Borneo Journal of Resource Science and Technology (2024), 14(2): 19-30
DOI: https:doi.org/10.33736/bjrst.6858.2024

Evaluation of Euphrates River Water Quality on Phytoplankton Biodiversity in Ramadi, Iraq

MOHAMMED M. SHARQI[1], ABDUL-NASIR A. AL-TAMIMI[1] & OMAR M. HASSAN[*2]

[1] Department of Biology, Education College for Women, University of Anbar, Ramadi, 31001, Iraq;
[2] Department of Biology, College for Science, University of Anbar, Ramadi, 31001, Iraq
Corresponding author: sc.omerhasan@uoanbar.edu.iq
Received: 28 March 2024 Accepted: 23 October 2024 Published: 31 December 2024

ABSTRACT

Water quality deterioration is a major global issue due to population growth and rapid economic development, making healthy water essential for human societies' and ecosystems' sustainable development. Therefore, the current study aims to evaluate the quality of Euphrates River water through its chemical and physical parameters, as well as the distribution of the phytoplankton community. An environmental comparison was conducted between three stations in Ramadi city to assess the Euphrates River's water quality. The comparison was based on physicochemical and biological variables. Fifteen environmental parameters were measured: temperature, pH, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total turbidity, total dissolved solids, alkalinity, bicarbonate, nitrate, sulfate, phosphate, calcium, magnesium, and chloride. The occurrence of seasonal phytoplankton communities was also examined, and the Palmer diversity index, water quality index, and Pearson correlation were calculated. Significant differences were found in the physical and chemical variables of the Euphrates water between studied stations, and in the biological diversity of phytoplankton. The highest average temperature was 26.5 °C at station 1, the highest average pH was 7.575 at station 3, and the electrical conductivity was high at both stations 1 and 3, reaching 810 µS/cm. The Biochemical Oxygen Demand (BOD) ranged from 1.375 to 1.675 mg/L, the lowest average total hardness was 304.5 mg/L at station 3 and the highest average was 310.75 mg/L at station 1. In addition, the study revealed a high diversity in phytoplankton species and groups. 45 genera of green algae were found at all stations, while only 4 genera of Euglenophyceae and Dinophyceae were found. The study confirmed that the quality of the Euphrates River's water is medium and is characterized by high contamination with organic materials, according to the pollution index for water. It was concluded that phytoplankton groups are a sensitive and useful indicator of waterway health.

Keywords: Biodiversity, bioindicators, Euphrates River, phytoplankton, water quality

INTRODUCTION

Water quality is a critical factor in determining the health status of water bodies, which directly affects human health. Human activities can cause significant damage to water bodies, thereby depleting natural water resources. As a result of rapid economic progress and population expansion, water quality degradation has emerged as a major concern worldwide (Zhang *et al*., 2021). Eutrophication, biodiversity extinction, and serious risks to public health are just a few of the negative impacts that this issue may have. Spatiotemporal variations and trends in water quality can be attributed to a variety of human activities, pollution sources, and geographic changes (Xu *et al*., 2022).

Water quality in many bodies of water is subject to a variety of influences, such as climate change (Akhtar *et al*., 2021), natural sources (Yousif *et al*., 2024), human activities, specifically mining (Soleimani *et al*., 2018), sewage discharge (Abbasnia *et al*., 2018), agricultural and urban activities, and industrial pollution (Pereira *et al*., 2023), while synergistic impacts have the potential to significantly alter water quality, leading to eutrophication, reduced dissolved oxygen levels, and other issues. Protecting and managing water quantity and quality is becoming more difficult due to the numerous threats to the aquatic environment (Weng *et al*., 2023).

Phytoplankton are essential to freshwater ecosystems because they are the principal producers and a fundamental component of aquatic ecosystems, and because of their short life cycle, extensive dispersion, and vital function in energy flow, material cycle, and information transmission (Li *et al*., 2019; Aboim *et al*., 2019; Huang *et al*., 2023). Considered crucial markers of river health, phytoplankton composition, population size, and variety reveal a lot about water quality (Fathan *et al*., 2020). Phytoplankton have varying levels of sensitivity to water contamination, making them an excellent early warning system for water quality deterioration. Therefore, phytoplankton are reliable environmental indicators for assessing the extent of pollution in different water bodies. The density of phytoplankton is influenced by various complex factors, which depend on the interactions and relationships between physicochemical parameters (Al-Anzy *et al*., 2023). The ever-changing nature of water environmental quality can be fully and promptly understood by studying phytoplankton community traits (Sabater-Liesa *et al*., 2018).

River health evaluation systems are now incorporating biological evaluation indices and water quality methodologies, which are crucial for assessing levels of water pollution and nutrition (Sabater-Liesa *et al*., 2018; Noon *et al*., 2021; Zhang *et al*., 2021; Qu & Zhou, 2024). Thus, in order to effectively safeguard the environment and comprehend the effects of human activities on water quality and its variability of spatio-temporal features, aquatic biology-based water quality assessments are crucial (Edan & Sharqi, 2020).

The Euphrates River is one of the two major rivers that flow through Iraq. Its source is in Turkey, and it flows through Syria before entering Iraq from the western border. Finally, it discharges into the Shatt al-Arab. It is considered one of the longest rivers in West Asia, with forty percent of its water flowing into Turkey, twenty-5% into Syria, and 35% into Iraq. Unfortunately, the most significant problem facing rivers and streams in Iraq is pollution (Sharqi *et al*., 2021). The assessment of the ecological condition or potential of rivers generally relies on the evaluation of biological components, including phytoplankton, phytobenthos (mostly diatomaceous), macrophytes, zoobenthos, and ichthyofauna (Dembowska, 2021). Phytoplankton communities thrive in large, continuous-flow rivers that have extended water retention periods. Phytoplankton, as the primary component of the trophic hierarchy, show the highest degree of response to changes in the aquatic environment, making them a very reliable indicator of water quality (Chidiac *et al*., 2023).

