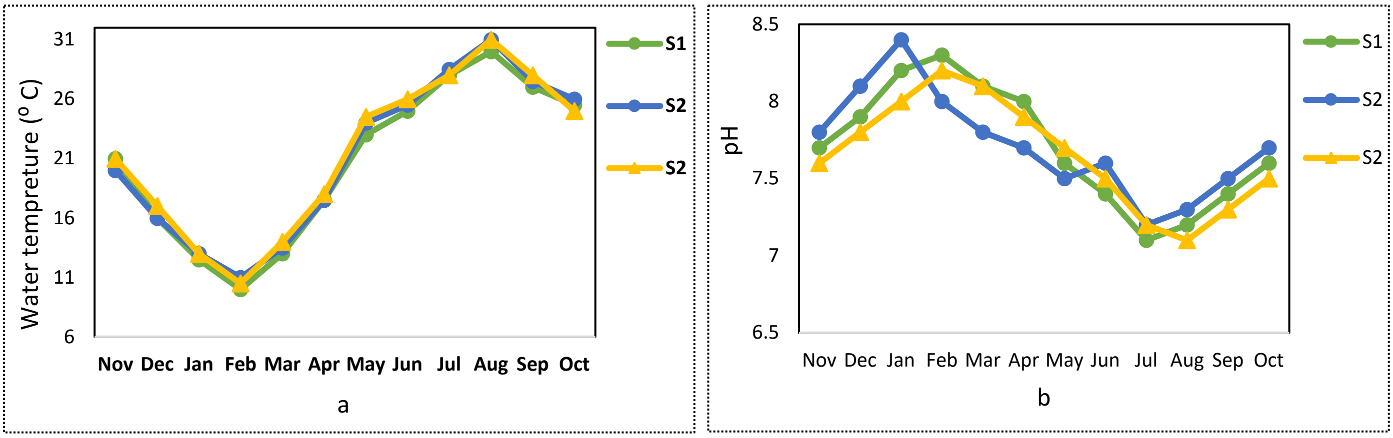

Fig. (2 a and b): Monthly variations in the water temperature and pH at three stations of the East Hammar Marsh from November 2018 to October 2019.

Fig. (3) shows the monthly changes in the values of the DO, BOD_5, light penetration, salinity, TDS and NO_3, at three stations of the East Hammar Marsh from November 2018 to October 2019. The lower and higher values ranged between (6.4-10.2) mg. l^{-1}, (0.7-2.2) mg. l^{-1}, (35-114) cm, (2.11-8.32) p.p.t., (2232-8673) mg. l^{-1} and (1.3-19.6) µ N atom. l^{-1} respectively.

