Assessment of Water Quality in the Middle Section of Shatt Al-Arab River Using Principal Component Analysis: A Temporal and Spatial Study

Nuha A. Mohsen[1] Mohammad Salim Moyel[1] Maher Jasim AL-Aboodi[2]

1 Department of Ecology, College of Science, University of Basrah, Iraq
2Department of Mathematics, College of Science, University of Basrah, Iraq

*Corresponding Author E-mail: mohammad.moyel@uobasrah.edu.iq

Received 02/01/2026 Accepted 01/03/2026 Published 03/03/2026

Abstract

The current study aimed to use principal component analysis to assessment Spatio-temporal changes in water quality in the middle section of the Shatt Al-Arab River, southern Iraq. Seasonal surface water samples (autumn, winter, spring and summer) were collected from four stations (Abu-Flous, Al-Baradeyea, Al-Maqal, and Al-Muhammadiyat) to measure 12 physicochemical and biological variables, including water temperature (WT), pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), nitrates (NO3), phosphates (PO4) and fecal coliform bacteria (FCB) from October 2024 to July 2025. Summer exhibited the poorest water quality associated with reduced flow, increased organic pollution, and saline intrusion from the Arabian Gulf. Principal component analysis identified three principal components (eigenvalues >1) explaining the greatest variance, linked to dissolved salts and organic pollution, nutrients (nitrates, phosphates), and fecal coliforms. This confirms the substantial influence of saline waters advancing from the Arabian Gulf toward the study area due to the sharp decline in freshwater inflows to Shatt Al-Arab River, compounded by domestic, agricultural and industrial discharges.

Keywords: Water quality, Shatt Al-Arab River, Middle section, PCA.

Introduction

One of the major rivers in Iraq is Shatt Al-Arab River which is the primary provider of fresh surface water for the Basrah Governorate (Al-Asadi, 2016). The river, however, is increasingly threatened by several pollution sources, which include population growth, agricultural practices, and the indiscriminate application of fertilizers and pesticides, untreated industrial and chemical effluents, power generation facilities, and the indiscriminate dumping of domestic sewage (Hamzah *et al.*, 2025; Mahdi *et al.*, 2023).

P-ISSN: 1812-237X, E-ISSN: 2788-5720, https://ijaqua.uobasrah.edu.iq/index.php/jaqua/index

These factors, in combination, contribute to increased organic loading, turbidity, and the proliferation of pathogens (Alrazaq *et al.*, 2025). Furthermore, the river's freshwater outflow and marine saline intrusion from the Arabian Gulf into the river system, particularly in the summer months, increased the river's physico-chemical anomalies, characterized by heightened levels of salinity and pollutants (Moyel *et al.*, 2023). In conjunction with these environmental challenges, the scarcity of fresh water makes the evaluation of Shatt Al-Arab's water quality vital to safeguarding the health of the population and the aquatic life (Mohsen *et al.*, 2025). Proper management and sustainability of water resources require scientific planning, modern monitoring techniques and reliable data analyses (Khalaf *et al.*, 2022). Assessing the quality of the water is involves using physical, chemical and biological methods (Ahmed *et al.*, 2024; Hashim *et al.*, 2025), which are further supported by using advanced statistical/model methods in order to interpret complex data sets and assist in identifying sources of pollution (Lusiana *et al.*, 2022). Therefore, the purpose of this study is to identify the major environmental factors affecting the water quality of Shatt Al-Arab River by employing multivariate statistical techniques to provide a comprehensive assessment and to assist decision makers in mitigating pollution and effectively managing the environmental risks related to this vital water resource.

Materials And Methods

Study Sites

This study was conducted on Shatt Al-Arab River, formed by the confluence of Tigris and Euphrates rivers at Al-Qurna, north of Basrah. The river flows southward and discharges into the Arabian Gulf near Al-Faw, with a total length of ~204 km, width ranging from 400 m in Basrah to 2000 m at its mouth and depth between 8 and 15 m, accounting for tidal fluctuations (Moyel, 2014; Al-Mahmood *et al.*, 2011). Four sampling sites were selected along the middle section, spanning ~31.6 km from Abu-Flous in the south to Al-Muhammadiyat in the north. Station 1 (Abu-Flous) is located in Abu Al-Khaseeb District, south of Basrah City. Station 2 (Al-Baradeyea) is in the city center. Station 3 (Al-Maqal) is near Al-Maqal Port, ~2 km north of the city center. Station 4 (Al-Muhammadiyat) serves as a reference site for waters flowing from the north before joining the Karmat Ali Canal, as shown in Table (1) and Figure (1).

Table (1): Study Stations along the Shatt Al-Arab River.

Station No.	Station Name	Longitude	Latitude
St.1	Abu-Flous	"E: 48°0'4.476"	"N: 30°27'52.137"
St.2	Al-Baradeyea	E: 47°51'7.516""	""N: 30°30'36.46
St.3	Al-Maqal	"E: 47°47'15.764"	"N: 30°34'5.84"
St.4	Al-Muhammadiyat	E: 47°45'29.629""	"N: 30°37'6.066"

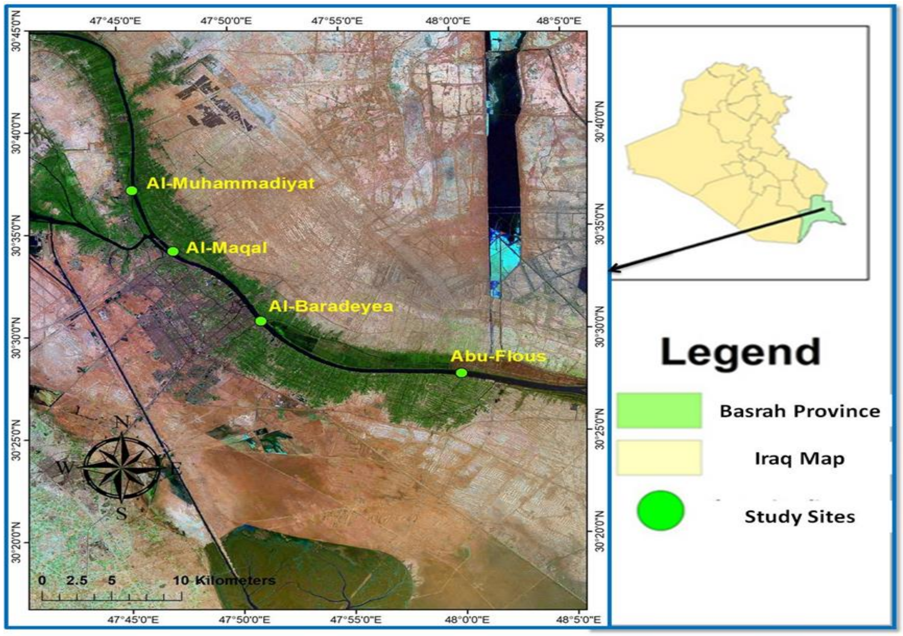

Fig. (1): Map showing the locations of the study stations along the Shatt Al-Arab River.