Limited studies have been conducted to assess the water quality of the Euphrates River using phytoplankton. It is crucial to comprehend the fluctuations in water quality over time and location, as well as the primary sources of influence. This understanding can aid in the developing effective methods for evaluating water quality, which is essential for environmental governance and public health. This study aimed to assess the water quality of the Euphrates River through its chemical and physical parameters, as well as the distribution of the phytoplankton community, by calculating pollution indices.

MATERIALS AND METHODS

Location of Study

The study was carried out in Ramadi, Anbar, Iraq. Three stations were chosen along the Euphrates River: the first station is situated at the eastern entrance to Ramadi, the second is in the city centre, and the third station is directly before the Al-Warar Canal Dam. Further details about the stations are included in Table 1 and Figure 1.

Table 1. Geographic location of study stations

Stations	Latitude (Northwards)	Longitude (Eastwards)
1	43° 15' 52″	25° 26' 23″
2	43° 17' 53″	27° 26' 33″
3	43° 19' 05″	36° 26' 33″

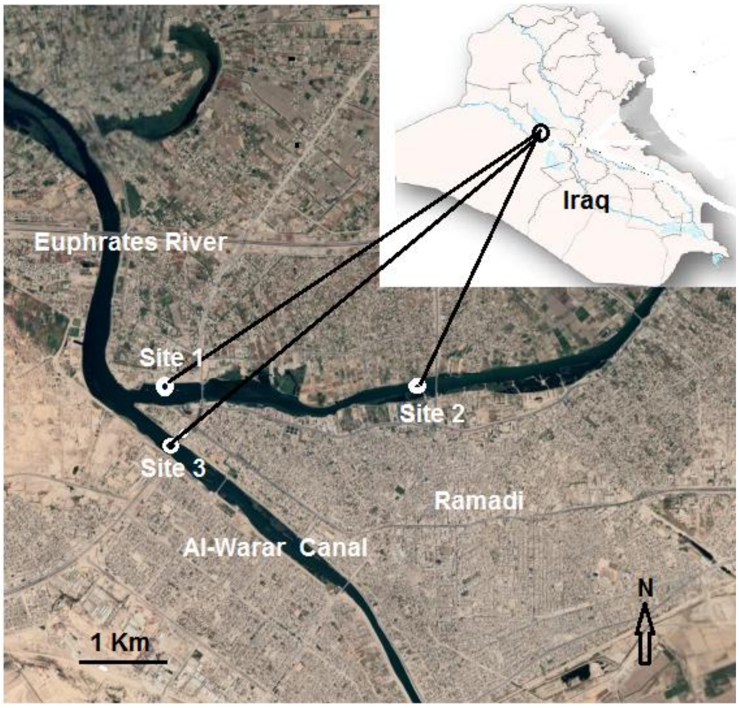

Figure 1. Sampling stations in the Euphrates River, Anbar, Iraq

Sample Collection

Physical and chemical parameters

Water samples were collected from the Euphrates River once a month during the period from July – October 2023 during the morning hours from 8:00 a.m. – 10:00 a.m. Water samples were collected in polypropylene bottles to measure turbidity and nutrients. Other water samples were collected in dark bottles for biochemical oxygen demand (BOD), immediately fixed with Winkler's reagent, and estimated in the lab using titration. A multi-sensor device (WTW 340i/set, Germany) was utilized for on-station measurement of water parameters, including temperature in Celsius, electrical conductivity (EC), pH, and dissolved oxygen (DO) concentration. Samples were analyzed in the lab using a spectrophotometer (PG T80$^+$, England). Turbidity was measured by the nephelometric method using a HACH 2100P Portable turbidimeter, USEPA 180.1, EU. Analysis of essential nutrient parameters (nitrite, nitrate, ammonia, and phosphate) was performed in accordance with Standard Methods for the Examination of Water and Wastewater, 24th Edition (Lipps *et al*., 2023). Each parameter was measured three times to ensure accuracy and consistency. The Water Quality Index (WQI) was calculated using Eq. (1) according to the National Sanitation Foundation Water Quality Index (NSF-WQI) method, and the water quality was determined based on the classification given in Chidiac *et al*. (2023) as shown in Table 2.

$$NSF\ WQI = \sum_{i=1}^{n} Qi\ Wi \qquad \text{Eq.(1)}$$

Where NSF-WQI is the score of the water quality index; Qi is the sub-index value of the water quality parameter; Wi is the weighted score; and n is the number of water quality parameters.

Phytoplankton Sampling and Identification

Phytoplankton samples were gathered from a depth of 1 m using a standard Towing-Henson plankton net (mouth diameter 0.35 nm) constructed of threaded nylon fabric (mesh size 25 µm). The obtained phytoplankton biomass was immediately transferred to 100 ml sample tubes containing 5% neutralized formalin for microscopic examination. Taxonomic identification was done using a compound light microscope at 1000X magnification and taken with a Nikon 90i Eclipse trinocular microscope.

A sample of 1 ml was collected and transferred into the counting chamber of the Sedgwick Rafter in order to conduct a quantitative analysis of phytoplankton communities. Once the substance had accumulated for a period of time, it was tallied. Each group was tallied a minimum of five times. Averaging was performed on the values. A calculation was performed to determine the overall count of phytoplankton in a 1 L water sample (Al-Obeidi & Al-Tamimi, 2024). The identification of phytoplankton species was conducted by consulting established guides and textbooks (Van Vuuren, 2006; Bellinger & Sigee, 2015). Water quality characteristics (low or high organic pollution) were evaluated using the pollution index developed by Palmer (1969) who created a list of 60 genera and 80 species of algae that are tolerant of organic pollution. He developed the Palmer algae genus index to assess the organic pollution of water bodies. This index is still used today and is calculated using a table listing the 20 algae genera that are most tolerant of organic pollution, each of which is assigned a number based on its relative tolerance. The total score obtained from the numbers assigned to each genus at each sampling station is used to assess organic pollution according to the classification given in Table 2.