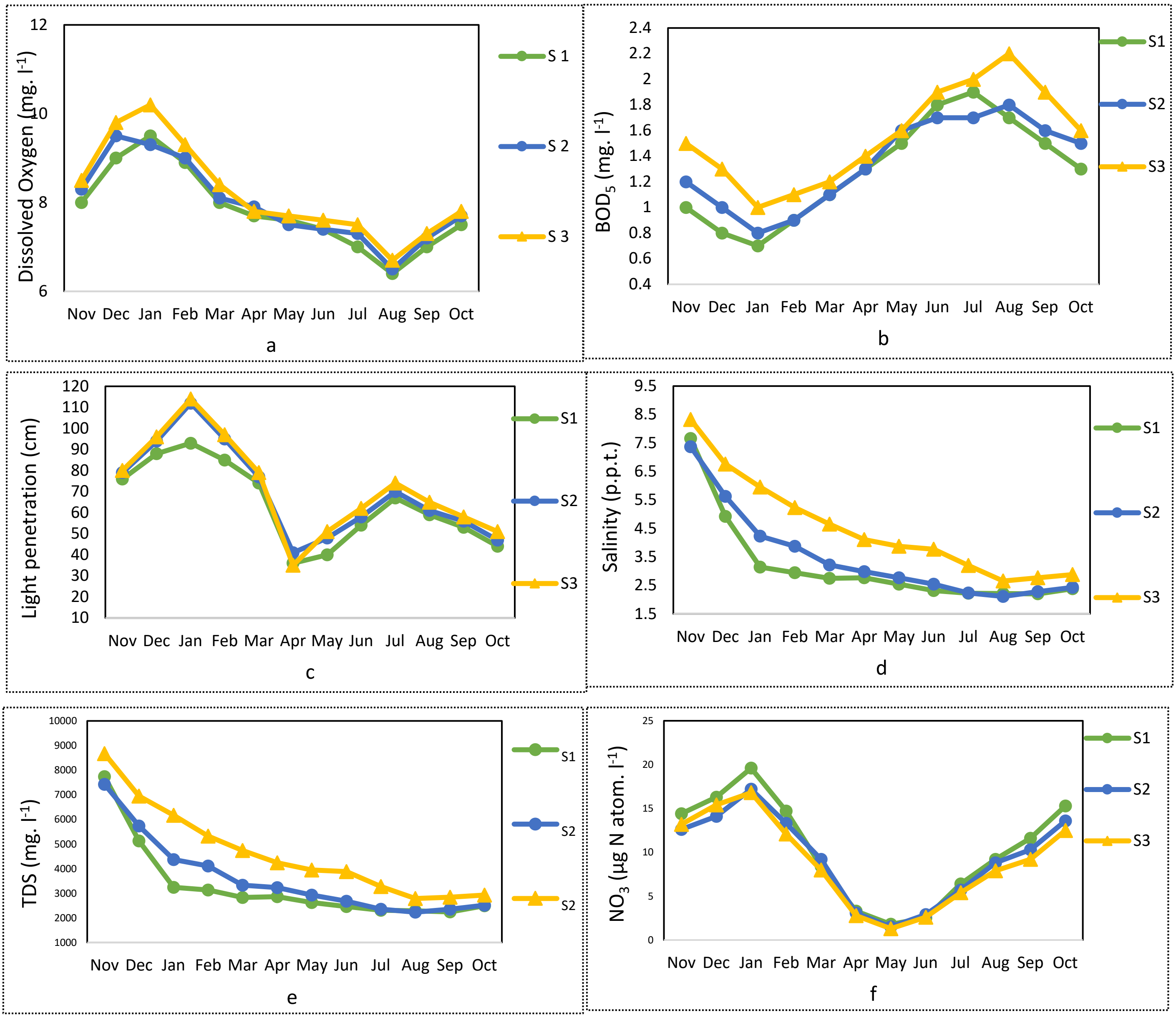

Fig. (3: a-f): Monthly fluctuations in the DO, BOD_5, Light penetration, Salinity, TDS, NO_3 at 3 stations of the East Hammar Marsh from November 2018 to October 2019.

Fig. (4) shows the monthly fluctuations in the values of NO_2, PO_4, SO_4^{-2}, Total Hardness, Ca^{+2} and Mg^{+2} at three stations of the East Hammar Marsh from November 2018 to October 2019. The lower and higher values ranged between (0.09-0.98) µ N atom. l^{-1}, (0.33-2.19) µ P atom. l^{-1}, (156-331) mg. l^{-1}, (537-1254) mg. l^{-1}, (131-263) mg. l^{-1} and (38-127) mg. l^{-1} respectively.

