Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

Planktonic Diatoms as Bio Indicators of Water Quality of Euphrates River between Saqlawiah and Amiriat Al-Fallujah – Iraq

Abdul-Nasir A. M. Al-Tamimi[1*] & Iman S. A. Al-Jumaily
[1]Department of Biology, College Education for Women, Anbar University
[*]Corresponding Author's email: edw.nasir63abdulla@uoanbar.edu.iq

Abstract:

The use of bio-indicators applications are an alternative method for assessing the quality of surface water, as well as the use of routine analysis of chemical and physical parameters. This study evaluated the ecological integrity of the Euphrates River between Saqlawiah and Amiriat –Al-Afallujah western of Iraq using planktonic diatoms. Water and planktonic diatom samples were collected from five sampling sites monthly for a period between Nov. 2019 to Aug. 2020 . Water quality parameters including Air and Water Temperature, Electrical Conductivity, Sanility, Turbidity, pH, Total Alkalinity, Total Hardiness, Calcium, Magnesium, Dissolved Oxygen, Percentage saturation of oxygen, Biological Oxygen Demand, Sulfates, Nitrate, Phosphate were analyzed standard protocols. Extract the least significant difference for the differences between sites and between seasons by SPSS statistical packages. A total 82 species of planktonic diatoms were identified at the study sites with *cocconeis pediculus and C. placentula* having the highest abundance were indicative of mesotrophic and moderate polluted water . The ranges of biological indices were as follows: Palmer's pollution index (8.6 – 13.2), Pollution tolerance index (2.77-2.86), Trophic diatomic index (49.48 - 56.73) and Shannon diversity index (2.777 - 3.270). It was concluded that the water quality of the Euphrates River during the study period ranged between slight pollution to moderate pollution.

Keywords : Planktonic diatoms , Applied ecology , Surface water Bio-indicators , Ecosystem health , Euphrates River

Introduction :

Diatoms have been used as a bio-Indicators in many Iraqi water bodies [1 , 2 , 3 , 4] because they are important organisms in assessing water quality and have importance in sustaining the river water ecosystem [5]. Planktonic diatoms freely exist within the water column of water bodies such as rivers [6] , and they are single-celled with Autotrophic and their walls are saturated with silica and form the largest Group of phytoplankton, and most diatoms are floating in fresh and marine waters [7 , 8] . It constitutes the largest proportion of the biomass of algal groups [9]. Diatoms account for 25-30% of primary productivity in Oligotrophic water and 75% in Eutrophic water [10 , 11] . Diatoms were used as biological indicators to estimate the water quality of aquatic systems, as it has a rapid response to the changes occurring in the aqueous environment, so it is possible to estimate the water quality [12] . A reduction in the number of species and an increase in the number of individuals in the aquatic environment gives the impression that it is polluted, which leads to a decrease in the values of biodiversity, while when the number of species increases and the

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

number of individuals increases, it gives the impression that the water is of high biodiversity and that the water is clean and a little biomass [13 , 14] . The aquatic ecosystems suffer a lot of degradation due to human activities, which leads to changes in sediments, a decline in the water quality of rivers, and a loss of biodiversity [4] .

The sensitivity of diatoms in polluted water and their use as a biological monitor in aquatic environments has been used in many studies [15 , 16 , 17 , 18] . In Iraq, many studies were conducted on phytoplankton groups and diatoms and their relationship to the physical and chemical factors of water [19 , 20 , 21] . Some studies were conducted on the use of phytoplankton as bio indicators for assessing water quality [4 , 17 , 22 , 23] . The current study aims at employing the quantity and quality of planktonic diatoms as biological indicators to estimate water quality through a set of biological indices and compare them with physical and chemical parameters and water quality index.

Material and Methods :

The current study included the collection of water samples and planktonic diatoms from five selected sites within a sector of the upper Euphrates River between Saqlawiyah and Ameriyat Al-Fallujah (Figure 1), and the geographical location of each site was determined (Table 1). Samples were collected monthly, starting from November 2019 to September 2021 .