Field and Laboratory Work

Seasonal water sampling was done starting October 2024 to July 2025, thus sampling cycling through the four seasons: autumn, winter, spring, and summer. Samples were taken from the midstream at each of the four stations during low tide in the morning with the use of a boat. Surface water samples (depth 20-30 cm) were taken in 2000 mL polyethylene bottles for physicochemical and biological analyses. Fecal coliform samples were taken in sterilized 250 mL glass bottles and were iced. Dissolved oxygen (DO) and five, day biochemical oxygen demand (BOD_5) was determined using 300 mL Winkler bottles, the field was where DO was fixed, while BOD_5 samples were transported unfixed for laboratory incubation. Temperature, electrical conductivity (EC), and pH were measured on, site using portable calibrated meters (WTW, Germany). In the laboratory, TDS and TSS were analyzed according to the APHA (2005) method. Turbidity was determined using a calibrated turbidity meter (NTU). DO was determined by the modified Winkler azide method, and BOD_5 according to APHA (2005). COD was determined using a spectrophotometric test kit (Lovibond, Germany). Reactive nitrate (NO_3) and phosphate (PO_3) were determined spectrophotometrically at 543 nm and 650 nm, respectively (Parsons *et al*., 1984; USEPA, 1978). Fecal coliform bacteria (FCB) were enumerated by membrane filtration technique, and results expressed as CFU/100 mL.

Principal component analysis (PCA)

Principal Component Analysis (PCA) was applied to obtain the most effective interpretation of the water quality data collected in this study. The Kaiser–Meyer–Olkin (KMO) measure was employed to assess the adequacy of the dataset for factor analysis and to ensure more reliable results (Abuzaid and Jahin, 2022). The KMO index compares the magnitude of observed correlation coefficients with that of partial correlation coefficients among the variables. A KMO value closer to 1 indicates that the dataset is suitable for factor analysis, where value (≥ 0.75) is considered strong, values between (0.5–0.75) are regarded as moderate, and values between (0.3–0.5) are considered weak (Everitt and Hothorn, 2011; Thi *et al*., 2023). Accordingly, to achieve more acceptable and reliable factor analysis results, a relatively high KMO value is required (Zhou *et al*., 2007). In the current study, the KMO test resulted in a high value of (0.803), thus the dataset is suitable for PCA application. The Varimax rotation together with the Kaiser criterion was used to maximize the variance of the components extracted and make them more interpretable. PCA was preceded by a standardization of the original data set (Z-scale transformation) to reduce the impact of variable magnitude differences and to remove the effects of measurement units differing (Fan *et al*., 2010).

Statistical Analysis

A completely randomized design was used. Data analyses were performed with one-way ANOVA using the Minitab version 16.1 software. Relative Least Significant Difference values were calculated in order to show significant spatial and temporal differences ($P \leq 0.05$) among the variables studied. The relationships between physicochemical and biological variables were examined using Pearson's correlation coefficients to determine the degree and direction of associations among variables.

Results and Discussion

Physical, chemical and biological water quality variables

Figures (2–13) concisely illustrate the seasonal changes of water quality variables. Summer marked the recording of the highest water temperature 33.15 °C at Al-Muhammadiyat, while the winter season led to the observation of the lowest temperature 14.6°C at Abu-Flous, Significant differences ($P \leq 0.05$) were observed among the seasons. Summer was the season when the highest (pH) value was recorded 8.6 at the Al-Muhammadiyat station, whereas the lowest was also at the same place 7.35, Statistical analysis showed no significant differences ($P \geq 0.05$) among seasons. The findings also demonstrated that the maximum electrical conductivity was found in summer at the Abu-Flous station 38.22 mS/cm, whereas the minimum was at the Al-Muhammadiyat station during winter 3.21 mS/cm, Statistical analysis showed no significant differences ($P \leq 0.05$) among seasons. As far as total dissolved solids (TDS) are concerned, the highest level 31667.3 mg/L at the Abu-Flous station was observed in summer, and the lowest one 2066.5 mg/L at the Al-Muhammadiyat station during winter. The season differences were significantly different according to the statistical test ($p \leq 0.05$).

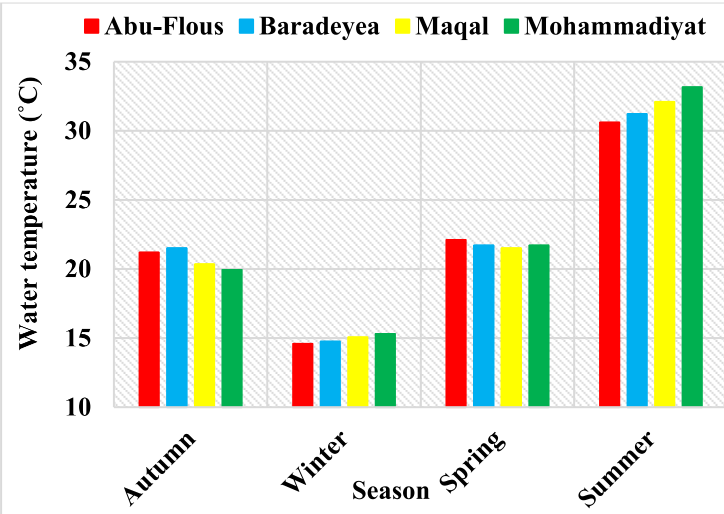

Fig. (2): Seasonal variations in wt. (°C)

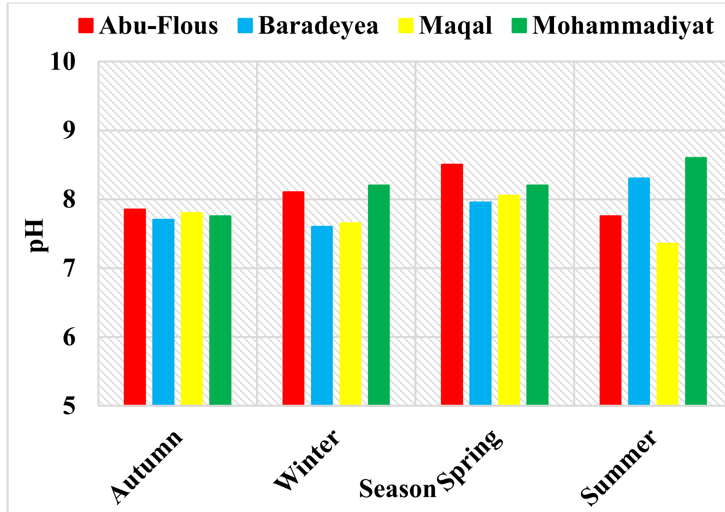

Fig. (3): Seasonal variations in pH

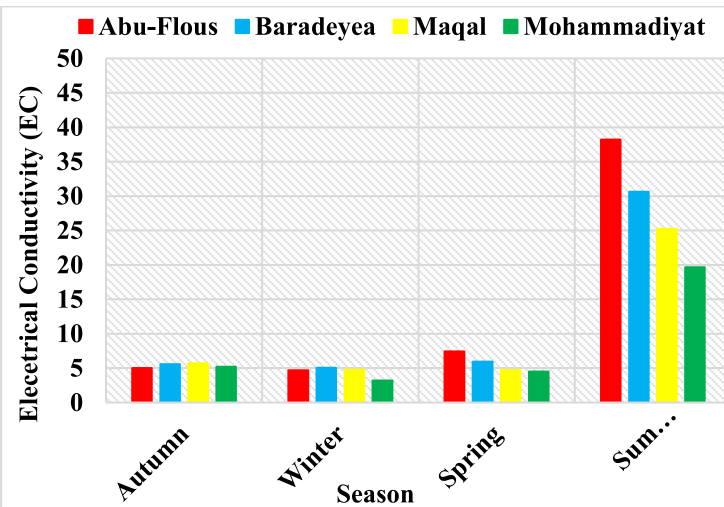

Fig. (4): Seasonal variations in EC.