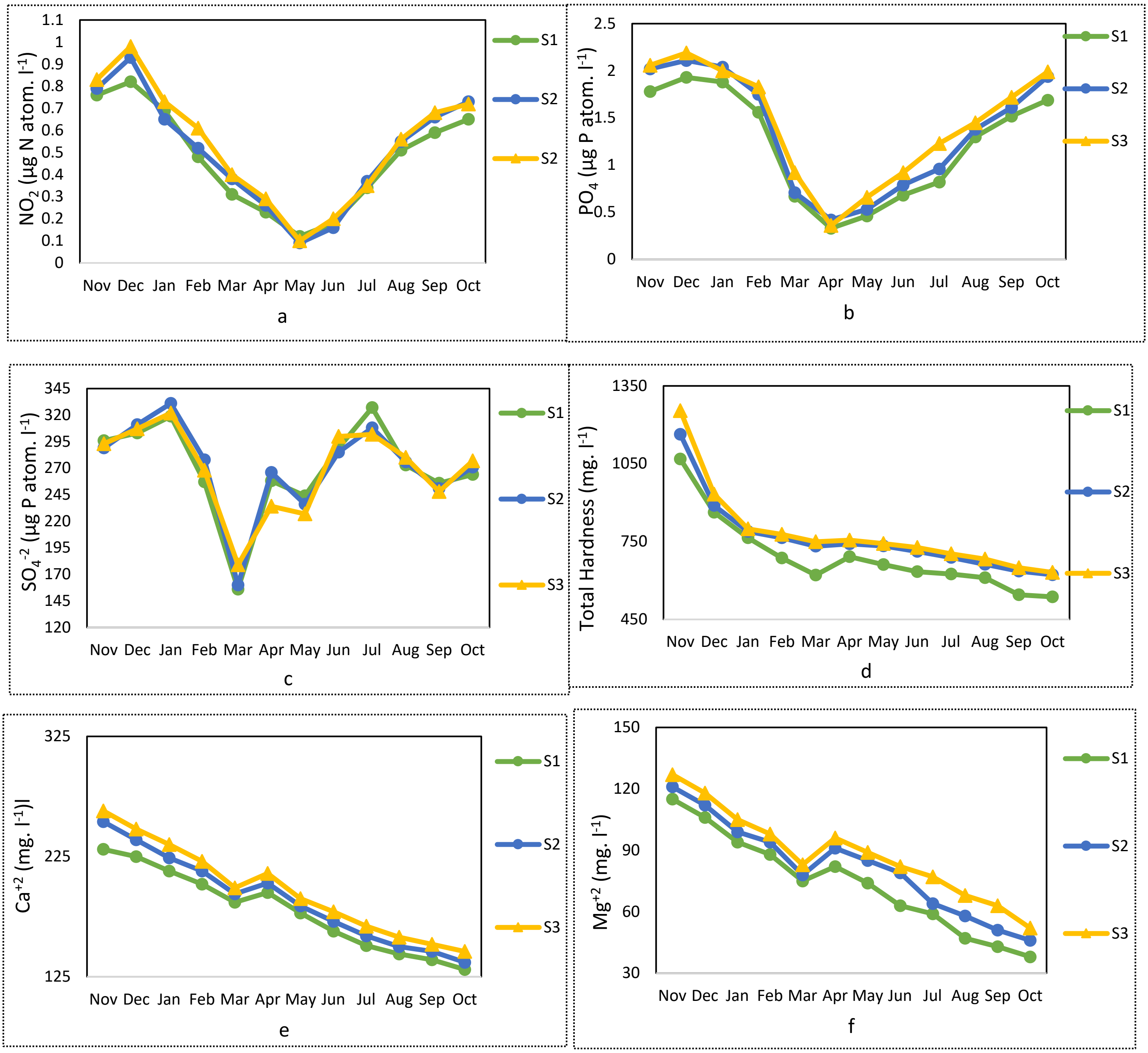

Fig. (4: a-f): Monthly changes in the NO_2, PO_4, SO_4^{-2}, Total Hardness, Ca^{+2} and Mg^{+2} at 3 stations of the East Hammar Marsh from November 2018 to October 2019.

In addition, it is noting that the investigation brought to light that the water quality in the East Hammar Marsh was particularly impacted by salt tides originating from the Gulf. The results shows that Winter season was lowest water quality, which was characterized by significant different in terms of salinity and dissolved solids contents. Nevertheless, an enhancement in water quality was observed during period of the other seasons, which may due to an increase in precipitation, flow rates and a decrease in salt tide outflow.

It is significantly to highlight that the results of current study clearly diverge from results of previous local studies conducted in same study area, including the changing of water quality and its spatial and temporal fluctuations. The strongly underscore is necessity for the application of efficient management strategies that can effectively reduce the risks associated with contamination and ensure the long-term viability of water resources in the East Hammar Marsh and its surrounding areas (Mohamed *et al*., 2017).

The Water Quality Index (WQI) provided a brief assessment and consider as good tool of water quality status in the study area. It has been summarized multi chemicals and physicals data. (CCME, 2001).