Table 2. Water quality and pollution indices classification

NSF WQI		Palmer Index	
Index score	Quality Status	Index score	Quality Status
0–25	Very Bad	< 10	Very light organic pollution
26–50	Bad	10 to 15	Light organic pollution
51–70	Moderate	15 to 20	Moderate organic pollution
71–90	Good	> 20	High organic pollution
91–100	Very Good		

Statistical Analysis

Statistical analysis was performed using SPSS version 23. All data were expressed as mean and standard deviation. Analysis of variance (ANOVA) was used to examine multivariate spatial and temporal differences in physicochemical parameters and phytoplankton data. Tukey's test was used for post-hoc multiple comparisons between means of variables. Significance was attributed to values at $p < 0.05$.

RESULTS AND DISCUSSION

Physical and Chemical Parameters

Data from measurements of physicochemical parameters of temperature, pH, conductivity, turbidity, dissolved oxygen, BOD, and nutrients in the Euphrates at different sites are presented in Table 3. The highest temperature at Site 1 was recorded in August at 29 °C, while Site 2 recorded the highest temperature in July at 28 °C. The highest water temperature for site 3 was recorded in July at 29 °C. Water temperature changes depending on the change in air temperature (Saod *et al*., 2019). As for the pH values, the highest value recorded in October was in Stations 1 and 3 (7.8), while it increased slightly in Station 2 and reached 7.9 for the same month. The lowest pH value was recorded in Station 1 and Station 2 at 7.3 for August and July, while it decreased slightly in Station 3 to reach 7.2 for the month as a result of the scarcity of water from the Euphrates River in the summer season.

The Euphrates River’s water is alkaline because of its highest carbonate and bicarbonate contents. The maximum values of electric conductivity noted in July were 1060, 1068, and 1071 µS/cm respectively. The lowest ones were recorded in September reaching 627 µS/cm. This is caused by the fact that river levels during rainy months are lower than their normal levels which makes the wet months have a smaller conductivity value. On the other hand, resistivity values are generally higher for the arid period and this can be related to the phenomenon of lower water levels, which are intensified by the higher temperature and the inflow of salt from human activities (Hussein *et al*., 2023). Regarding DO value, the highest value of DO was reported in October reaching up to 13 mg/L in station 2, whereas 12 and 13 mg/L in stations 1 and 3. The lowest value was 8 mg/L for July in stations 1 and 3 whereas 9 mg/L in station 2. Therefore, the Euphrates River water is wellaerated (Muhammad & Ali, 2013; Hanjaniamin *et al*., 2022). Furthermore, the highest value of BOD was 2 mg/L at stations 1 and 2 for October, while the highest was 1.9 in station 3 for July and October, but the lowest value was 1.2 and 1.4 mg/L in August and September, respectively. Based on these results, the Euphrates River water can be classified as clean water. The results of this study are consistent with the results indicated by (Khlaif & Al-Hassany, 2023). The highest total hardness (TH) value was recorded in July for all study stations and amounted to 353, 358, and 356 mg/L, respectively, while the lowest value was recorded in October in Stations 1 and 2, where it reached 226 mg/L, while Station 3 recorded It rose to 253 mg/L. Based on the findings of the present investigation of total hardness values, the Euphrates River is classified as having medium hardness (Khudair, 2023). As for calcium ions, the highest value for this element was recorded in July in all study stations and was 124, 129, and 128 mg/L, respectively, while the lowest value recorded in October and in all stations was 50, 52, and 56 mg/L, respectively.

High calcium values during dry seasons may be caused by lower water levels at higher temperatures (Dey *et al*., 2021). As for magnesium (Mg), the highest value obtained was in August at all study stations; as it reached 49 mg/L for Stations (1 and 2) while Station (3) recorded a value of about 48 mg/L where October had the lowest values. It can occur in 24, 28, and 25 mg/L for all study stations to exist high Mg values of dry season may be caused by river water heat up accompanied by low river water levels (Wiranegara *et al*., 2023), or the river may enter and pass-through agricultural land and precipitate, or it may be due to the decomposition of algae or other living organisms and their return to the river water (Han *et al*., 2022). The greater influence of the calcium concentration over Mg values can be explained by sewage and irrigation wastewater that is poured into the river saturated with sulphate, resulting in magnesium precipitation as $MgSO_4$ (Potasznik *et al*., 2015). The highest value of total dissolved solids in water was recorded during July for all study stations and amounted to 562,569 and 560 mg/L, respectively, while the lowest value was recorded during October for all study stations and was 331, 326, and 322 mg/L, respectively. The values recorded for TDS in the present study are within the permissible limits (Al-Heety *et al*., 2011). The highest total alkalinity (TA) value was recorded in August, and for all study cases, it was 188, 185, and 180 mg/L of $CaCO_3$, respectively, while the lowest value was recorded during October and for all states of the study and was 115, 116, and 113 mg/L of $CaCO_3$, respectively. Higher TA values in the dry season may be attributed to lower phytoplankton densities, leading to lower carbonate and bicarbonate consumption from water (Rao & Rao, 2016).