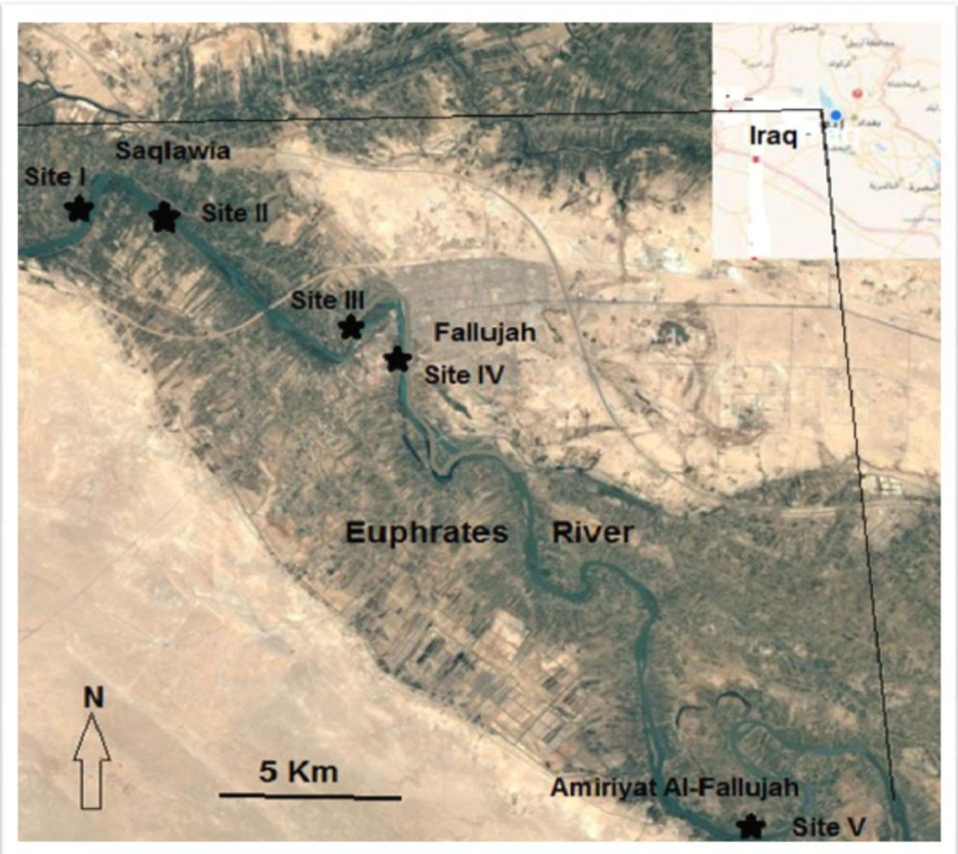


Figure (1) Map of the Euphrates River and the location sampling Sites .(Google Earth)

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

Table (1) The geographical positions (GPS) of the sampling sites .

Sites	Location	Longitudes (Eastward)	Latitudes (Northwards)
I	Alb-Shalal	33° 23' 50.93"	43° 39' 21.17"
II	Saqlawiah	33° 23' 23.07"	43° 40' 7.60"
III	Azraqia	33° 21' 4.85	43° 44' 46.75
IV	Fallujah	33° 20' 18.02	43° 45' 43.37
V	Amiriat Al-Fallujah	33° 10' 25.79"	43° 52' 40.2"

Physical and Chemical Analysis :

All physical and chemical factors were analyzed according to APHA [24] , but Nitrate and Phosphate were analyzed according to Strickland and Parsons [25] , and the average results were calculated within the studied seasons (Table 3).

Planktonic Diatoms Analysis :

Water sample for planktonic diatoms counting was transferred to a 500 ml cylinder and fixed with a Lugol' s iodine solution (5ml) . The preserved sample was left to stand in the dark for 10 days to allow concentration by decantation . Then the layer 20- 25 ml containing the sediment of diatoms was transferred to a 50 ml cylinder . The second decantation was conducted after 7 days , and the lower layer 10ml containing sediment of diatoms was put in a plastic vial and stored in a dark box [26] . The planktonic diatoms frustules were cleaned was done by concentrated sulfuric acid and potassium dichromate method of Patric and Reimer [27] .The preparation for counting methods of diatoms were followed furet and Benson – Evans and micro-transect method used for counting [28] . Diatoms were identified according to the following references [27 , 29 . 30] . Four biological indices and NSF-water quality index were used for this study of water quality . These indices have been calculated according to references marked in front of each index (Table 2) .

Table (2) The biological indices and NSF-WQI used in study Period .

Biological indices	**References**
Palmer pollution index (PPI)	Bellinger and Sigee [31]
Trophic diatom index (TDI)	Kelly and Whitton [32]
Pollution tolerance index (PTI)	Lang-Bertalot [33]
Shannon diversity index (*H*)	Bellinger and Sigee [31]
NSF-Water quality index (NSF-WQI)	BASIN [34]

Statistical Analysis :

Use the statistical program SPSS ver. 19 to extract the least significant difference for the differences between sites and between seasons .

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

Results and Discussion :

Physical and Chemical Parameters Analysis :

The studied physical and Chemical parameters are shown in Table (3) . The results of the current study showed clear seasonal differences in the average air temperature, as it recorded its highest average 48.4 ° C in the summer, and its lowest average 10 ° C in the winter . These seasonal variations explain the nature of Iraq's climate, which is characterized by high temperatures in the summer and low in the winter, with a thermal contrast between night and day [22]. The air temperature is low in the morning and rises gradually at midday [35] . The highest average water temperature 28 ° C was recorded in the summer and its lowest 3 ° C was recorded in the winter. Therefore, the water of the Euphrates River is described as warm. The conductivity and salinity results showed clear seasonal variations, as the highest average were recorded 913.8 μ .s / cm and 0.56 ‰ in the autumn respectively, and the lowest average 606.2 µ.s / cm and 0.36 ‰ in winter respectively. Given that salinity values are recorded in the range of 0.5 ‰ , so the water of the Euphrates River in the study area is considered oligohaline [36 , 27] . Close pH and alkalinity values were recorded in the water of the Euphrates River, which were described with their light alkalinity , with their high values in winter 8.3 and 150 mg $CaCO_3$/l respectively due to the abundance of plants and aquatic organisms through the consumption of Co_2 present in the water in the process of photosynthesis, which leads to an increase in the pH in the water [23] , therefore, the water of the Euphrates River in the study area is of high buffer capacity . The seasonal variations showed clear differences in the turbidity values, as the highest average turbidity was recorded 20.12 NTU in the autumn and the lowest average 3.36 NTU in the summer, and the higher turbidity values in the autumn may be due to the increase in the current velocity and the rise in the water level of the river. The Euphrates for the autumn , as well as the processes of soil erosion that the river passes through and friction with its edges [22] . The water of the Euphrates River is Hard to Very Hard, where its values exceeded 300 mg CaCO3 / l. The increase in hardness may be due to the effect of wastewater, human activities, and untreated industrial water discharged into the river, as well as the nature of the soil [37] . Magnesium concentrations showed lower than calcium concentrations 76.8 mg/l and 80.6 mg/l respectively , which is an expected result in most studies on the Euphrates basin as in Lake Habbaniyah [4] and the Euphrates River between Ramadi and Fallujah [22] .