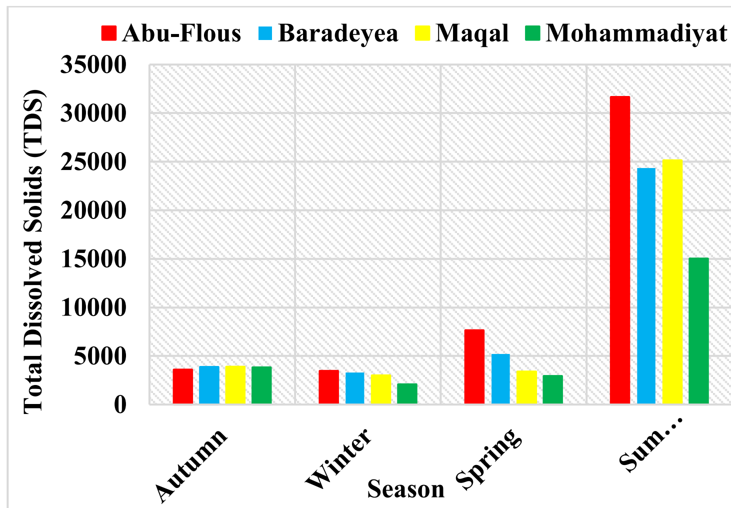

Fig. (5): Seasonal variations in TDS.

Regarding the total suspended solids (TSS), the highest level 33.9 mg/L was determined at Abu-Flous during the Autumn season, whereas the TSS level 6.2 mg/L that was the lowest was at Al-Maqal in spring, Statistical analyses showed significant differences ($P \leq 0.05$) between seasons. In turbidity terms, the value of peak 36.95 NTU was recorded during fall at the Abu-Flous location, whereas the value of nadir 6.93 NTU was recorded at the Al-Baradeyea location in Autumn season. However, there is no statistically significant seasonal variation ($p \geq 0.05$). The study's findings showed a marked difference in dissolved oxygen (DO) levels. The peak DO level recorded was during winter 8.525 mg/L at Abu-Flous station, and on the contrary, the minimum DO level was during summer 3.84 mg/L at the same station. Seasonal variations in DO levels were found to be statistically significant ($p \leq 0.05$).

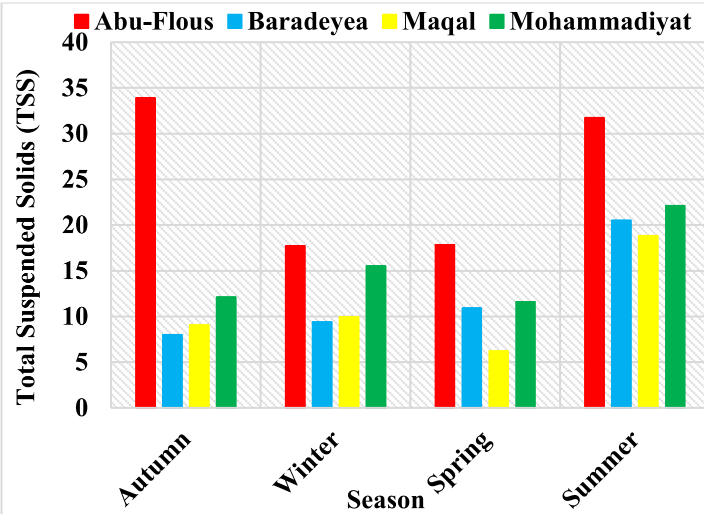

Fig. (6): Seasonal variations in TSS.

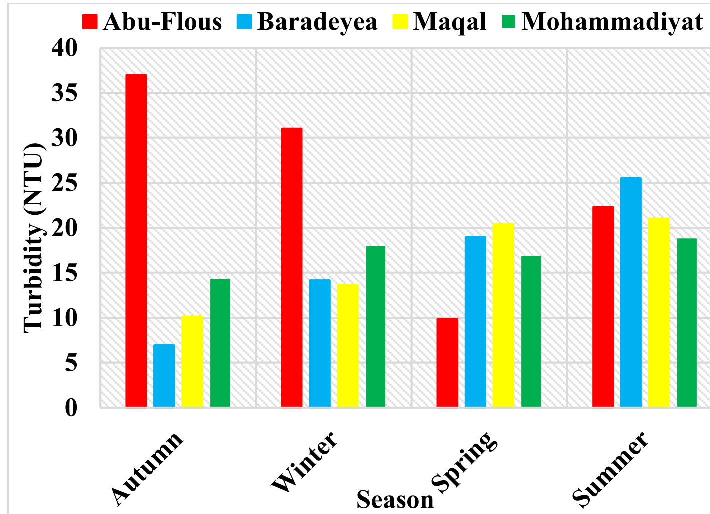

Fig. (7): Seasonal variations in Turbidity

Furthermore, the highest biochemical oxygen demand (BOD_5) was found during autumn at the Abu-Flous location with the average concentration of 7.57 mg/L. Contrarily, the lowest BOD_5 level 3.4 mg/L was measured during spring at the Al-Maqal station. The BOD_5 measurements also showed significant seasonal differences according to statistical analysis ($p \leq 0.05$). In the same way, the peak chemical oxygen demand (COD) level was detected during summer at Al-Baradeyea station 67.91 mg/L, On the other hand, the lowest concentration 31.7 mg/L was found in spring at the Abu-Flous station, Statistical analyses showed significant differences ($P \leq 0.05$) between seasons. The largest amount of nitrate (NO_3) was found in the water during Autumn 2.4305 mg/L, whereas the lowest concentration 0.6745 mg/L was detected in spring at the Al-Maqal station. The changes in nitrate levels between the seasons were significant at ($p \leq 0.05$) level.

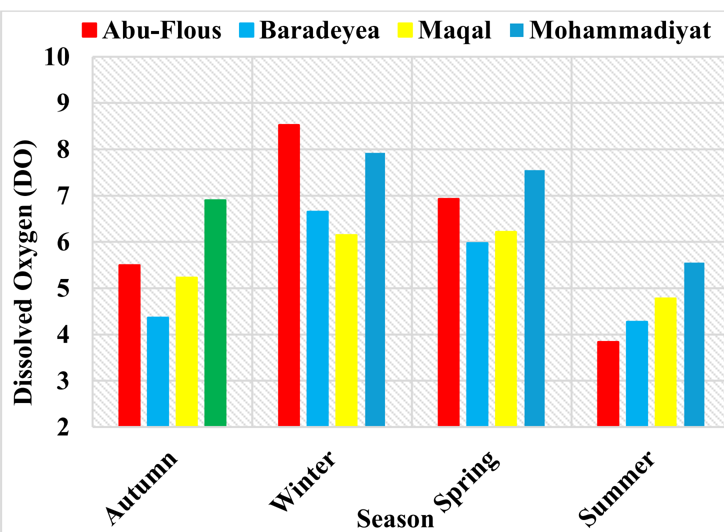

Fig. (8): Seasonal variations in DO.

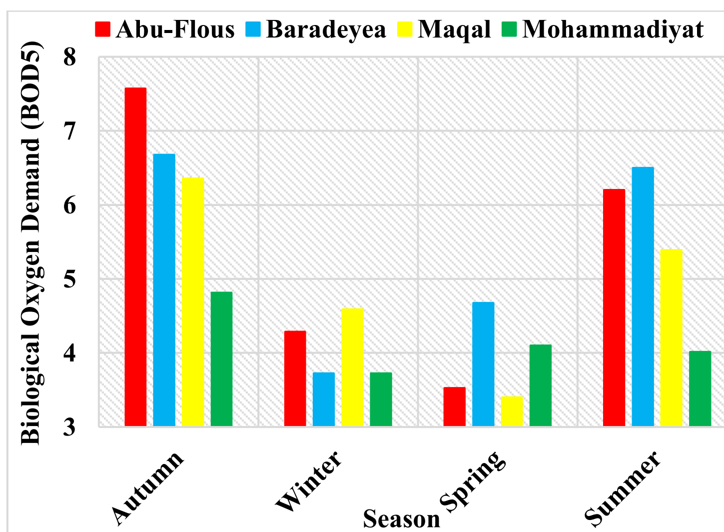

Fig. (9): Seasonal variations in BOD_5.