The highest value recorded for the chloride ion (Cl) was at Station 1 of 168 mg/L during July, while the lowest value was recorded at Station 3 of 72 mg/L during September. The values recorded for Cl in the current study are within permissible limits (Saod *et al*., 2019). In terms of sulfate values, the highest concentration was recorded at Station 3 during July, reaching 296 mg/L. On the other hand, the lowest concentration was recorded during October in the same location, reaching 164 mg/L. The high concentration of sulfates in the water is due to the decrease in water levels and the influence of agricultural lands adjacent to the Euphrates River (Jalal *et al*., 2023). The phosphate PO_4 values monitored at Station 3 reached 0.31 mg/L in October, while the lowest value was at Station 2 and was 0.1 mg/L during August. The high phosphate values in the wet season may be attributed to the rains, which wash away (PO_4) from agricultural lands laden with phosphate fertilizers into the river water (Mekawey *et al*., 2023). In the nitrate (NO_3), the highest value was recorded at Station 1, which was 4.2 mg/L in August; the lowest value was recorded at Station 1; it was 1.4 mg/L in October; the high NO_3 values during the dry season may be due to the effect of the river on sewage water and agricultural land water (Li *et al*., 2023); and finally, the highest rate of turbidity (Tur.) was in the share of Station 1, and it was 18 NTU during September, while the lowest value for it was in Station 3, and it amounted to 6 NTU in October. The high turbidity values at Station 1 are due to the turbulence of the water, as it is located near the Ramadi Dam.

Table 3. Physicochemical parameters in the modeling stations of Euphrates River – Ramadi

Parameters	Station 1	Station 2	Station 3	p value
Temp. (°C)	26.5±4.04	25.25±3.30	26.25±3.10	0.800
pH	7.5±0.26	7.55±0.24	7.575±0.32	0.944
EC. (µs/cm)	810±202.98	804.75±199.95	810.25±210.64	0.989
DO (mg/L)	9.5±1.29	11±0.82	10.75±1.71	0.039
BOD (mg/L)	1.675±0.26	1.375±0.48	1.525±0.36	0.044
T.H. (mg/L)	310.75±45.98	305.5±59.44	304.5±57.69	0.598
Ca (mg/L)	91.25±32.26	89.75±28.62	91±30.17	0.986
Mg (mg/L)	39±10.49	37.75±12.66	38.75±.88	0.690
T.D.S (mg/L)	425±102.30	428.25±99.69	429±104.89	0.998
AlK (mg/L)	148.75±33.75	154.25±34.94	152±33.67	0.489
Cl (mg/L)	106±37.17	111±42.97	108.5±0.29	0.052
SO_4 (mg/L)	225.25±61.05	225.75±58.35	225.75±61.14	0.999
PO_4 (mg/L)	0.2575±0.12	0.325±0.13	0.25±0.13	0.025
NO_3 (mg/L)	2.625±0.99	2.875±1.26	0±0	0.019
Turb. (mg/L)	11.5±3.87	13.75±3.77	0±0	0.001

Phytoplankton Diversity

Table 4 shows the classification and density of phytoplankton for all the studied stations during the study period. Regarding the algal classes that were diagnosed, they were connected to many algal classes and genera. In Station 1, green algae were dominated Chlorophyceae with 45 genera, then Cyanophyceae with 17 genera, and so was Euglenophyceae. The Euglenophyceae, diagnosed with four genera, is considered evidence of organic pollution, and its absence indicates clean river water (Khudair, 2023). The Dinophyceae, with three genera, the Bacillariophyceae centrals, with six genera, and the pennales, with twenty genera, followed. Finally, the Crysophyceae, identified as a single genus, was found. As for Station 2, the Bacillariophyceae (pennales) were diagnosed with 44 genera and the Bacillartophyceae (certrales) with 6 genera, as well as the sentesns, and almost 11 sub-species were recorded. As for Station 3, the dominance was for the Chlorophyceae with 24 genera, then the Cyanophaceae with 17 genera, then the Euglenophyceae with 5 genera, the Dinophyceae with 2 genera, and finally the golden algae (Crysophyceae) with one genus.

The greater percentage of green algae density (52%) over blue-green algae (8%) confirms that the Euphrates River water in the current study stations is fresh and moderately polluted water (Khaleefa & Kamel, 2021). The highest total number of phytoplankton cells was recorded in Station 1 with limits of 1.272×10^7 cell/ml (Table 4), which may be attributed to the station not being affected by human activities (Yousif *et al*., 2024), while lower numbers were recorded in Station 2 and 3.

NSF-WQI and Palmer's Index

According to the NSF-WQI (Figure 2), most of the stations recorded values during the months of the study that exceeded 60. Therefore, the Euphrates River water in the current study area is considered to be of medium quality despite recording values that exceeded 20 according to Palmer's Pollution Index (Figure 3). This result indicates that the water in the studied area has high organic pollution, which may be due to the large numbers of species recorded in the study stations, which have a high classification according to the table prepared by this guide, Euglena and Oscillatoria (Al-Kanani & Al-Essa, 2018; Khalaf & Sharqi, 2023).

A group of blue-green algae and euglenoids, indicative of the eutrophication water condition, were classified as *Ocsillatoria limosa*, *O. tenuis*, *Euglena acus*, and *E. gracilis*. While the species of daitoms were classified for the condition of the eutrophication water, which is as follows: *Cocconeis placentula*, *Cyclotella meneghiniana*, *Diatoma vulgare*, and *Hantzschia amphioxys*, this confirms that the water in the Euphrates River at the current study stations suffers from high organic pollution. This result is consistent with the study conducted by Tamaki and Obedi (2023).