The water of the Euphrates River is considered among the current study sites its low ventilation and did not exceed the oxygen saturation limit, as the highest dissolved oxygen rate reached 2.5 mg / l in the winter and the lowest rate 2.2 mg / l in the autumn , and this may be attributed to the effect of river water by the waste of human and industrial activities containing the organic materials presented to the river from the main cities such as Fallujah and Saqlawiyah [38] . The values of the Biological Oxygen demand (BOD) showed high values, as the highest average values 16.8 mg / l were recorded in the summer and the lowest average 13 mg / l in the spring, and the high BOD values in the summer were attributed to the high temperatures and the increase in the concentration of substances Organic due to evaporation and low water levels [20] . Nitrate concentrations did not

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

record high values during the current study, as the highest average was recorded 1.66 mg / l in winter and its lowest average 0.90 mg / l in summer, while phosphate concentrations showed higher values, as the highest average values were recorded 6.34 mg / l in summer and the lowest average 5.30 mg / l in winter, the high phosphate values in the Euphrates River are generally due to the increase in the water level due to the effect of rain, and may be due to the increase in the use of fertilizers rich in nitrogen and phosphorous elements and soil washing operations [1] . Sulfate concentrations recorded high values in the waters of the Euphrates River at the current study sites, as the highest average 197 mg / l was recorded in the autumn and the lowest average 151.2 mg / l in the winter. This increase may be attributed to their influence with the waters of the Tharthar and Habbaniyah lakes for the long period of storage of their water [22] .

Table (3) Means of Physico – chemical factors in Euphrates River during the study period .

Parameters	Autumn2019	Winter 2020	Spring 2020	Summer 2020
Air Temperature(C°)	19	10	32.2	48.4
Water Temperature(C°)	17.2	3.4	15.8	27.6
Turbidity (NTU)	20.124	9.24	19.9	3.36
PH	7.8	8.3	7.56	7.6
Total Alkalinity (mg $CaCO_3$/ l)	116.8	150.2	129.4	114.8
E.C (µs/ cm)	913.8	606.2	838	851.6
Salinity (‰)	0.56	0.36	0.51	0.52
Total Hardness (mg $CaCO_3$/ l)	329.6	282.4	273.4	265.2
Calcium (mg/ l)	5.8	3.9	9.0	80.6
Magnesium (mg/ l)	76.8	66.5	24.5	16.0
Sulphate (mg/ l)	197.0	151.2	181.8	181.4
Nitrate (mg/ l)	1.52	1.66	1.60	0.90
Phosphate (mg/ l)	6.16	5.30	5.96	6.34
Dissolved Oxygen (mg/ l)	2.2	2.5	2.4	2.3
DO %	22.22	18.6	24.5	29.7
BOD (mg/l)	15.6	15.4	13.0	16.8

In the current study, 82 species of planktonic diatoms included 3 genera, 9 species of centric diatoms (Order : Centrales) , 22 genera, and 73 species of Pinnate diatoms(Order : Pinnales) . The seasonal variations of the total number of planktonic diatoms did not show a clear variation during the study seasons, as their rates were generally converging, with the highest mean 1121 cells / ml recorded in the summer and the lowest average 437 cells / ml in the autumn . Table (4) shows the species and density of planktonic diatoms Identified in the present study . A Total of 7 dominant and common species was reported of all seasons were Aulacoseira varians , Cyclotella ocellata , Cocconeis placentula , *C. pediculus* , Cymbella affinis , Fragilaria crotonensis , Synedra rumpens .

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

Table (4) diversity and Classification of planktonic Diatoms In Euphrates River .
– (Not Found) + (1- 100 Cell/ml) ++ (101 – 200 Cell/ml) +++(201- 1000 Cell/ml)

Taxa	Sites				
	I	II	III	IV	V
BACILARIOPHYCEAE					
CENTRALES					
Aulacoseira distans (Ehr.) Kuetzing	-	-	+	+	-
A. granulata (Ehr.) Ralfs	-	+	-	+	+
A. italica Ehr.	+	-	-	-	-
A. varians Agardh	+	+	+	+	+
Coscinodiscus lacustris Grunow	-	-	-	+	-
Cyclotella comta (Ehr.) Kuetzing	+	-	+	+	+
C. glomerata Bachmann	-	+	-	+	+
C. meneghiniana Kuetzing	+	+	-	+	+
C. ocellata Pantocsek	+	+	+	+	++
PENNALES					
Achnanthes brevipes Agardh	-	+	-	-	-
A. inflate Agardh	+	-	-	-	-
Amphora ovalis (Ktz.) Kuetzing	+	-	+	-	-
Anomoeoneis exilis (Ktz.) Cleve	-	+	+	+	-
Caloneis amphisbaena (Bory) Cleve	-	-	-	-	+
C. bacillum (Grun) Cleve	-	-	+	-	+
C. permagna (Bail) Cleve	-	-	-	-	+
Cocconeis pediculus Ehrenberg	+	++	+	-	++
C. placentula var. lineata (Ehr) Cleve	+	++	+	+	+
C. pseudomarginata Gregory	+	+	-	-	+
Cymatopleura elliptica (Breb)	+	+	-	+	-
C. solea (Breb) W.Smith	-	+	-	-	+
Cymbella affinis (Kuetzing)	+	+++	+	+	+
C. aspera (Ehr) H.Paragallo	-	-	-	+	+
C. cistula (Ehr) Kirchn	+	-	+	+	+
C. cymbiformis (Ktz.) Van Heurck	+	+	-	-	-
C. gracilis (Rabenhorst) Cleve	+	+	+	+	-
C. naviculiformis Auersw	-	+	+	-	-
C. prostrata var. prostrata Cleve	-	-	-	-	+
C. tumida (Breb)	-	-	+	+	+
Denticula elegens Kutz.	+	-	-	-	-
D. rain Sov	+	-	-	+	-
Diatoma elongatum (Lyngb) Agardh	+	+	-	+	+
D. vulgare Bory	+	+	+	-	+
D. vulgare var. breve Grunow	+	-	+	-	+