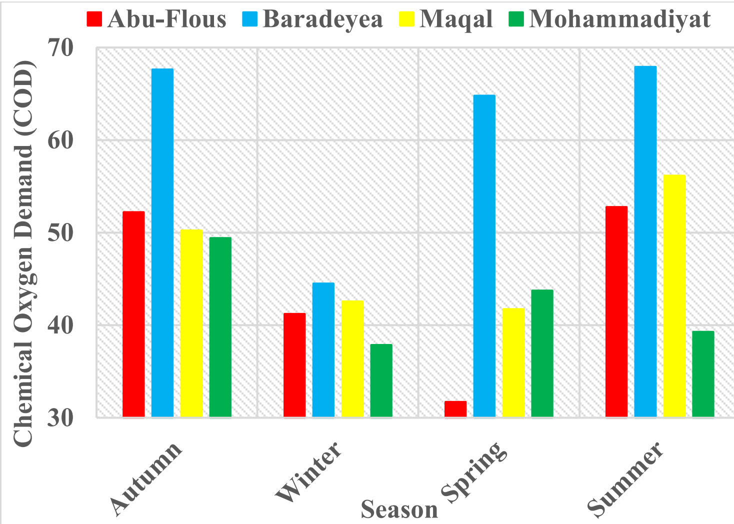

Fig. (10): Seasonal variations in COD

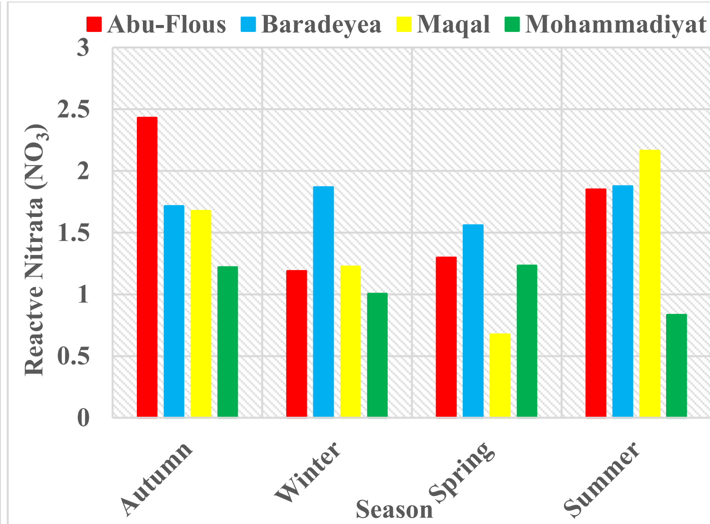

Fig. (11): Seasonal variations in NO_3

Seasonal changes in phosphate (PO_4) concentrations were also evident whereby the highest average amount 5.87 mg/L was during summer at the Al-Maqal station and the lowest 0.237 mg/L during winter at the Abu-Flous station. Statistical analysis showed a significant difference between seasons ($p \leq 0.05$). In addition, the bacterial load of fecal coliform has significantly changed as well. The maximum contaminating load 3650 CFU/100 mL was encountered at Al-Baradeyea during Autumn while the minimum 60 CFU/100 mL was seen during summer at Al-Muhammadiyat. The analysis of variance results showed that the differences in means between the seasons were statistically significant ($p \leq 0.05$).

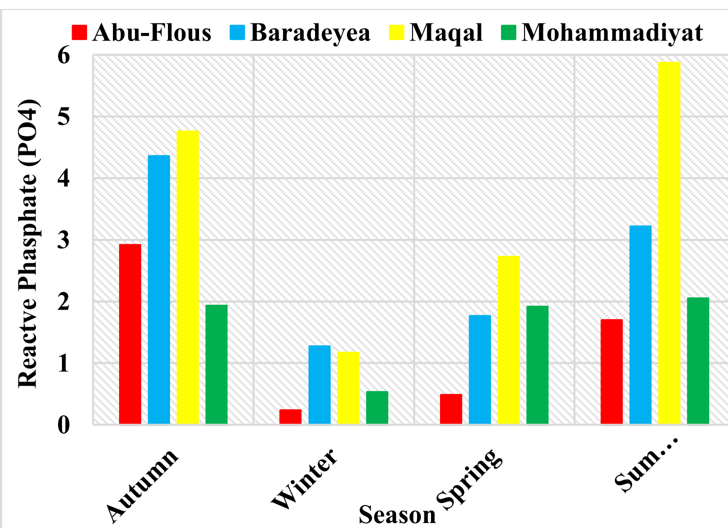

Fig. (12): Seasonal variations in PO_4.

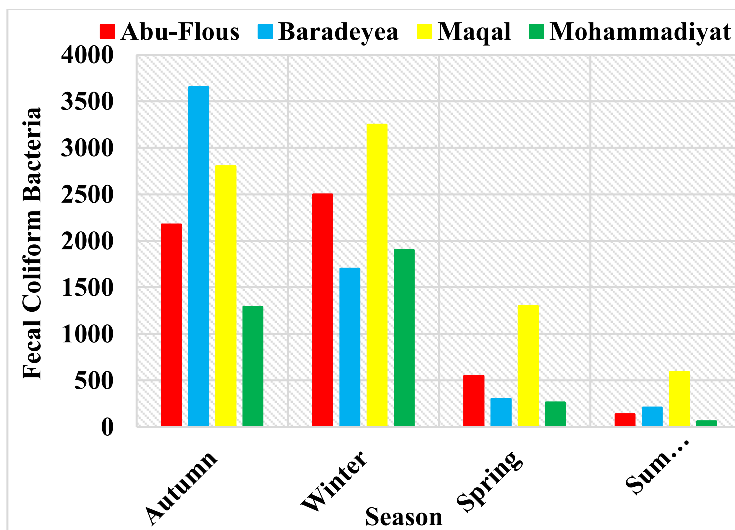

Fig. (13): Seasonal variations in FC.

Principal component analysis (PCA)

Table (2) presents the eigenvalues of each principal component, which were used to determine the number of acceptable principal components (PCs) for describing and interpreting the structure of the original dataset included in the statistical analysis. In addition, the table shows the factor loadings of the three principal components for the twelve studied variables. Three principal components with eigenvalues greater than or equal to 1 (Eigenvalue ≥ 1) were extracted, collectively explaining 70.794 % of the total variance of the original data. The first principal component (PC1) accounted for 40.028 % of the total variance and was characterized by high factor loadings of 0.823, 0.869, 0.862, −0.815, 0.644, 0.561, 0.614, and 0.565 for the water quality variables water temperature (WT), electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), nitrate (NO_3), and phosphate (PO_4), respectively, as shown in Table (2) and Figure (14 The second major component of variation (PC2) accounted for 18.972% of the overall variance. It was mostly linked with fecal coliform bacteria (FC) which had a positive loading of 0.639, as shown in Table (2) and Figure (14). The third major component of variation (PC3) explained 11.795% of the total variance. It was mainly associated with suspended load, represented by turbidity and total suspended solids (TSS), which had positive loadings of 0.602 and 0.787, respectively (Table 2 and Figure 15).

Table (2): Factor loadings of the principal components (PCs), their eigenvalues, the percentage of explained variance (Variability %), and the cumulative explained variance (Cumulative %) for the data of the present study.