Table 4. Classification and density of phytoplankton (cell/ml) in during the study period

Taxa	Station 1	Station 2	Station 3
Cyanophyceae			
Anabaena aequalis	++	++	+
Anabaena wisconsinensis	++	-	+
Chroococcus disperses	++	++	+
C. turgidus	+	+	+
Gomphosphaeria aponima	+	+	+
Merlsmopedia aponglauca	++	++	+
M. punctata	+	-	++
Nostoc linckia	+	+	+
Oscillatoria amoena	+	+	+
O. angusta Koppe	+	+	+
O. limosa Roth	+	+	+
O. tenuis	+	++	+
O. nigra	+	++	+
O. sancta	+	+	+
Rhabdoderm sigmoidea	+	+	+
R. linuaris	++	-	+
Spirulina laxa	++	++	+
Euglenophyceae			
Euglena proxima	+	+	+
E. convolute	+	+	+
E. acus	+	-	+
E. gracilis	+	+	+
Crysophyceae			
Mallomouas caudate	+++	++	+
Dinophyceae			
Peridinium cinctum	+++	+++	+
P. cinctum	++	++	+
P. puillum	++	++	+
Chlorophyceae			
Chlorella vulgaris	+++	+++	+
Closterium lanceolatum	++	++	++
C. setaceum	+++	+++	++
Cosmarium bioculatum	+++	+++	+
C. botrytis	+++	+++	+
C. depressum	++	-	+
C. granatum	+++	+++	+
C. quadrifarium	++	++	+
C. subtumidum	+++	+++	+
C. subcrenatum	+++	+++	++
Crucigenia rectangularis	+++	+++	+
Dictyosphaerium pulchellum	+	++	+
D. ehrenbergianum	+++	-	+
Golenkinia paucipina	+++	-	+
G. radiata	+++	+++	++
Kirchneriella obesa	+++	+++	++
Lagerheimia citriformis	++	++	+
L. subsala	+++	+++	++
Microspora	++	++	++
M. floccose	++	++	+
Mougeotia elegantula	+	+	+
Oedogonium cardicum	++	++	+
O. gallicum	+	+	+
O. gigas	+	-	+
O. elliptica	++	++	++
O. eremosphaeria	++	++	++
O. plusiosporum	+	+	+

Table 4 (continued).

O. undulatum	++	++	+
Pediastrum boryanum	+	+	+
P.simplex meyen	++	++	+
P. simplex	++	++	++
Scenedesmus aburdanus	+++	+++	++
S. aburdanus	+++	++	+
S. armatus	+++	++	+
S. arcuatus	++	++	++
S. quadricarda	++	++	+
Spirogyera collinsii	++	++	+
S. subsalsa	++	++	+
Staurastrum anatinum	+++	+++	+++
S. polymorphum	++	++	++
S. punctulatum	++	+	+
S. tetracerum	+++	++	+
Ulothrix subilissiuma	++	++	+
Bacillaptophyceae - Centrates			
Aulacoseira granulate	+	+	+
A. italic	++	+	+
A. varians	+	+	++
Cyclotella meneghiniana	+++	+	++
C. ocellata	+++	++	+
Stephanodiscus astera	++	++	+
Bacillaptophyceae- Pennales			
Amphora venta	+++	++	+
Asterionella bleakeleyi	++	++	+
Bacillaria paxillifer	++	+	+
Cocconeis pediculs	+++	+++	+++
C. placentula	+++	+++	+++
Cymbella affinis	+++	+++	++
Cymatopleura solea	++	+	+
C. tumida	+	+	+
Diploneis psudovalis	+	+	+
D. smuthii	++	++	+
Diatoma vulgare	++	++	+
Fragllaria covotonursis	+	+	+
F. pulchella	++	+	+
Gomphonema gracile	++	+	+
G. olivaceum	++	+	+
Hantzschia amphioxys	++	++	+
Mastogloia brauni	+	+	+
M. elliptica	+	+	+
M. smithi	++	+	+
M. smithi	+	+	+
Navicula anglica	+	+	+
N. laterostarata	+	+	+
N. parva	++	+	+
N.salinarum	++	-	-
N. subrhyncocephata	++	++	+
Nitzschia acicularia	+	+	+
N. amphibia	++	+	+
N. dissipata	++	++	++
N. fasciculate	++	+	+
N. elongatula	+	+	+
N.obtusa	+	+	+
N. palea	+	+	+
Pleurosigma angulatum	+	+	+
P. elongatum	+	+	+

Table 4 (continued).

Rhapalodia gibba	+	+	+
Rhaicosphenia abbreviate	+	+	+
Synedra fasciculate	++	++	+
S. pulchella	+	+	+
S. ulna	+	+	+
Surirella ovalis	+	+	+
Tryblionella hungarica	+	+	+
T. levidensis	+	+	+
T. littralis	+	+	+
Total count	1272	927	510

+ (< 5 cell/ml), ++ (5- 10 cell/ ml), +++(> 10 cell/ ml)