Diploneis pseudovalis Hustedt	-	-	-	+	-
Fragilaria construens (Ehr) Grunow	-	-	+	-	++
F. crotonensis Kitton	+++	+	++	++	+
F. intermedia Grunow	+	+	-	-	+
Fragilaria sp.	+	-	-	-	+
Gomphonema acuminatum var. turris (Ehr)	-	-	-	+	+
G. constrictum var. Capitata (Ehr)	-	-	-	-	+
G. gracile Ehrenberg	-	-	-	-	+
G. Helvetica Kuetzing	-	-	-	+	+
Gyrosigma attenuatum (Ktz.)	-	+	-	-	-
G. tenuirostrum (Grun.) Cleve	-	+	-	-	-
Hantzschia amphioxys (Ehr.) Grunow	-	-	+	-	-
Navicula cryptocephala Kuetzing	-	-	++	-	+
N. cuspidate (Ktz.) Kuetzing	+	+	+	-	-
N. gracilis (Ehr.)	+	-	-	-	-
N. lanceolata (Ag) Kuetzing	-	+	-	+	-
N. radiosa Kuetzing	-	-	+	+	-
N. saxophilla Bock	+	-	-	+	-
N. schroeteris Meister	-	-	+	-	-
N. tuscula (Ehr.)	+	+	-	-	-
Nitzschia acicularis (Ktz.) Smith	+	-	-	-	+
N. commutata Grunow	-	-	+	-	-
N. dissipata (Ktz.) Grunow	-	-	++	+	+
N. fasciculata (Grun.) Grunow	-	+	+	+	-
N. filiformis (W.Smith) Van Heurck	+	-	-	-	-
N. gracilis Hantzsch	-	+	+	+	+
N. hungarica Grunow	-	+	-	-	-
N. lottoralis Grunow	-	+	+	+	-
N. Macilenta (Gregory)	+	+	+	+	-
N. obtusa W.Smith	-	-	+	-	+
N. palea (Ktz.) W.Smith	+	+	-	-	-
N. saxophilla (Bock)	-	-	-	+	-
N. sigmoeda (Ehr.) W.Smith	-	-	+	+	-
N. trybionella Hantzschia	-	-	-	+	-
N. umbonata (Ehr.) Lange-Bertalot	-	-	+	-	-
N. vermicularis (Ktz.) Hantzsch	+	-	+	-	+
Peronia intermedium Comber	-	+	-	+	+
Pinnularia globiceps Greg	-	+	-	-	-
Rhoicosphenia curvata (Ktz.) Grunow	+	+	-	+	+
Synedra acus Kuetzing	+	-	-	-	-
S. delcatissma (Kutz.)	-	-	+	-	+
S. fosciculata (Ag) Kuetzing	-	-	-	+	-
S. pulchella (Ralf) Kuetzing	+	-	-	-	+
S. rumpens var. rumpens Kutz	+	+	+	+	+

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

S. ulna (Nitz.) Ehrenberg	++	-	-	-	+
Surirella ovalis de Brebisson	-	-	+	-	+
S. robusta Ehrenberg	-	-	+	-	+
Tetrastrum staurogeniaforme	-	-	+	+	-

Biological Indices and Water quality Index :

The results of the quantitative and qualitative study of planktonic diatoms were employed in the current study sites in assessing the water quality of the Euphrates River and comparing it with the measured physical and chemical factors and the water quality index (Table 4) . . The highest average values of Palmer's pollution index (PPI) were recorded 13.2 in the summer and the lowest average was 8.6 in the spring as their values varied during the current study seasons, and the local variations of the PPI showed a clear variation during the study period, and this may be attributed to the variation in the water quality of these sites within the course of a river [22] , where the highest average of Palmer index values reached 16 in the site III during the summer and the lowest rate was 5 in the site IV during the spring (Figure 2 A) , the results of the statistical analysis showed that there are differences Significance between all sites as well as between seasons at a probability level (P <0.05) .

The values of the PPI in all sites in the current study did not exceed the value of 19 , so the Euphrates River in this studied area between Saqlawiyah and Ameriyat al-Fallujah is considered to be a medium organic pollution (table 4), that the presence of a group of planktonic diatoms that appeared in most of the study sites and the indication of Medium water quality Contamination confirms the results of the PPI in the current study, namely *Nitzschia dissipata*, *Nitzschia acicularis*, *Navicula cryptocephala*, *Diatoma vulgaris*, *Cyclotella meneghiniana*, and *Cocconeis placentula* [39]. The results of the current study are in agreement with many local studies [3 , 20 , 23] .

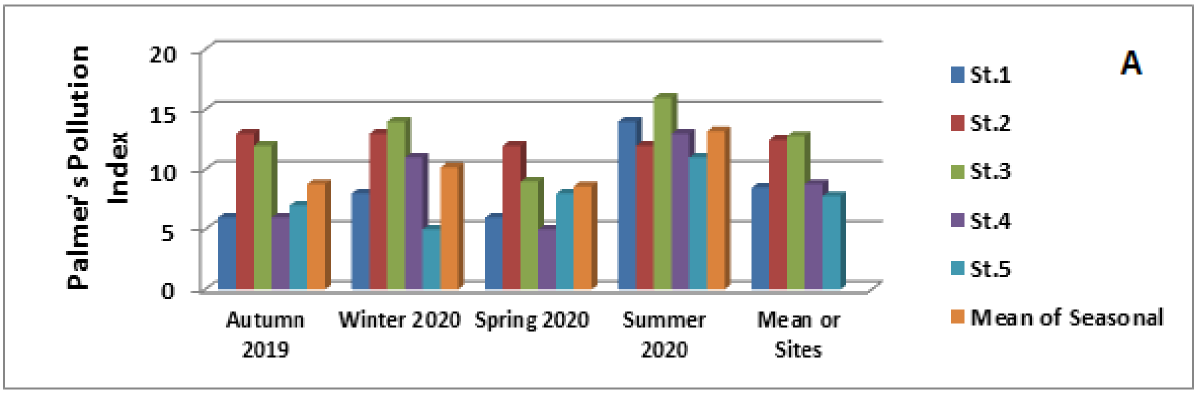
The seasonal and site changes of the pollution tolerance index (PTI) varied according to the planktonic diatoms , as it recorded the highest average of 2.86 in the autumn , the lowest average of 2.77 , and the highest average for the sites recorded 2.96 in the site IV , the lowest average of 2.77 in the site III (figure 2 B) . Statistical analysis revealed significant differences between seasons and sites with a probability level (p <0.05). Low values of the PTI are considered to be that the water is highly polluted, while higher values indicate that the water is less polluted [33] . According to the current results, the water of the Euphrates River is considered moderately polluted [44] . The presence of planktonic diatoms such as *Cocconice plancentula* indicates that the water is of moderate pollution, as it was recorded in most of the current study sites (Table 4) . The results of this study are consistent with local studies in the Al-Shamiah River in southern Iraq [41] , in the Euphrates River between Ramadi and Fallujah [22] and in Upper part of Euphrates River [23] .