Variables	PCA1	PCA2	PCA3
WT	**0.823**	-0.259	-0.218
pH	0.058	-0.618	-0.146
EC	**0.869**	-0.320	-0.129
TDS	**0.862**	-0.319	-0.149
DO	**-0.815**	-0.293	0.212
BOD_5	**0.644**	0.487	0.324
COD	**0.561**	0.390	-0.197
TSS	0.553	-0.423	**0.602**
NO_3	**0.614**	0.502	0.272
PO_4	**0.565**	0.463	-0.205
Turbidity	0.266	-0.306	**0.787**
FC	-0.319	**0.639**	0.281
Eigenvalue	4.803	2.277	1.415
Variability (%)	40.028	18.972	11.795
Cumulative %	40.028	59.000	70.794

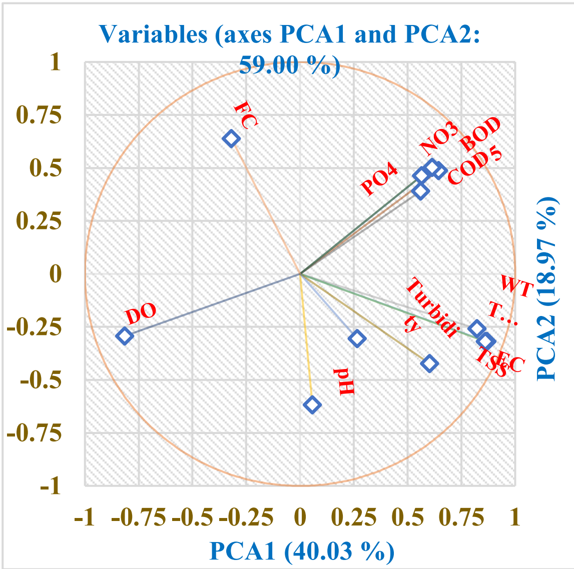

Figure (14): Factor loadings of the first and second principal components (PC1 and PC2) of the current study dataset.

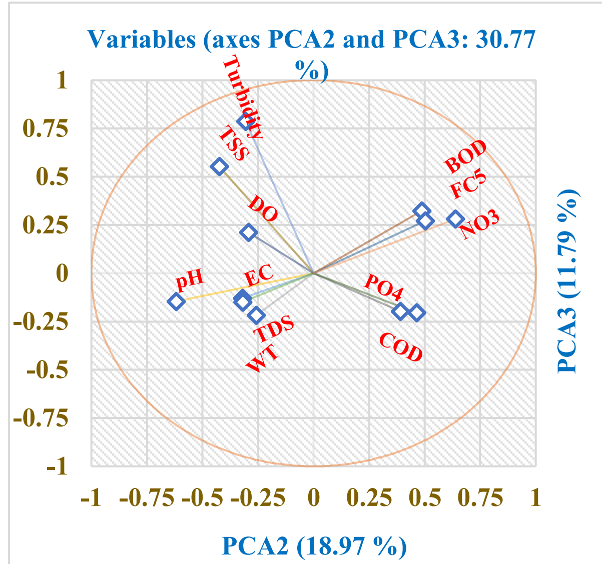

Figure (15): Factor loadings of the first and second principal components (PC2 and PC3) of the current study dataset.

Results and Discussion

Physical, chemical and biological water quality variables

The present study disclosed distinct seasonal changes in all the environmental variables that were examined. The highest water temperatures were detected during the extended summer season, while the lowest ones were noted during the short winter season. This trend can be explained by the climatic features of Basrah city, which has cold and rainy winters and hot, dry summers. These weather conditions influence the ambient temperature, which is known to be positively correlated with water temperature (Al-Hejuje, 2014). Temperature is regarded as one of the most crucial water quality variables since it significantly affects other physicochemical and biological properties of surface waters (Hashim *et al.*, 2025; Kahami *et al.*, 2023). The pH levels did not deviate from the normal alkaline range throughout the research period. This is a typical trait of Iraqi waters in general, and the Shatt Al, Arab River in particular, due to their high buffering capacity that comes from carbonate and bicarbonate ions, which play a role of buffer solutions and thus prevent large changes in pH (Moyel *et al.*, 2023; Ali and Resen, 2021). Moreover, carbon dioxide is released as a result of the decomposition of organic matter by bacteria, and it is then taken up by aquatic plants and phytoplankton during photosynthesis (Jassim and Al-Amiri, 2023).

Higher values of electrical conductivity were recorded during the hot summer months, the maximum being at the Abu Flous station, which is downstream the river. Such a rise can be explained by evaporation, a natural consequence of high daytime temperatures (Al-Shahri *et al.*, 2016), and also the intrusion of saline marine water from the Arabian Gulf due to the decrease in freshwater discharge from the Tigris River (Lateef *et al.*, 2020). In addition to this, human activities such as the discharge of domestic sewage and agricultural drainage containing high levels of dissolved salts have also contributed to the increase in salinity (Rahi, 2018; Postolache, 2014). The highest level of TDS was noticed at the Abu Flous station, followed by Al-Baradeyea, Al-Maqal, and Al-Muhammadiyat, in that order. The observed distribution pattern is a result of the combined effects of seawater intrusion, lowering water levels, and rising temperatures due to the sun, which collectively intensify the concentration of salts. TDS is the sum of all the dissolved salts in water (Abdullah *et al.*, 2016), and its levels are further amplified by untreated domestic wastewater and household effluents discharged directly into the river (Hassan *et al.*, 2019). Significant spatial and temporal fluctuations in total suspended solids (TSS) were recorded. Both stations of Abu-Flous and Al-Maqal showed very high TSS levels in the month of July, which was the time when river discharge dropped sharply and the intrusion of tidal currents from the Arabian Gulf increased, thus, these two phenomena together lead to a rise in suspended sediment load (Khalaf *et al.*, 2023). Besides, the role of wastewater discharge, industrial effluents, return flows from the connected canals is significant, along with tidal movements and storms, in the resuspension process of fine sediments from the riverbed back into the water column (Moyel and Hussain, 2015; Moyel *et al.*, 2023). A strong correlation between turbidity and TSS was evident throughout the different study stations. The changes in turbidity over space and time were primarily caused by domestic wastewater, industrial effluents, and return flows of subsidiary canals, which carry pollutants to the river especially during ebb tide conditions (Moyel *et al.*, 2023). Besides that, tidal currents and dust storms also play roles in raising turbidity levels (Jassby *et al.*, 2003). A drastic drop in river discharge in the course of the study period further facilitated the intrusion of marine tidal currents, which resulted in elevated levels of suspended sediments (Khalaf *et al.*, 2023). The stronger the force of the incoming tidal mass, the larger the amount of fine suspended sediments that accumulates, hence, turbidity values in Shatt Al-Arab River will be higher (Hamza, 2023). The findings also showed fluctuations in dissolved oxygen (DO) levels, whereby the Abu Flous station had the lowest DO levels compared to other locations. The reason for this drop is that the water in the Shatt Al-Arab River keeps getting polluted because of the declining freshwater inflows and at the same time increasing load of domestic, industrial, and agricultural wastewater, especially during the hot summer months (Moyel *et al.*, 2023). These pollutants discharge enormous amounts of organic matter that, when decomposed by microbes, require huge amounts of dissolved oxygen (Al-Hejuje *et al.*, 2017; Al-Aboodi *et al.*, 2018). On the other hand, the increased DO levels during the winter period may be related to the effect of lower temperature in increasing oxygen solubility, besides the decline in salinity and slowdown of organic matter decomposition (Shafi *et al.*, 2022). The highest biochemical oxygen demand (BOD_5) figures were observed in the most crowded districts due to the influx of large pollutant loads which are used as microbial activity substrates. Moreover, warmer conditions promote the increased functioning of microbes which, together with the degradation of organic matter, use up more dissolved oxygen resulting in higher BOD_5 concentrations (Banana *et al.*, 2016). Pollution from a contaminated branch canal is a source of additional organic material (Mohammed and Al-Chalabi, 2022) which, together with such factors as lowered freshwater input, increased salinity, and death of salt, sensitive species, can lead to a high demand for oxygen for the decomposition of dead organisms (Al-Saad *et al.*, 2017; Hamdan *et al.*, 2018). Summer witnessed the peak of chemical oxygen demand (COD) which could be due to more organic and inorganic wastes from different sources being discharged into the river and its connected canals (most of which have been converted from irrigation canals into wastewater channels) (Moyel and Hussain, 2015). The problem of these discharges is made worse by a decrease in freshwater inflows, which hampers the dilution capacity. Besides that, higher water temperatures speed up the decomposition of organic matter and microbial activities, which in turn, raise the COD levels (Kumari *et al.*, 2023). Differences in nitrate concentration were mostly due to variations in the amount of domestic wastewater, industrial effluents (Moyel, 2014), and agricultural drainage waters rich in nitrogenous compounds. These compounds, through oxidation processes catalyzed by microorganisms, result in the release of nitrate into the aquatic system (Singh and Gupta, 2016). Phosphate concentrations also had very significant seasonal and spatial changes that can be explained by the complexity of the pollution sources including the release of untreated domestic wastewater, agricultural drainage, and detergent residues to the river (Mahdi *et al.*, 2023; Ha *et al.*, 2023). These variations are quite consistent with changes in freshwater inflows and pollutant concentrations. Moreover, the differences in the salt concentration between stations and during different seasons may trigger phosphate release from the sediments (Hameed and Al-Jorany, 2011). Various factors determine the amount of phosphorus in aquatic ecosystems including the density of organisms, the nature of soil and rock, as well as human activities (Bingham *et al.*, 2020). Bakan *et al.* (2010) also noted that both high temperature and low oxygen level can boost the release of phosphate. Fecal coliform bacteria count for the different locations investigated showed significant variations. The situational factors of the human settlements where the heavy densities were found were those with concentrated population and elevated human activities (Moyel *et al.*, 2023). This change can be related to various pollution sources, especially the disposal of untreated domestic wastewater and sewage from residential areas, markets, restaurants, and boat docks (Al-Enazi, 2016).