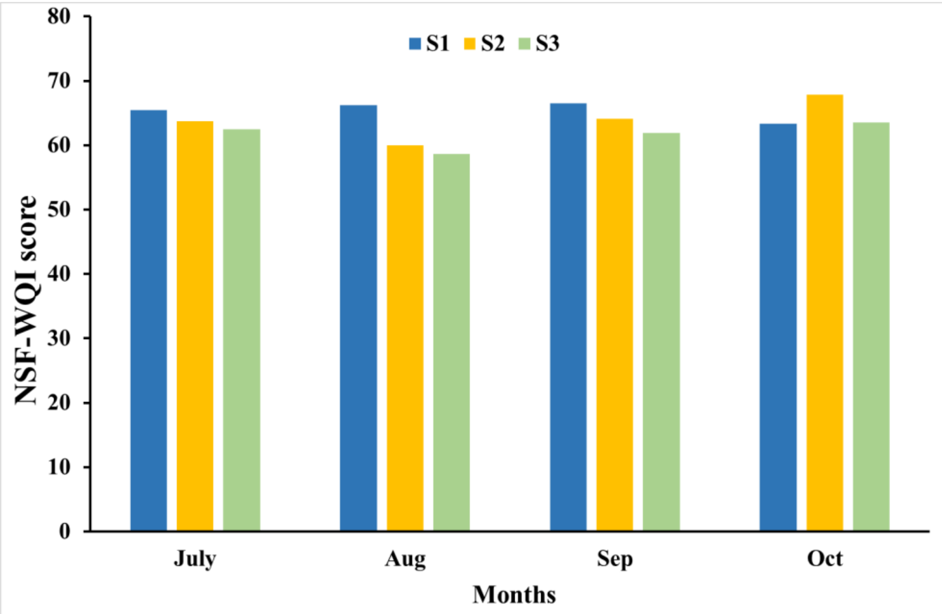

Figure 2. The values of the NSF-WQI in the study stations

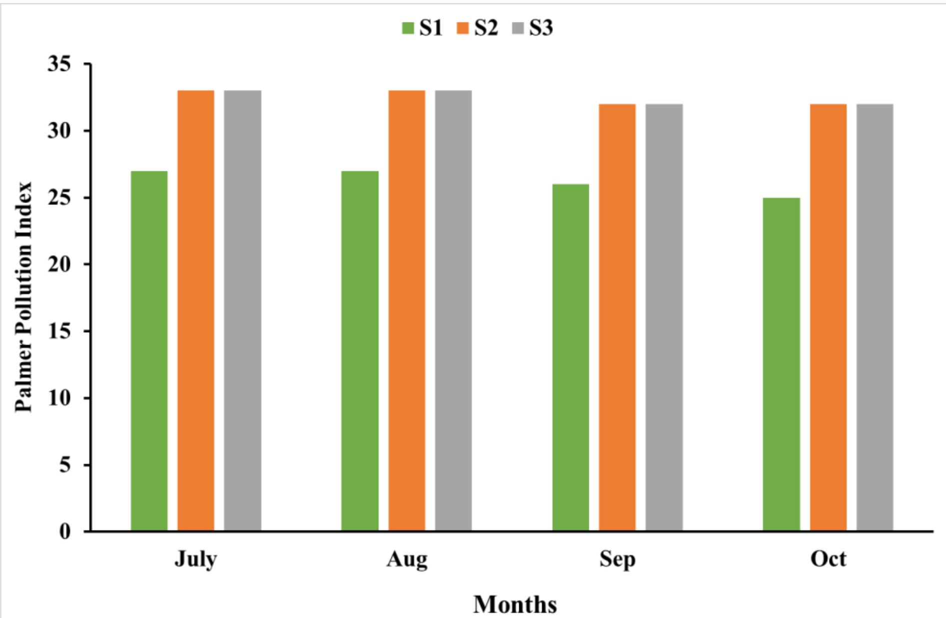

Figure 3. Spatial and temporal variations of Palmer pollution index in the Euphrates River

CONCLUSION

Many rivers around the world suffer from pollution problems. Therefore, the current study focused on evaluating the quality of Euphrates River water using chemical, physical, and biological criteria in the presence of phytoplankton. A spatial and temporal comparison was made for three stations in the Euphrates River in Ramadi city. The comparison was based on physical, chemical, and biological variables. The current study showed a variation in physical and chemical tests at all stations and in different months, and a large biological diversity was observed in algae categories and at all study stations. The Euphrates River water in the current study area is considered medium quality and has high organic pollution. We recommend conducting a comprehensive assessment of the Euphrates River in Iraq and the need to address its pollution problems, especially organic pollution.

ACKNOWLEDGMENT

The authors want to thank the Department of Environment in Anbar Governorate for providing assistance in completing this study.

Funding Information

Authors state no funding involved.

Conflict of interest

Authors state no conflict of interest.

REFERENCES

Abbasnia, A., Radfard, M., Mahvi, A.H., Nabizadeh, R., Yousefi, M., Soleimani, H. & Alimohammadi, M. (2018). Groundwater quality assessment for irrigation purposes based on irrigation water quality index and its zoning with GIS in the villages of Chabahar, Sistan and Baluchistan, Iran. *Data in Brief*, 19: 623–631. DOI: 10.1016/j.dib.2018.05.061

Aboim, I.L., Gomes, D.F. & Mafalda Junior, P. O. (2019). Phytoplankton response to water quality seasonality in a Brazilian neotropical river. *Environmental Monitoring and Assessment*, *192*(1):70. DOI: 10.1007/s10661-019-7882-5

Akhtar, N., Syakir Ishak, M.I., Bhawani, S.A. & Umar, K. (2021). Various natural and anthropogenic factors responsible for water quality degradation: A review. *Water*, 13(19): 2660. DOI: 10.3390/w13192660

Al-Anzy, D.H.S., Al-Tamimi, A.N.A.M. & Sharqi, M.M. (2023). Biological and ecological monitoring using epiphytic diatoms on two aquatic plants to estimate the water quality of Habbaniyah Lake, Western Iraq. *IOP Conference Series: Earth and Environmental Science*, 1262(2): 022012. DOI: 10.1088/1755-1315/1262/2/022012

Al-Heety, E.A., Turky, A.M. & Al-Othman, E. M. (2011). Physico-chemical assessment of Euphrates River between Heet and Ramadi Cities, Iraq. *Journal of Water Resource and Protection*, 03(11): 812–823. DOI: 10.4236/jwarp.2011.311091

Al-Kanani, H.M. & Al-Essa, S.A. (2018). Assessment of Shatt Al-Arab River Water quality by using Palmer’s Algal Index, Basrah, Iraq. *Basrah Journal of Agricultural Sciences*, 31(1): 70–77. DOI: 10.33762/bagrs.2018.160122

Al-Obeidi, N.A.S. & Al-Tamimi, AN.A.M. (2024). Ecology and Biodiversity of Epiphytic Algae (Non-diatoms) on Typha Domingensis Pers. In the Upper Euphrates River Between Haditha Dam and Al Baghdadi in Western Iraq. In: Obaid, A.J., Al-Heety, E.A., Radwan, N., Polkowski, Z. (eds.) *Advanced Studies on Environmental Sustainability. ICES 2023*. Springer Proceedings in Earth and Environmental Sciences. Springer, Cham. pp. 41–58. https://doi.org/10.1007/978-3-031-57054-4_4

Bellinger, E.G. & Sigee, D.C. (2015). *Freshwater Algae: Identification, enumeration and use as bioindicators* (2nd ed.). John Wiley & Sons.