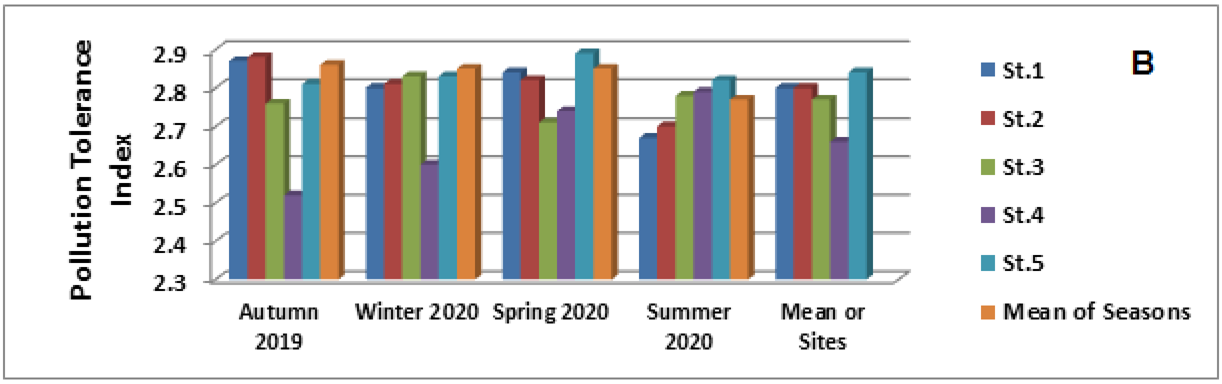
Trophic Diatomic index (TDI) is a good tool for monitoring river , diatoms community are liable to alter of factors that not related to nutrients [31] . The present

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

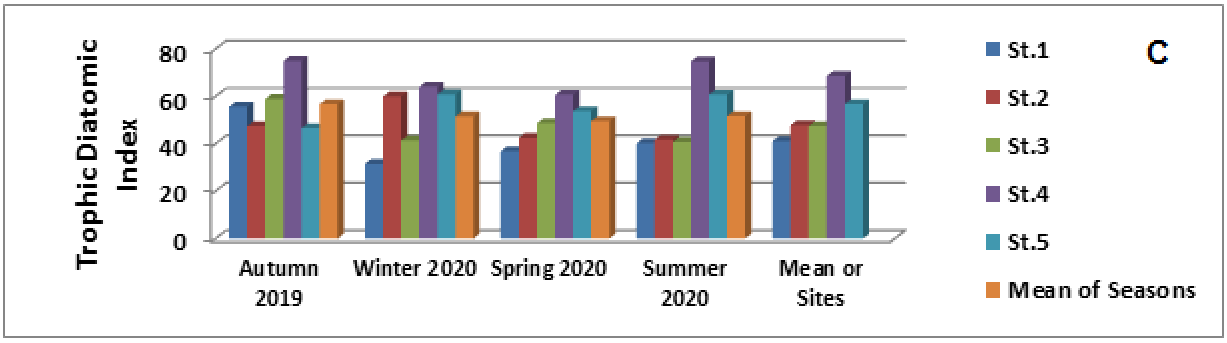
study results of TDI mean values ranged from 49.48 in spring to 56.73 in autumn according to the planktonic diatoms , (fig. 2 C) . The results of the statistical analysis show a significant difference between the seasons well as between the sites ($P \leq 0.05$) . According to this index the Euphrates River was tended to be mesotrophic , this might be confirmed by existence of *Cocconeis pediculus* at most study sites , this species found in mesotrophic River [42] .

The Shannon Diversity index (*H*) is the most widely used biological diversity factor in the environmental study related to the analysis of the community of living organisms, because it does not change. Aquatic ecosystems whose biological diversity is high are considered to be a good indicator of the clean water, while water whose biological diversity is low are considered to be their water' s questionable cleanliness [45] . The values of the (*H*) did not show a clear discrepancy in their seasonal variations, as their values converged, where the highest average values were recorded 3.270 in the summer and the lowest average was 2.777 in the winter. , While the local variations showed a clear variation, as the highest average for (*H*) values was 3,544 in the site IV during the summer, while the lowest rate was 2,494 in the site IV also during the winter (Figure 2 D). The results of the statistical analysis showed that there are significant differences Between all seasons at a probability level ($p < 0.05$) . The record of the lowest biological diversity in the site IV (Fallujah) is due to the increase in decomposition and the lack of other types of planktonic diatoms due to the fact that this site is exposed to a lot of pollutants being released into the river water. Higher values that appeared in the current study indicate that the water of the Euphrates River is of high biodiversity with no dominance for certain species of planktonic diatoms and its water quality is moderately polluted [17 , 46 , 47] (table 4) .





Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.