According to Al-Nagar *et al*. (2020), the water quality in the East marsh deteriorated due to a sudden increase in salinity concentrations during Summer 2018. They also classified the water quality in the fifth category as poor, where indicated that it does not support aquatic life and un suitable for drinking or irrigation.

East Hammar marsh, a tidal marsh, effected by the waters of Shatt Al-Arab river. Mohamed *et al*. (2014) found that the marsh has been impacted by industrial and agricultural activities, as well as marine tides. Al-Saboonchi *et al*. (2011) classified the water quality in the marsh as poor, with high concentrations of sodium and nitrogen that frequently exceed acceptable limits, in addition, they concluded that the water quality does not meet standard requirements. These changes are likely due to the dams construction upstream in the Tigris and Euphrates rivers, which have caused deteriorated water quality of Shatt Al-Arab river.

East Hammar Marsh is linked to Shatt Al-Arab river through Qarmat Ali river in the south, therefore is effected by salt tides from the Arbian Gulf (Mohamed *et al*., 2014). WQI index value show decreased during Winter period, with water quality classified as poor in all three stations due to sharp rises in salinity and dissolved solids concentrations. Though, there was an improvement in water quality during the other seasons until it reached a marginal fourth category in the Autumn 2019, may due to increased rainfall, flow rates, and decreased salt. The results of the statistical analysis indicated significant differences between the stations at a significance level of P≤0.05. Fig. (3) illustrates the PCA analysis of the correlation coefficients between some environmental factors during the study period from the three stations in the East Hammar Marsh to determine the relationships between them.

The direction and magnitude of the arrow indicate the degree of influence on the WQI. As seen in the fig. (3), six environmental parameters had a significant effect on the WQI, namely temperature, salinity, electrical conductivity, total dissolved solids, calcium, and magnesium. These parameters were chosen from multiple factors affecting the WQI in previous studies conducted on Al-Hammar marsh and Qarmat Ali rive. (Mohamed *et al*., 2014; Yassen *et al*., 2019)

Fig, (5) shows PCA analysis of the correlation coefficients between some environmental factors at three stations of East Hammar marsh from November to October 2019.

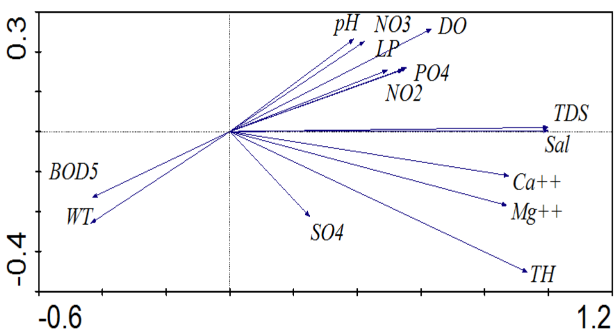

Fig. (5): PCA analysis of the correlation coefficients between some environmental factors at three stations of the East Hammar Marsh from November 2018 to October 2019.

The special variations on water quality index values among stations and the temporal variations among seasons can be related to the extent of variables values from the standard during the study period.

According to the study of Al-Nagar *et al.* (2020), all the variables being studied display an negative correlation with the WQI index, which eventually indicate to water quality deterioration, with the magnitude of their impact playing a critical role in determining the overall water quality. Among the variables considered, TDS, salinity, total hardness, calcium, magnesium, and sulfate showed the most significant differences, therefore exerting the highest level of influence on the water quality index. The results obtained during the winter season of 2018 in the present study corroborated the findings of Al-Nagar *et al.* (2020), except for the remaining seasons, where a sharp increase in salinity was observed, resulting in the classification of water as poor and unsuitable for various purposes. However, throughout the rest of the year, the outcomes of this study aligned with those reported by Al-Saboonchi *et al.* (2014) for the East Hammar Marsh and Moyel (2010) for the Shatt Al-Arab river, where the water quality was classified as fair to marginal and deemed suitable for irrigation and other applications. It is worth noting that the East Hammar Marsh experienced a poor water quality status during the period between 2005 and 2006 due to a decline in water quality (Al-Saboonchi *et al.*, 2011), whereas the Hawizeh and Al-Chibayish marshes were classified as marginal during the period spanning from 2005 to 2008.