Chidiac, S., El Najjar, P., Ouaini, N., El Rayess, Y. & El Azzi, D. (2023). A comprehensive review of water quality indices (WQIs): history, models, attempts and perspectives. *Reviews in Environmental Science and Bio/Technology*, 22(2): 349–395. DOI: 10.1007/s11157-023-09650-7

Dembowska, E.A. (2021). The Use of Phytoplankton in the assessment of water quality in the lower section of Poland’s largest river. *Water*, 13(23): 3471. DOI: 10.3390/w13233471

Dey, S., Botta, S., Kallam, R., Angadala, R. & Andugala, J. (2021). Seasonal variation in water quality parameters of Gudlavalleru Engineering College Pond. *Current Research in Green and Sustainable Chemistry*, 4: 100058. DOI: 10.1016/j.crgsc.2021.100058

Edan & Sharqi. (2020). A study some physico-chemical and bacterial properties of wastewater for Ramadi Teaching Hospital and its impact on the Euphrates River. *Indian Journal of Forensic Medicine & Toxicology*. 14(4): 2319-2325. DOI: 10.37506/ijfmt.v14i4.11903

Fathan, M.R.R.N., Hasan, Z., Apriliani, I.M. & Herawati, H. (2020). Phytoplankton community structure as bioindicator of water quality in floating net cage area with different density at Cirata Reservoir. *Asian Journal of Fisheries and Aquatic Research*, 6(4): 19–30. DOI: 10.9734/ajfar/2020/v6i430103

Han, C., Dai, Y., Sun, N., Wu, H., Tang, Y. & Dai, T. (2022). Algae bloom and decomposition changes the phosphorus cycle pattern in Taihu Lake. *Water*, 14(22): 3607. DOI: 10.3390/w14223607

Hanjaniamin, A.E., Tabrizi, M.S. & Babazadeh, H. (2022). Dissolved oxygen concentration and eutrophication evaluation in Yamchi dam reservoir, Ardabil, Iran. *Applied Water Science*, 13(1):9. DOI: 10.1007/s13201-022-01786-1

Huang, Z., Pan, B., Soininen, J., Liu, X., Hou, Y. & Liu, X. (2023). Seasonal variation of phytoplankton community assembly processes in Tibetan Plateau floodplain. *Frontiers in Microbiology*, 14: 1122838.DOI: 10.3389/fmicb. 2023.1122838.

Hussein, A.K., Muneam, R.R., Jafer, N.A., Ibrahimand, A.A. & Abojassim, A.A. (2023). Surface water assessment using water quality index: A case study of the Euphrates River, Najafi, Iraq, by using the GIS Technique. *IOP Conference Series: Earth and Environmental Science*, 1225(1): 012012. DOI: 10.1088/1755-1315/1225/1/012012.

Jalal, A.D., Ani, Y.A., Thameel, S.S. & Ismael, Z.M. (2023). Study of the Euphrates River’s water quality in front of and behind the Haditha Dam in Anbar Province, Iraq. *IOP Conference Series: Earth and Environmental Science*, 1222(1): 012042. DOI: 10.1088/1755-1315/1222/1/012042.

Khalaf, H.K.A., & Sharqi, M.M. (2023). Identification of phytoplankton and its relationship to monthly changes and biological indexes in the water system of Warar Canal, Anbar Ramadi, Iraq. *Annals of Agri Bio Research*, 28(2): 386–392.

Khaleefa, O., & Kamel, A.H. (2021). On the evaluation of water quality index: Case Study of Euphrates River, Iraq. *Knowledge-Based Engineering and Sciences*, 2(2): 35–43. DOI: 10.51526/kbes.2021.2.2.35-43.

Khlaif, B.M., & Al-Hassany, J.S. (2023). Assessment of the Euphrates River’s Water Quality at a some sites in the Iraqi governorates of Babylon and Karbala. *IOP Conference Series: Earth and Environmental Science*, 1262(2): 022021. DOI: 10.1088/1755-1315/1262/2/022021.

Khudair, B.H. (2023). Assessment of water quality index and water suitability of the Tigris River for drinking water within Baghdad City, Iraq. *Journal of Engineering*, 19(6): 764–773. DOI: 10.31026/j.eng.2013.06.08.

Li, X., Xu, Y.J., Ni, M., Wang, C. & Li, S. (2023). Riverine nitrate source and transformation as affected by land use and land cover. *Environmental Research*, 222: 115380. DOI: 10.1016/j.envres.2023.115380.

Li, X., Yu, H., Wang, H. & Ma, C. (2019). Phytoplankton community structure in relation to environmental factors and ecological assessment of water quality in the upper reaches of the Genhe River in the Greater Hinggan Mountains. *Environmental Science and Pollution Research*, 26(17): 17512–17519. DOI: 10.1007/s11356-019-05200-3.

Mekawey, M., Gamal, A. & Hussien, A. (2023). Assessment of water suitability to aquatic life using some water physicochemical variables and water quality index. *Egyptian Journal of Aquatic Biology and Fisheries*, 27(6): 739–757. DOI: 10.21608/ejabf.2023.330195.