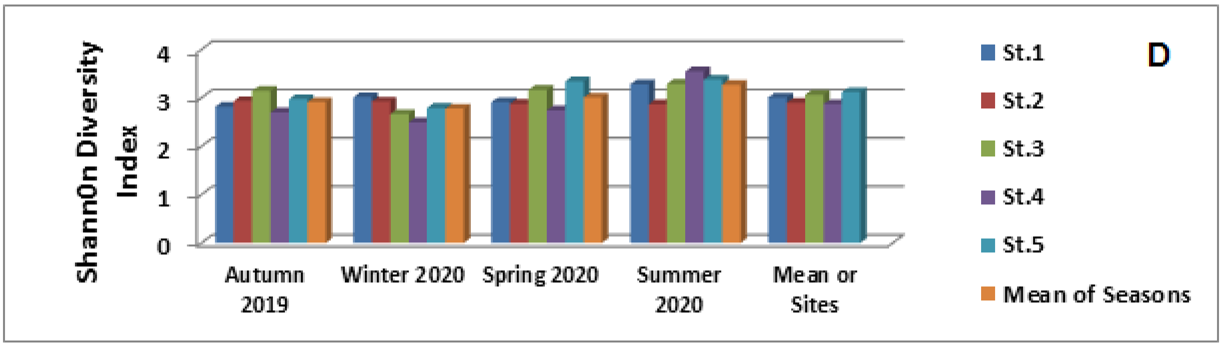


Figure (2) Seasonal variation in biological indices for planktonic diatomic in Euphrates River (A) Palmer's Pollution Index , (B) Pollution Tolerance Index , (C) Trophic Diatomic Index and (D) Shannon Diversity Index .

The high water quality index (WQI) values indicate that the water is clean and free of pollution, while the low index values indicate that it is contaminated or not clean [34] . By conducting this indicator, a good indication of the impact of industrial and human activities on water and the extent of its use can be given [49] . The results of the current study showed that there were no significant seasonal variations in the values of the WQI index between all sites, as the highest average values were recorded 46.97 in the summer and the lowest average was 43.28 in the winter. Water quality index 51.40 in the site II during the summer and the lowest rate was 36.65 in the site IV during the winter (figure 3) . The results of the statistical analysis showed that there were significant differences between all sites with no significant difference between all seasons and at a probability level ($P <0.05$) . The water of the Euphrates River in the current study sites is of good to medium quality and this is in line with the results of the current study with the chemical and physical parameters of the river water , such as high values of dissolved oxygen, low values of salinity, Alkalinity , hardness, biological oxygen Demand , and low values of nutrients such as phosphates and nitrates [50] .

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

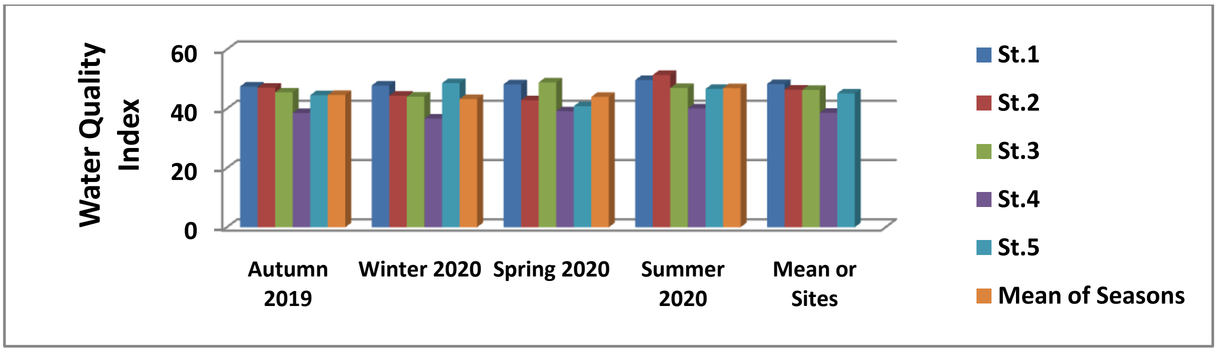


Figure (3) Seasonal variation in NSF- Water quality Index in Euphrates River .

Table(4) Classification of water quality according to values of Biological indices and water quality index values in studied sites .

Pollution indices	Range - Mean Values	Water quality	reference
Palmer's Index (PPI)	8.6 – 13.2 10.9	Moderate pollution	Palmer [40]
Pollution Tolerance Index (PTI)	2.77- 2.86 2.82	Moderate pollution	Lang-Bertalot [33]
Trophic Diatomic Index (TDI)	49.48-56.73 53.12	Mesotrophic Moderate pollution	Van Dam *et al* . [43]
Shannon Diversity Index (*H*)	2.777 - 3.270 3.024	High Biodiversity- Moderate pollution	Shannon-weaver [48]
NSF-Water quality Index	43.28 - 46.97 45.13	Good - Medium	Basin [34]

The results of the water quality index showed its compatibility with all other biological indices for assessing the quality of the Euphrates river water in the selected sites in the current study with some minor exceptions as it reflected the correlation of the quality and quantity of the planktonic diatoms with the variations of chemical and physical factors through the studied biological indices and their compatibility with the NSF- water quality index. (figure 4) .

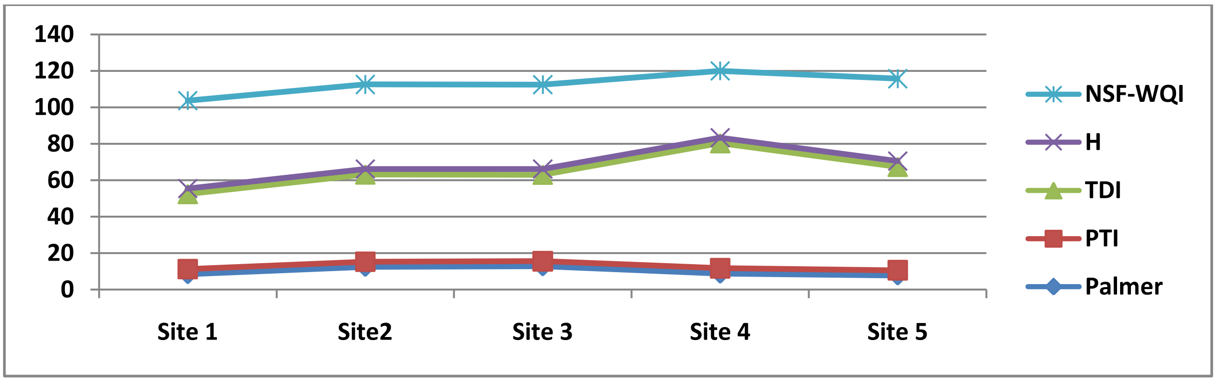


Figure (4) Relationship between biological indices and Water quality index in studied sites .