It is demanding that further studies be conducted and cooperating actions be undertaken to reduce the risks to freshwater ecosystems and to protect drinking water sources and identified issues and enhance the implementation of sustainable water resource management within marsh area. By doing so, the long-term health and viability of the water bodies can be ensured, benefiting both the environment and the communities that rely on these invaluable resources for various purposes.

Conclusion

Based on the results discussed previously, it can be concluded that the major source of water quality degradation in East Hammar Marsh is the insufficient outflow of freshwater from the Shatt Al-Arab river (the main source of fresh water for the marsh) and the intrusion of seawater from Arabian Gulf. We recommend future studies to monitor water quality in East Hammar Marsh.

Acknowledgments

The authors would like to thank the Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, for providing support and assistance in carrying out this article.

Contributions of authors

N.S.H.: Suggest a title of the research, Sample collection, Laboratory methodology, and writing the manuscript.

M.A.T.A.: Equation design, graphs, and editing revision.

S.A.A.: Suggest a title of the research, graphs, statistical analysis, and editing revision.

A.K.J.: Sample collection and reviewed the final manuscript.

A.A.M.: Statistical analysis and Interpretation of results.

ORCID

N.S.H.: https://orcid.org/0000-0002-5668-104X

M.A.T.A.: https://orcid.org/0000-0002-4703-2224

S.A.A.: https://orcid.org/0000-0001-6124-4023

A.K.J.: https://orcid.org/0000-0003-0656-2867

Conflicts of interest

The authors declare that they have no conflict of interest.

References

Abdel-Satar, A. M., Ali, M. H., & Goher, M. E. (2017). Indices of water quality and metal pollution of Nile River, Egypt. *The Egyptian Journal of Aquatic Research*, *43*(1), 21-29. https://doi.org/10.1016/j.ejar.2016.12.006

Abdullah, S. A., Hammadi, N.S., & Ouda, Y.W. (2018). Assessment of the lower reaches of Tigris River by a development of a water quality index (WQI). *Research Journal Science and Technology*, *10*(1), 01-08. https://doi.org/10.5958/2349-2988.2018.00001.3

Al-Ansari, N., Ali, A. A., & Knutsson, S. (2014). Present conditions and future challenges of water resources problems in Iraq. *Journal of Water Resource and Protection*, *6*(12), 1066-1098. http://doi.org/10.4236/jwarp.2014.612102

Al-Gburi, H. F. A., Al-Tawash, B. S., & Al-Lafta, H. S. (2017). Environmental assessment of Al-Hammar marsh, Southern Iraq. *Heliyon, 3*(2), 1-26. https://doi.org/10.1016/j.heliyon.2017.e00256

Al-Mosewi, T. J. K. (2009). Water quality of Al-Hammar marsh South Iraq. *Journal of Engineering, 15*(3), 3999-4008. https://www.iasj.net/iasj/article/24300

AL-Musawi, N. O., Al-Obaidi, S. K., & Al-Rubaie, F. M. (2018). Evaluating water quality index of AL Hammar Marsh, South of Iraq with the application of GIS technique. *Journal of Engineering Science and Technology*, *13*(12), 4118–4130. https://jestec.taylors.edu.my/V13Issue12.htm

Al-Nagar, G. A., Douabul, A. A., & Al-Noor, S. S. (2020). Studied Water Quality Index (WQI) as indicator of the East Hammar marsh after sharpe salinity increase during summer 2018. *Marsh Bulletin*, *15*(1), 1-11.