Muhammad, S.A. & Ali, A.F. (2013). Physio-chemical propreties and rotifera population density of Darbandikhan Lake, Kurdistan-Iraq. *Current Research Journal of Biological Sciences*, 5(2): 53–57. DOI: 10.19026/crjbs.5.5473.

Noon, A.M., Ahmed, H.G.I. & Sulaiman, S.O. (2021). Assessment of water demand in Al-Anbar Province- Iraq. *Environment and Ecology Research*, 9(2): 64–75. DOI: 10.13189/eer.2021.090203.

Palmer, C.M. (1969). A composite rating of algae tolerating organic pollution. *Journal of Phycology*, *5*(1): 78–82. DOI: 10.1111/j.1529-8817.1969.tb02581.x.

Pereira, L.C.C., Sousa, N.D.S.D.S., Silva, B.R.P.D., Costa, A.L.B.D., Cavalcante, F.R.B., Rodrigues, L.M.D.S., & Costa, R.M.D. (2023). Influence of Anthropogenic Activities on the Water Quality of an Urban River in an Unplanned Zone of the Amazonian Coast. *Limnological Review*, 23(2): 108–125. https://doi.org/10.3390/limnolrev230 20007

Potasznik, A., Szymczyk, S. & Potasznik, A. (2015). Magnesium and calcium concentrations in the surface water and bottom deposits of a river-lake system. *Journal of Elementology*, 20(3): 677-692. DOI: 10.5601/jelem.2014.19.4.788.

Qu, S. & Zhou, J. (2024). Phytoplankton community structure and water quality assessment in Xuanwu Lake, China. *Frontiers in Environmental Science*, 11: 1303851. DOI: 10.3389/fenvs.2023.1303851.

Rao, D. & Rao, G. (2016). Seasonal abundance of phytoplankton in relation to physico chemical features of Venkammacheruvu Veeraghattam, Sriakulam(Dist.)A.P, India. *IOSR Journal of Pharmacy and Biological Sciences*, 11(04): 91–98. DOI: 10.9790/3008-1104049198.

Sabater-Liesa, L., Ginebreda, A. & Barceló, D. (2018). Shifts of environmental and phytoplankton variables in a regulated river: A spatial-driven analysis. *Science of the Total Environment*, 642: 968–978. DOI: 10.1016/j.scitotenv.2018.06.096.

Saod, W.M., Mohammed, E. A. & Hussenc, A. H. (2019). Euphrates River water quality studies in Iraq: Critical Review. *Anbar Journal of Engineering Sciences*, 10(1): 61–66. DOI: 10.37649/aengs.2019.171364.

Sharqi, M., M Hasan, O. & A Salih, T. (2021). Effect of Urban Sewage Water on Pollution of the Euphrates River, Iraq. *Indian Journal of Ecology*, 48: 296–298.

Soleimani, H., Nasri, O., Ojaghi, B., Pasalari, H., Hosseini, M., Hashemzadeh, B., Kavosi, A., Masoumi, S., Radfard, M., Adibzadeh, A., & Feizabadi, G. K. (2018). Data on drinking water quality using water quality index (WQI) and assessment of groundwater quality for irrigation purposes in Qorveh & Dehgolan, Kurdistan, Iran. *Data in Brief*, 20: 375–386. https://doi.org/10.1016/j.dib.2018.08.022

Tamaki, A.N.a.A. & Obeidi, N.a.A. (2023). Use of epiphytic diatoms in *Cyperus Papyrus* L. as bioindicators in the assessment of the health of the upper Euphrates River Between the Haditha Dam and Al-Baghdadi, Iraq. *IOP Conference Series Earth and Environmental Science*, 1222(1): 012020. DOI: 10.1088/1755-1315/1222/1/012020.

Van Vuuren, S.J. (2006). *Easy identification of the most common freshwater algae: a guide for the identification of microscopic algae in South African freshwaters*. Resource Quality Services (RQS).

Weng, X., Jiang, C., Yuan, M., Zeng, T. & Sheng, M. (2023). Assessment of a new nutrient management strategy to control harmful cyanobacterial blooms in Lake Taihu using a hydrodynamic-ecological model. *Environmental Research Communications*, 5(12): 125002. DOI: 10.1088/2515-7620/ad1063.

Wiranegara, P., Sunardi, S., Sumiarsa, D. & Juahir, H. (2023). Characteristics and changes in water quality based on climate and hydrology effects in the Cirata Reservoir. *Water*, 15(17): 3132. DOI: 10.3390/w15173132.

Xu, W., Duan, L., Wen, X., Li, H., Li, D., Zhang, Y. & Zhang, H. (2022). Effects of seasonal variation on water quality parameters and eutrophication in Lake Yangzong. *Water*, 14(17): 2732. DOI: 10.3390/w14172732.

Yousif, Y. M., Hassan, O. M. & Ibraheem, I. J. (2024). Fabrication of nanocellulose membranes from freshwater green algae (*Chara corallina*) and their application in removing bacteria from water. *Environment and Ecology Research*, 12(2): 154–162. DOI: 10.13189/eer.2024.120206.

Yousif, Y. M., Mutter, T. Y., & Hassan, O. M. (2024). Health risks and environmental assessments of heavy metals in road dust of Ramadi, Iraq. *Journal of Degraded and Mining Lands Management*, 11(2): 5301–5306. DOI: 10.15243/jdmlm.2024.112.5301.

Zhang, Y., Gao, W., Li, Y., Jiang, Y., Chen, X., Yao, Y., Messyasz, B., Yin, K., He, W., & Chen, Y. (2021). Characteristics of the Phytoplankton Community Structure and Water Quality Evaluation in Autumn in the Huaihe River (China). *International Journal of Environmental Research and Public Hhealth*, 18(22): 12092. https://doi.org/10.3390/ijerph182212092