Conclusion :

The dominance of *Cocconeis pediculus* and *C. plancentula* was indicative of mesotrophic and moderate polluted water . The community structure of planktonic diatom indices , however , ranked the quality of the river during the study period slight pollution to moderate pollution water . There is a close correlation between physical and chemical parameters and planktonic diatom abundance , distribution , species composition and community structure indicated the powerful influence the physical- chemical parameters had on planktonic diatoms . The use of planktonic diatoms can be relied on as bio-indicators of water quality of the Euphrates River. More so, among the sampling sites , site IV (Al-Fallujah) emerged as the most impacted in terms of organic pollution .

References :

1- Eassa AM, Al-Maliky , Al-Saad RT and Mehson NK (2015) . Assessment of eutrophication and organic pollution ststus of Shaat Al-Arab River bu using diatom indices . Mesopotamia Environmental Journal . 1 (3) : 44-56 .
2- Shaawiat AO and Hassan FM (2017) . Qualitative and quantitative study of Epiphytic diatoms on tow macrophytes in a lotic ecosystem , Iraq .Indian Journal of Ecology . 44(3) : 504- 515 .
3- Ali SF ,Hassan FM and Abdul-Jabar RA .(2017) . Water quality assessment by diatoms in Tigris River /Iraq . International journal of environment and water . 6 (2) : 53-64 .
4- Al-Tamimi A.A.M. and Al-Mersomy S.M.S.(2018) Using diatoms as biological indicators to determine water quality of Al-Habbaniyah Lake – Iraq .Association of genetic and environmental resources conservation (AGERC) . Proceeding of the 5th international conference of genetic and environment , Baghdad , Iraq . 159-169 .
5- Kelly MG,Jugging S , Bennion H , Burgess A, Yellop M , Hiret H , King L , Jamieson BJ , Guthrie R , and Rippey B . (2008) . Use of diatoms for evaluation ecological statuse in UK freshwaters ,Science Report . SC030103/SR4; Environment Agncy ,Rio House , Waterside Drive , Aztec West , Almondsbury , Bristol , BS32 4UD .
6- Taylor JC .(2004) . The application of diatoms –based pollution indices in the veal catchment .Msc . Dissertation , North-West University.
7- Theriot EC.(2012) . Diatoms ,citable reviews in the life sciences (Online) .(31 Jan 2015) .
8- UCMP.(2015) . Diatoms : Life history and ecology , (31 Jan . 2015).
9- Lemke P , and Zgrundo A , (2009) . Studies on planktonic –methodological aspects (case study from the Vistula River mouth) , in Van dam and Cadee (eds), Proceedings of the joint Meeting of the Dutch –Flemish Society of Diatomists (NVKD) and 3rd Central European Diatom Meeting (CE-Diatom) 26-29 March , Diatomededelingen , 33.100-103 .
10- Nelson DM , Tregur P, Brezinski MA , Leynaert A and Queguiner B (1995) . Production and dissolution of biogenic silica in the ocean :revised global estimates ,

comparison with regional data and relationship to biogenic sedimentation , Global Biochemical Cycles , 9: 359-372 .

11- Mann DG , (2010) . Diatoms , Version 07 February 2010 (Online) , in The Tree of Life Web Project .
12- Kshirsagar AD (2013) . Use of algae as a bioindicator to determine water quality of River Mute from pure city mararaahtra (India) .Journal of Environment Research and Technology , 3 (1) : 79-85 .
13- Hellwell JM , (1986) . Pollution monitoring serirs biological ivdicators of fresh water pollution and environment management , Elsevier , New York .
14- Bere T and Tendisi , DG (2011) . Diatoms – Based water quality Assessment in influence by urban pollution : Effects of natural and tow selected artificial substrates . SAO Carto –sp, Brazil . Brazilian Journal of Aquatic Science and Technology . 15 (1) : 54 – 63 .
15- Muscio C , (2002) . The diatom pollution tolerance index : Assigining tolerance values watershed protection development Review , p 17 .
16- Lavoie I, Hamilton PB , Wang Y , Dillo PJ , and Campeaa S . (2009) . A comparison of stream bio assessment in Qubec (Canada) using six European and North American diatom-basead indices – Nova Hedwigia , Beiheft 135. P . 37-56 .
17- Hassan FM , and Shaawiat AO. (2015) . Application of Diatomic indices in lotic ecosystem Iraq . G.D.B.B. 4 (4) p : 381-388 .
18- Kelly MG , (1989) . Use of the trophic diatom index to monitor eutrophication in River Water Research . 32 (1) : 236-242 .
19- Hassan FM , Taylor WD , Al-taee MS , and Al-Fatlawi HJ . (2010) . Phytoplankton composition of Euphrates River in Al-Hindiyabarrage Kifil city region of Iraq . Journal of Environment of Biology ., 31(3) : 343-350 .
20- Salman JM , Jawad HJJ , Nassar AJ . and Hassan FM . (2013) . A study of phytoplankton communities and related environmental factors in Euphrates River (Between tow cites : Al-Musayyab and Hindiya) ,Iraqi Journal of Eviron. Prot. , 4 : 1071-1071 .
21- Salman JM and Hadi , SJ . (2015) . Environmental study of epiphytic algae on some aquatic plants in Al-Abasiya River , Iraq . Mesopotamia Environmental journal . 1 (3) 1-15 .
22- Al-Tamim A.A.M. and Braak M.M. (2019) . Water quality ,diatoms , Pollution and Shannon Diversity Indices for the Euphrates River .Online Journal of Veterinary Research . 23 (2) : 161-169.
23- Al-Tamimi AAM and Al-Obeidy NAS (2021) . Water quality assessment by epiphytic diatoms in Euphrates River between Haditha and Al-Bghdadi – Iraq . Annals of the Romanian Society for Cell Biology , 25 (3 0) : 2022-2032 .
24- APHA(American Public Health Association) . (2005) Standard Method for the Examination of Water and Wastewater " 21 st ed . American Water Work Association and Environment Federation , USA .
25- Strickland JDH and Parsons TR (1972) .A Practical handbook of sea water analysis .Bull. Fish . Res . Board of Canada .