Principal component analysis (PCA)

The use of multivariate statistical techniques is believed to be one of the most effective statistical tools in a wide range of scientific disciplines, particularly in environmental studies (Moyel, 2023). Such techniques are commonly employed in pollution monitoring activities and in assessing water quality data from various aquatic environments (Oketola *et al.*, 2013). Principal Component Analysis (PCA) is among the most significant and frequently utilized multivariate statistical methods in environmental research (Verma *et al.*, 2019), since it helps determine the primary factors explaining the spatial and temporal variations in water quality within the study area (Wu *et al.*, 2010). Therefore, PCA was used in this research to provide the most insightful interpretation of the water quality data from the study area. The first principal component (PC1) accounted for 40.028% of the total variance, revealing that the major factors influencing water quality in the mid, section of Shatt Al-Arab River are salinity intrusion and organic pollution. These conclusions align with the findings of Moyel (2023), who conducted a previous study in the same area. The continuous rise in salt concentration levels during the whole year, especially in the summer, severely endangers Shatt Al-Arab ecosystem and its aquatic life, besides rendering it less suitable for various uses. A number of sources contribute to the salinity of Shatt Al-Arab River. The single most important one is the intrusion of saline water from the sea which is associated with tidal currents, especially when freshwater discharge from Tigris River (its only source) is at a minimum (Al-Asadi *et al.*, 2022). Besides that, return flows of agricultural drainage as well as the release of untreated municipal and industrial wastewater further increase the concentrations of dissolved salts (Al-Mahmoud, 2019). This component was also linked to organic pollution, especially that of biodegradable organic pollutants represented by Biochemical Oxygen Demand (BOD_5), which come from either natural source like the decomposition of dead organisms or anthropogenic sources such as domestic sewage and the discharge of wastewater. Besides, this factor was very closely correlated with Chemical Oxygen Demand (COD) which is a measure of both biodegradable and non, biodegradable organic materials pollution that come from multiple natural and anthropogenic sources, among which industrial effluents seem to be the main source. Besides liquid waste from industries, PC1 was linked to nutrient pollutants, including nitrogenous and phosphate compounds, which are the result of different sources. On one hand, natural sources of these compounds are the natural decomposition of organic matter and the weathering of phosphorus, containing rocks and soils. On the other hand, human activities of producing and disposing of domestic and industrial wastewater, along with sewage, carrying large amounts of detergents, generate these compounds. Besides these sources, agricultural drainage water that is enriched with nitrogenous and phosphate fertilizers is also a major contributor to nutrient pollution in the river (Moyel, 2010). The 2nd main component (PC2) was responsible for 18.972% of the total variation and its largest contribution was the fecal coliform bacteria (FC) that showed a dominant relationship. This component refers to bacterial pollution and it is an extremely significant measure of contamination by human waste. Fecal coliform bacteria can mainly get into the river water when sewage from residential, industrial, and commercial areas getting directly and without treatment into Shatt Al-Arab River (Moyel, 2023). The third main component (PC3) accounted for 11.795% of the overall variance and was largely related to the suspended load, which was turbid turbidity and total suspended solids (TSS). This component is a measure of the effect of suspended matter on the water quality of the stations under study. How much suspended solids and turbidity are present in the river water is mainly determined by the availability of inorganic particles such as clay, sand, and silt which are the products of weathering and soil and rock erosion processes within the river course. Additionally, it is affected by the organic matter that is naturally present in the river such as organic debris, microorganisms, algae, and materials that have been introduced into the river by pollutant discharges from different sources (Moyel and Hussain, 2015).

Conclusions

The investigation conducted in the present study exhibited an alarming disturbance in the ecological system of the middle section of Shatt Al-Arab River. This degradation has been caused by a combination of factors that include the limited flow of freshwater from Tigris and Euphrates rivers, lower precipitation and the gradual penetration of saline water from the Arabian Gulf, as well as the increasing pressures from various human activities. Hence, these factors have led to a significant decline in water quality of Shatt Al-Arab River. Principal Component Analysis indicated that the total variation in the water quality of the middle section of Shatt Al-Arab River is mostly accounted for by the intrusion of salinity, organic pollution and nutrient enrichment, altogether with bacterial contamination and suspended load.

References:

Abdullah, A.D.; Karim, U.F.A.K.; Masih, I.; Popescu, I. and Zaag, P.V.D. (2016). Anthropogenic and tidal influences on salinity levels of the Shatt al-Arab River, Basrah, Iraq. Int. J. River Basin Manag., 14, (3): 357 – 336.

Ahmed, M.H.; Al-Baghdadi, N.M. and Aufy, L.A. (2024). An assessment of the water quality of some areas of Shatt Al-Arab and the East Hammar Marsh using the Water Quality Index (WQI). Egypt. J. Aquat. Biol. Fish.,28, (6): 2413 – 2423.

Abuzaid, A.S. and Jahin, H.S. (2022). Combinations of multivariate statistical analysis and analytical hierarchical process for indexing surface water quality under arid conditions. J. Contam. Hydrol., 248, 104005.