Al-Saad, H. T., Al-Hello, M. A., Al-Taein, S. M., & DouAbul, A. A. Z. (2010). Water quality of the Iraqi southern marshes. *Mesopotamian Journal of Marine Science, 25*(2), 188-204. https://doi.org/10.58629/mjms.v25i2.204

Al-Saboonchi, A., Mohamed, A. R. M., Alobaidy, A. H. M. J., Abid, H. S., & Maulood, B. K. (2011). On the current and restoration conditions of the southern Iraqi marshes: Application of the CCME WQI on East Hammar Marsh. *Journal of Environmental Protection, 2*(3), 316-322. http://doi.org/10.4236/jep.2011.23035

Al-Saboonchi, A. A., Mohamed, A. R. M., & Radee, F. K. (2014). Assessment of water quality of East Hammar marsh using WQI, Basra, Iraq. *Journal of Thi-Qar Science*, *5*(1), 24-31.

APHA (American Public Health Association) (2005). *Standard Methods for the Examination of Water and Waste Water*. Washington D. C., 1193pp. https://www.standardmethods.org/doi/full/10.2105/SMWW.2882.001

Borchardt, D., Bogardi, J. J., & Ibisch, R. B. (2016). *Integrated Water Resources Management: Concept, Research and Implementation.* Springer: Basel, The Switzerland, 781pp. https://link.springer.com/book/10.1007/978-3-319-25071-7

CCME (Canadian Council of Ministers of the Environment) (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, Canadian Council of Ministers of the Environment, Winnipeg. 5pp. https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines

Dunea, D., Bretcan, P., Tanislav, D, Serban, G, Teodorescu, R, Iordache, S, Petrescu, N., & Tuchiu, E (2020), Evaluation of Water Quality in Ialomita River Basin in Relationship with Land Cover Patterns. *Water*, *12*, 735: 1-19. https://doi.org/10.3390/w12030735

Echeverría, C., Guiomar, R. P., Puertes, C, Samaniego, L, Barrett, B., & Francés, F (2019). Assessment of Remotely Sensed Near-Surface Soil Moisture for Distributed Eco-Hydrological Model Implementation. *Water*, *11*(12), 2613. https://doi.org/10.3390/w11122613

Galal, T. M., Gharib, F. A., Al-Yasi, H. M., Al-Mutairi, K. A., Mansour, K. H., & Eid, E. M. (2022). Nutrient remediation efficiency of the sedge plant (*Cyperus alopecuroides* Rottb.) to restore Eutrophic Freshwater Ecosystems. *Sustainability*, *14*(5), 2823. https://doi.org/10.3390/su14052823

Hussain, N. A. (2014). *Biotopes of Iraqi Marshlands*. *Dhifaf publications*, 432pp. (In Arabic). https://www.thatsbooks.com/LBDFF/28107.jhtml

Khalaf, Z. N., Nashaat, M. R., & AL-Sariy, J. S. (2021). Limnological Features of the Southern Part of Gharaf River and the Impacts of Floodplain Period on its Characteristics. *Iraqi Journal of Science*, *62*(2), 415–430. https://doi.org/10.24996/ijs.2021.62.2.7

López-Felices, B., Aznar-Sánchez, J.A., Velasco-Muñoz, J.F., Piquer-Rodríguez, M. (2020). Contribution of irrigation ponds to the sustainability of agriculture. A Review of Worldwide Research. *Sustainability*, *12*, 5425. https://doi.org/10.3390/su12135425

Maytham A. A., Hammadi, N. S., & Abed, J. M. (2019). Environmental study of zooplankton in the middle part of the Shatt Al-Arab River, Basrah, Iraq. *Basrah Journal of Agriculture Science, 32* (Spec. Issue 2), 85-96. https://doi.org/10.37077/25200860.2019.259

Mohamed, A. M., Al-Saboonchi, A. A., & Raadi, F. K. (2017). Ecological assessment of East Hammar marsh, Iraq using a number of ecological guides. *Journal of King Abdulaziz University, Marine Science, 26*(2), 11-22. https://doi.org/10.4197/Mar.26-2.2

Mohamed, A. M., Hussein, S. A., & Mutlak, F. M. (2014). Composition of fish assemblage in the East Hammar marsh, southern Iraq. *Baghdad Science Journal*, *11*(3), 1373-1381. https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/2738

Moyel, M. S. (2010). *Water quality assessment of the northern part of Shatt Al-Arab River, using water quality index (Canadian version).* M. Sc. Thesis, University of Basrah, 100pp. (In Arabic).