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

26- APHA(American Public Health Association) . (2003) Standard Method for the Examination of Water and Wastewater " 20 st ed . American Water Work Association and Environment Federation , USA .
27- Patrick R and Reimer CW . (1975) . The diatoms of the united states Philadephia , Monograph 13.
28- Furet , J.E. and Benson – Evans , K. (1982) An evaluation of the time required to obtain complete sedimentation of fixed algae particles prior to enumeration . Br. Phyco. J. 17 : 253 – 258.
29- German H (1981) > Flora des diatoms , Diatomophyceae eau douces et douce et saumatres du Massif Armoricion et des contrees voisines deurope occind emal , sciete Nouvelle des Editin Boubee Paris .
30- Burliga AL and Patrick J .(2016) . Diatoms (Bacillariophyta) in River . In: Necchi Jr., O. (ed.) : River algae . Spriger International Puplishing . Switzerland . pp: 93-127 .
31- Bellinger EG and Sigee DC (2010) . Freshwater algae Identification and use as biomindicators . Chichester , West Sussex , UK : Wiley – Blackwell , 284 **pp.**
32- Kelly MG and Whitton BA . (1995) . The trophic diatoms index : A new index for monitoring eutrophication in river , journal pf Applied Phycology . 7: 433- 444 .
33- Lang-Bertalot H. (1979) . Pollution tolerance of diatoms as Criterion for water quality estimation : Nova Hedwigin , 64 : 285- 304 .
34- Basin (2002) . National Sanitation Foundation Water Quality Index . Boulder Area Sustainability Information Network (BASIN) htt://bcn.boulder.co.us/basin/watershed/wqi_nsf.html(downloaded 14.11.2004).
35- Hassan FM , Salah MM , and Salman JM (2007) . Quantitative and Qualitative variability ofepiphytic algae on three plat in Euphrates River – Iraq . J. Aquat. 4(1) : 1-16 .
36- Reid GK (1961) . Ecology of Inland waters andEusteries. Van Nostrand Rein hold Publishing . Co New York , pp. 375 .
37- Mcneely RN , Neimanis VP, and Dweyer I . (1979) . Water quality source book : A guide to water quality parameters . Inland Waters Directorate , branch Ottawa , Canada : 88 pp.
38- Sharma S, Tali I , Pir Z , Siddique A and Mudgal K. (2012) Evaluation of Physico-Chemical parameters of Narmada River , MP , India Resercher , 4(5) : 13-19 .
39- Wang X , Zheng B , Liu L and Li L. (2014). Use of diatoms in river health assessment . Annual Research & Review in Biology, 4054-4074.
40- Palmer C M (1969). A composite rating of algae tolerating organic pollution . J. Phytocol., 5: 78-82.
41- Hassan F M and Shaawiat A O (2015) Application of Diatomic indices in lotic ecosystem Iraq. G. d. B. B vol . 4(4)
42- Rimet F. (2012) .Diatom an ecoregional indicator of nutrients , organicmatter . and micropollutants pollution . THESE Oour obtenir ie grade de DOCTEUR DE L 'UNIVERSITE DE GRENOBLE Specialite : Biodiversity ecologie , environment . France . 203 pp.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 3, 2021, Pages. 6799 - 6813
Received 16 February 2021; Accepted 08 March 2021.

43- Van Dam H, Mertens A , and Sinkeldam J. (1994) . A coded ckeck list and ecological indicator values of freshwater diatoms from the Netherland . Netherland Journal of Aquatic ecology 28 : 117- 133 .

44- Lowe RL and Pan Y.(1996) Benthic Algal Communities As Biological Monitors .In ; Algal Ecology . Fresh Water Benthic Ecosystem (Edster by Stevenson ,RJ : Bothwell , ML and Lowe RL) Academic Press , Sam Diego , 753 pp .

45- Wu ,Schmaiz B. and Fohrer N. (2014) . Study Progress in riverine phytoplankton and its use as bioindicators – a review . Austin Journal Hydrobiology . 1 (1) : 1-9 .

46- Junshum , P., & Traichaiyaporn, S. (2007) .Biological indices for classification of water quality around Mae Moh power plant.

47- Kumar R N and Solanki, R. & Kumar J I (2012a) Spatial variation in Phytoplankton diversity in the Sabarmate river at Ahmed abad . Gujarta , India . J. Enviro. Sci. 6: 13-28.

48- Shannon CE and Weaver W (1949) . The Mathematical Theory of Communcation . University of llinois Press , Urbana : 117 pp.

49- Radwam M (2005). Evaluation of Different Water Quality Parameters for the Nile River and the Different Drains. 9th . Int. Water Tech. Conference , Sharm El-Sheikh, Egypt.

50- Javid A , Yaghmaeian K , Abbasi E and Roudbari A. (2014). Aevalution of water quality from Majen river by NSF – WQI Index J. of Ecological engineering . 15 (4) : 1-6 pp .