Al-Aboodi, A.H.; Abbas, S.A. and Ibrahim, H.T. (2018). Effect of Hartha and Najibia power plants on water quality indices of Shatt Al-Arab River, south of Iraq. Appl. Water Sci., 8, (2): 1 – 10.

Al-Asadi, S.A. (2016). A study of pH values in the Shatt al-Arab river (southern Iraq). Int. J. Mar. Sci., 6, (29): 1 – 8.

Al-Asadi, S.A.; Alhello, A.A.; Ghalib, H.B.; Muttashar, W.R. and Al-Eydawi, H.T. (2022). Seawater intrusion into Shatt Al-Arab River, Northwest Arabian/Persian Gulf. J. Appl. Water Eng. Res., 1 – 14. https://doi.org/10.1080/23249676.2022.2113460.

Al-Enazi, M.S. (2016). Evaluation of wastewater discharge from Al-Sadr teaching hospital and its impact on the Al-Khorah channel and Shatt Al-Arab River in Basra City-Iraq. Evaluation, 6, (12): 55 – 56.

Al-Hejuje, M.M. (2014). Application of water quality and pollution indices to evaluate the water and sediments status in the middle part of Shatt Al-Arab River. Ph. D. Thesis, College of Science, University of Basrah,212 p.

Al-Hejuje, M.M.; Al-saad, H.T. and Hussain, N.A. (2017). Assessing the Organic Pollution and Aquaculture Activity of Surface water at Shatt-Al-Arab Estuary Southern of Iraq. Indones. J. Mar. Sci. / Ilmu Kelautan., 22, (4): 161 – 168.

Ali, A.W. and Resen, A.K. (2021). Water Quality Assessment of Shatt Al-Arab River, Southern Iraq Using NSF-WQI. Biol. Appl. Environ. Res., 5, (2): 194 – 202. https://doi.org/10.51304/baer.2021.5.2.194.

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 J. Sci., 28, (1): 1 – 14.

Alrazaq, B.A.; Khanjar, E.F.; Muhsin, I.J. and Al-Ali, I.A. (2025). Assessment of Shatt al-Arab water quality using water indices in Basrah City of South Iraq. E3S Web of Conferences, 633, Article 03001. https://doi.org/10.1051/e3sconf/202563303001.

Al-Saad, H.T.; Al-Timari, A.A.; Douabul, A.A.A.; Hantoush, A.M.N. and Saleh, S.M. (2017). Status of oil in water and sediments from Shatt Al-Arab Estuary and North West Arabian Gulf. J. Mar. Sci., 32, (1): 9 – 18.

Al-Shahri, Y.J.; Maulood, B.K. and Toma, J.J.A. (2016). study on a sulfur spring (Ain Al Kibrit) ecosystem along Tigris River Mosul, Iraq. J. Adv. Lab. Res. Biol., 7, (1): 8 – 13.

APHA, (American Public Health Association). (2005). Standard method for the examination of water and wastewater – 21th edition, Washington, D. C., pp. 1193.

Bakan, G.; Özkoç, H.B.; Tülek, S. and Cüce1, T.H. (2010). Integrated environmental quality assessment of the Kızılırmak River and its coastal environment. Turk. J. Fish. Aquat. Sci., 10, (4): 453 – 462.

Banana, A.A.; Al-Gheethi A.A.; Mohamed, R.M.S.R.; Efaq A.N. and Gadawi A.M.S. (2016). Environmental impact assessment for disposal of sewage into sea water at Sabratah, Libya. 3rd International conference on green energy and environmental engineering, GEEE.1– 5.

Bingham, S.T.; Buss, H.L.; Mouchos, E.M.; Johnes, P.J.; Gooddy, D.C. and Bagnall, J.P. (2020). Rates of hydroxyapatite formation and dissolution in a sandstone aquifer: Implications for understanding dynamic phosphate behavior within an agricultural catchment. Appl. Geochem, 104534.

Dash, S. and Kalamdhad, A.S. (2021). Hydrochemical dynamics of water quality for irrigation use and introducing a new water quality index incorporating multivariate statistics. Environ. Earth Sci., 80, (3): 1–21.

Everitt, B. and Hothorn, T. (2011). An introduction to applied multivariate analysis with R. Springer Science and Business Media.

Fan, X.; Cui, B.; Zhao, H.; Zhang, Z. and Zhang, H. (2010). Assessment of river water quality in Pearl River Delta using multivariate statistical techniques. Procedia Environ. Sci., 2, 1220 – 1234.

Farhan, A.F.; Al-Ahmady, K.K. and Al-Masry, N.A.A. (2020). Assessment of Tigris River water quality in Mosul for drinking and domestic use by applying CCME water quality index. In IOP Conference Series: Mater. Sci. Eng., IOP Publishing., 737, (1): 1–13.

Ha, D.W.; Baek, J.; Choi, J.Y.; Kim, B.I.; Lee, Y. and Shin, D.S. (2023). Water quality trend and pollutant load and source analysis of Tamjin River water system. Environ. Monit. Assess., 195, (6): 1 – 13.

Hamdan, A.; Dawood, A.; and Naeem, D. (2018). Assessment study of water quality index (WQI) for Shatt Al-arab River and its branches, Iraq. MATEC Web of Conferences 162, 05005. EDP Sciences. https://doi.org/10.1051/matecconf/201816205005.

Hameed, A.H. and Aljorany, Y.S. (2011). Investigation on nutrient behavior along Shatt Al-Arab River, Basrah, Iraq. J. Appl. Sci. Res, 7, (8): 1340 – 1345.

Hamzah, Z.A.H. (2025). Water quality of the Shatt Al-Arab River evaluation using the Nemerow pollution index method. Adv. Sci. Technol. Res. J., 19, (5): 14 – 20. https://doi.org/10.12913/22998624/201132.

Hashim, M.Gh.; Resen, A.K. and Ankush, M.A.T. (2025). Evaluation of water quality in the northern region of the Shatt al-Arab River, Southern Iraq. Egypt. J. Aquat. Biol. Fish., 29, (1): 187 – 202. https://doi.org/10.21608/ejabf.2025.404116.

Hassan, A.A.; Dawood, A. S. and AL-Mansori, N.J. (2019). Assessment of Water Quality of Shatt Al-Basrah Canal using Water Pollution Index. Int. J. Eng. Technol., 8, (1.5): 325 – 331.

Jassby, A.; Cloern, J. and Mueller-Solger, A. (2003). Phytoplankton fuels Delta food web. Calif. Agric., 57, (4): 104 – 109.

Jassim, I.N. and Al-Amiri, N.J. (2023). Indicate the pollution extent at Shatt Al-Arab waters by water quality index (Canadian model). J. Surv. Fish. Sci., 10, (3S): 2737 – 2754.

Kahami, A.A.; Abdullah, A.F. and Al-Shawi, I.J. (2023). A comparative study on water quality assessment of Shatt Al-Arab Estuary and Al-Ashar Canal, Basrah, Iraq. Iraq. J. Aquac., 20, (2): 167 – 192. https://doi.org/10.58629/ijaq.v20i2.484.

Khalaf, R.Z.; Hussien, N.A. and Al-Hejuje, M.M. (2023). Application of modified WQI Canadian version on Shatt Al-Arab River. Ann. For. Res., 65, (1): 10092 – 10104. https://www.e-afr.org/.

Kumari, P.; Babu, N.J.; Singh, S.; Chandrasekar and Raj, A. (2023). Multivariate Statistical Analysis for Water Quality Variation in Baraila Lake, Bihar, India. Austin Environ Sci., 8, (1): 1090.

Lateef, Z.Q.; Al-Madhhachi, A.S.T. and Sachit, D.E. (2020). Evaluation of water quality variables in Shatt Al-Arab, Southern Iraq, using spatial analysis. Hydrology, 7, (4): 79. https://doi.org/10.3390/hydrology70400793.