Othman, A. A., Al-Afify, A. D.G., Abdel-Satar, A. M., & Ramadan, M. F. (2021). Quality assessment of surface water using the Nile Chemical Pollution Index (NCPI) and microbiological pollution of the Rosetta Branch (Nile River, Egypt). *African Journal of Aquatic Science*, *46*(2), 129-141. https://doi.org/10.2989/16085914.2020.1807898

Parsons, T. R., Matia, Y., & Lalli, C. M. (1984). *A manual of chemical and biological methods for sea water analysis*. Pergamon press, Oxford, 360pp. https://doi.org/10.1016/C2009-0-07774-5

Stoner, E. W., & Albrey Arrington, D. (2017). Nutrient inputs from an urbanized landscape may drive water quality degradation. *Sustainability of Water Quality and Ecology*, *9–10*, 136–150. https://doi.org/10.1016/j.swaqe.2017.11.001

Syed, A. T., & Jodoin, R. S. (2006). Estimation of nonpoint-source loads of total nitrogen, total phosphorous, and total suspended solids in the Black, Belle, and Pine River basins, Michigan, by use of the PLOAD model: Date Posted: October 25, 2006: U.S. Geological Survey Scientific Investigations Report 2006-5071, 42 p. https://pubs.water.usgs.gov/sir20065071/

Uddin, Md. G., Nash, S., & Olbert, A. I. (2021). A review of water quality index models and their use for assessing surface water quality. *Ecological Indicators*, *122*, 107218. https://doi.org/10.1016/j.ecolind.2020.107218

Yaseen, D A., Abualhail, S., & Khanfar, H A. (2019). Assessment of water quality of Garmat Ali river for irrigation purposes. *E3S Web of Conferences 118*, 03054. https://doi.org/10.1051/e3sconf/201911803054

تقييم نوعية مياه هور شرق الحمّار باستخدام مؤشر نوعية المياه (WQI) بعد إنتهاء مشكلة المد الملحي في 2018

نعيم شند حمادي[1] ومجتبى عبدالوهاب طاهر العنكوش[1] وسجاد عبدالغني عبدالله[2] وعادل قاسم جاسم[1] والاء عبد العالي ميثم[1،3]

[1] قسم الاسماك والثروة البحرية، كلية الزراعة، جامعة البصرة، العراق

[2] قسم علوم الحياة، كلية التربية – قرنة، جامعة البصرة، العراق

[3] مركز علوم البحار، جامعة البصرة، العراق

المستخلص: تمت دراسة مؤشر نوعية المياه (WQI) شهريًا، من نوفمبر 2018 إلى أكتوبر 2019 ، في ثلاث محطات (السدة والبركة والمرسى) في محافظة البصرة شرق هور الحمّار. تم قياس بعض العوامل البيئية المختلفة، بما في ذلك درجة حرارة الماء، والأس الهيدروجيني، والأوكسجين المذاب، والمتطلب الحيوي للأوكسجين، ونفاذية الضوء، والملوحة، والأملاح الذائبة الكلية، والعسرة الكلية، والنترات، والنتريت، والفوسفات، والكبريتات، والكالسيوم، والمغنيسيوم. بعد انتهاء المد الملحي في عام 2018 ، أظهرت المحطة الأولى أدلة موسمية ضعيفة 43.7 (درجة WQI منخفضة) في الشتاء، ومعتدلة 67.6 و 64.9 (الفئة الثالثة) في الربيع، وهامشية 55.9 (الفئة الرابعة) في الصيف والخريف. كان للمحطتين الثانية والثالثة درجات هامشية في WQI في جميع الفصول. تشير النتائج إلى إن نوعية المياه ملوثة وتنحرف عن الحالة المثلى. اختلفت قيم WQI بشكل كبير عبر جميع المواقع. يعد نقص تصريف المياه العذبة وتأثير المياه البحرية المستمر من أسباب تدهور نوعية المياه، ونوصي بمعالجة هذه المشكلة.

الكلمات المفتاحية: النموذج الكندي لتقييم نوعية المياه، ، هور شرق الحمار، المياه الداخلية، جنوب العراق.