Lusiana, E.D.; Mahmudi, M.; Hutahaean, S.M.; Darmawan, A.; Buwono, N.R.; Arsad, S. and Musa, M. (2022). A multivariate technique to develop hybrid water quality index of the Bengawan Solo River. Indones. J. Ecol. Eng., 23, (2): 123 – 131.

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. Iraq. J. Sci., 64, (1): 480 – 491. https://doi.org/10.24996/ijs.2023.64.1.42.

Mohammed, A.A. and Al Chalabi, A.S. (2022). Environmental Impact Assessment Study for Shatt Al-Arab River Receiving Industrial Wastewater. Basrah J. Eng. Sci., 22, (1): 93 – 98.

Moyel, M.S. (2010). Assessment of water quality of the northern section of Shatt al-Arab river, using water quality index (Canadian version). M.Sc. Thesis. University of Basrah, college of science, biology.

Moyel, M.S. (2014). Assessment of water quality of the Shatt Al-Arab River, using multivariate statistical technique. Mesopot. Environ. J.,1, (1): 39 – 46.

Moyel, M.S. and Hussain, N.A. (2015). Water quality assessment of the Shatt Al-Arab River Southern Iraq. J. Coast. Life Med., 3, (6): 459 – 465.

Moyel, M.S. (2023). Ecosystem index of the middle section of the Shatt Al-Arab River. Ph.D. Thesis, University of Basrah, College Education for Pure Sciences. 159 pp.

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, South. Iraq J. Ecol. Eng., 24, (4): 297 – 311. https://doi.org/10.12911/22998993/161014 jeeng.net+1.

Obais, A.A. and Al-Fatlawi, A. H. (2012). Assessment and Monitoring of Shatt Al-Hilla River with the middle Euphrates Region. J. Aquat. Sci. 31, (2): 205 – 227.

Oketola, A.A.; Adekolurejo, S.M. and Osibanjo, O. (2013). Water quality assessment of River Ogun using multivariate statistical techniques. Journal of Environmental Protection, 4, 466 – 479.

Parsons, T.R.; Matia, Y. and Lalli, C. M. (1984). A manual of chemical and biological methods for sea water analysis. Pergamon press. Oxford,360 pp.

Postolache, O.; Pereira, J.D. and Girão, P.S. (2014). Wireless sensor network-based solution for environmental monitoring: Water quality assessment case study. IET Sci. Meas. Technol., 8, (6): 610 – 616.

Rahi, K.A. (2018). Salinity management in the Shatt Al-Arab River. Int. J. Eng. Technol., 7, (4.20): 128 – 133.

Resen, A.K.; Al-Zuwar, J.K. and Abbas, R.H. (2014). Assessment of water quality of the Shatt Al-Arab River in northern Basrah. Iraq. J. Aquac., 11, (1): 37 – 56.

Scott, J.L. (2012). Evaluating Water Quality and Biotic Indices in the Lower Little Bow River, Alberta, University of Alberta. Thesis.134 pp.

Şener, Ş.; Şener, E. and Davraz, A. (2017). Evaluation of water quality using water quality index (WQI) method and GIS in Aksu River (SW-Turkey). Sci. Total Environ., 584, 131 – 144.

Shafi, M.; Prakash, C. and Gani, K.M. (2022). Application of remodeled water quality indices for the appraisal of water quality in a Himalayan lake. Environ. Monit. Assess., 194, (8): 576. DOI:10.1007/s10661-022-10268-5.

Singh, M.R. and Gupta, A. (2016). Water pollution-sources, effects and control. Centre for Biodiversity, Dep. of Botany, Nagal and University.

USEPA, (United States –Environmental Protection Agency). (1978): Total Phosphorus and orthophosphate, (ascorbic acid), Method 365.3.

Thi T.H.T.; Quan, T.A.; Hanh, N.T.H. and Tong, N.X. (2023). Assessing water quality in the Dong Nai River (Vietnam): implications for sustainable management and pollution control. Water Sci. Technol., 87, (11): 2917 – 2929.

Zhou, F.; Liu, Y. and Guo, H. (2007). Application of multivariate statistical methods to water quality assessment of the watercourses in Northwestern New Territories, Hong Kong. Environ. Monit. Assess., 132 (1), 1 – 13.

Verma, R.K.; Murthy, S.; Tiwary, R.K. and Verma, S. (2019). Development of simplified WQIs for assessment of spatial and temporal variations of surface water quality in upper Damodar river basin, eastern India. Appl. Water Sci., 9, (1): 1 – 15.

تقييم نوعية مياه الجزء الاوسط من شط العرب باستخدام تحليل المكونات الأساس: دراسة فصلية ومكانية

نهى علي محسن[1]، محمد سالم مويل[1]، ماهر جاسم العبودي[2]

1 قسم علم البيئة، كلية العلوم، جامعة البصرة، العراق
2 قسم الرياضيات، كلية العلوم، جامعة البصرة، العراق

*Corresponding Author E-mail: mohammad.moyel@uobasrah.edu.iq

تاريخ الإستلام: 2026/01/02 تاريخ القبول: 2026/03/01 تاريخ النشر : 2026/03/03

المستخلص

هدفت الدراسة الحالية الى استخدام تحليل المكونات الرئيسية لتقييم التغيرات المكانية والزمانية في نوعية المياه في الجزء الأوسط من نهر شط العرب جنوب العراق، جمعت عينات المياه موسمياً (الخريف، الشتاء، الربيع، والصيف) من أربع محطات (أبو فلوس، البراضعية، المعقل، والمحمديات) لقياس 12 متغيراً فيزيائياً، كيميائياً وبيولوجياً، شملت درجة حرارة الماء (WT)، الأس الهيدروجيني (pH)، التوصيلية الكهربائية (EC)، المواد الصلبة الذائبة الكلية (TDS)، المواد الصلبة العالقة الكلية (TSS)، العكارة، الأكسجين الذائب (DO)، المتطلب الحيوي للأكسجين (BOD_5)، المتطلب الكيميائي للأكسجين (COD)، النترات (NO_3)، الفوسفات (PO_4) وبكتيريا القولون البرازية (FCB)، ذلك خلال الفترة من أكتوبر 2024 الى يوليو 2025. بينت النتائج وجود تباين معنوي ($p \leq 0.05$) في قيم المتغيرات باختلاف مواقع وفصول الدراسة، حيث سجلت نتائج مؤشر جودة المياه أن أدنى مستويات جودة المياه سجلت خلال فصل الصيف مع ارتفاع درجات الحرارة وقلة الإطلاقات المائية وزيادة التلوث العضوي، وقد حدد تحليل المكونات الرئيسية ثلاث مكونات رئيسية (بقيمة ذاتية أكبر من 1) فسرت أكبر نسبة من التباين، وارتبطت هذه المكونات بالأملاح الذائبة والتلوث العضوي، والمغذيات (النترات والفوسفات)، وبكتيريا القولون البرازية. وتؤكد هذه النتائج التأثير الكبير لتقدم المياه المالحة من الخليج العربي باتجاه منطقة الدراسة نتيجة الانخفاض الحاد في واردات المياه العذبة الى نهر شط العرب فضلاً عن تأثير التصاريف المنزلية والزراعية والصناعية.

الكلمات المفتاحية: نوعية المياه، نهر شط العرب، القسم الأوسط، تحليل المكونات الاساس.

OPEN ACCESS

Iraqi Journal of Aquaculture
Ministry of Higher Education and Scientific Research
University of Basrah Marine Science Center