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Water Quality Assessment by Epiphytic Diatoms in Euphrates River between Haditha and Al-Baghdadi - Iraq

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Abstract :

The current study aims to study the environment and the presence of Epiphytic diatoms communities to the plants *Ceratophllumdemersum* and *Phragmetsaustrales* and the extent to which they are affected by the water environment of the Euphrates River from physical, chemical and biological factors, and to employ the quantitative and qualitative of epiphytic diatoms to the plants under current study in estimating the quality of the water of the Euphrates River. Fore biological indices and NSF-Water Quality Index were used hn this study for the period from November 2019 to July 2020. The results revealed that the water quality of the Euphrates River were moderately to high polluted , mesotrophic and high diversity epiphytic diatoms .

Keywords: Euphrates River , Biological Indices , Water Quality , Macrophytes , Epiphytic Diatoms ,

Introduction:

Diatoms are considered as important components in the algae community in most aquatic ecosystems , especially in a lotic systems , in addition to their role in aquatic food chains [1] as primary products , and a refuge for many invertebrate and fish [2] .

Epiphytic microalgae have a big role in implication for the lotic ecosystem Processes such as environmental balance , water quality [1] . Diatoms were considered as an important part of biota in a lotic ecosystem [3 , 4]. Many diatoms are important in the study of water quality assessment and monitoring du to its fast response to the environmental changes in different aquatic systems [5] .

Classic physical and chemical monitoring reflects instantaneous measurement while biotic parameters provide better evaluation of environmental changes . Because community development integrate a period of time reflecting conditions that might not be any longer present at the time of sampling and analysis [6] diatoms are preferred than other algae [7] . Epiphytic algae attach to macrophytes vegetative boody , mobility is restricted and the ability to capture nutrients from the water column is limited macrophytes my provide epiphytes with dual the benefits of substrate and a nutrient source [8] , but increased epiphytic algae may reduce the diffusion of nutrients from water column to aquatic macrophyte leading to reduced plant biomass all growth [9] .

A few studies were conducted on the upper part of Euphrates River . This part is the main source of drinking water and other agricultural and industrial activities of many towns along the River . Most the studies to study the phytoplankton and physic-chemical properties of the River basin as in Haditha Lake [10] , Al-Habbaniyah Lake [11, 12] , and in the River [13 , 14] . Some studies examined the use of planktonic diatoms to assess water quality in Al-Habbaniyah Lake [15] and in the River between Ramadi and Fallujah [16] . The aim of this study was undertaken to determine the species of epiphytic diatoms on tow macrophytes plants *Phragmitsausrtalis and Ceratophyllumd*emersium and to test the utility and suitability of some biological indices as indicators of water quality of Euphrates River between Haditha and Al-Baghdadi western of Iraq .

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Material and Methods :

The Upper part of Euphrates River between Haditha and Al-Baghdadi western of Iraq was selected for application indices (Figure 1) . Monthly sampling was taken from six sites along Euphrates River during the period from November 2019 to September 2020 and the results presented seasonally (Fig. 1 , Table 2) . All physic-chemical parameters were determined follow APHA [17] , nitrate and phosphate [18] .

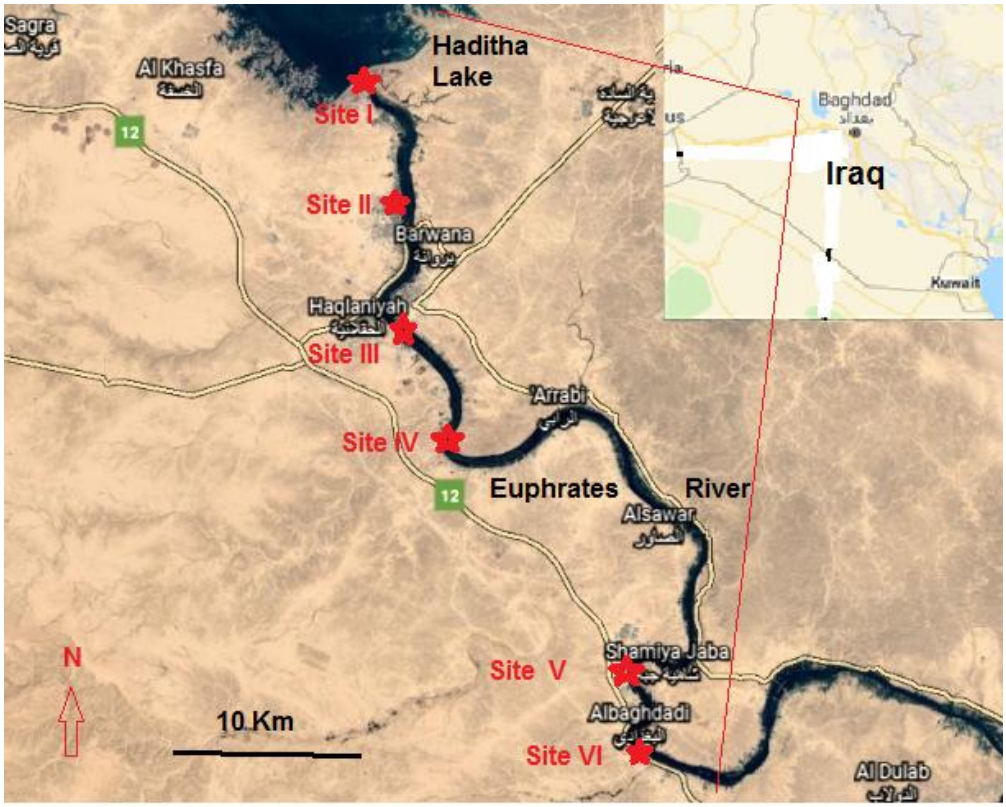

Figure 1. Map of the Euphrates River between Haditha and Al-Baghdadi and the location sampling sites .

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

Sites	Location	Longitudes (eastward)	Latitudes (northwards)
I	Haditha Dam	42° 21' 43"	34° 12' 10"
II	Haditha	42° 23' 20"	34° 07' 39'
III	Haklaniah	42° 22' 43'	34° 05' 13"
IV	Aaloos	42° 24' 03"	34° 01' 14"
V	JOOBA	42° 32' 03"	33° 54' 33"
VI	Al-Baghdadi	42° 31' 47"	33° 52' 16"

Epiphytic diatoms analysis : The sample of the epiphytic diatoms on tow aquatic plants (*Ceratophyllumdemersum* and *Phragmtsaustralis*) . The epiphytic diatoms were determined on

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*C.demersum*by shaking strongly with distilled water to remove the diatoms from the aquatic plants surface . The attached diatoms on *P .australis* was treated manually by toothbrush and shaking then preserved with Lugol's iodine solution [19]. The cleaning of diatoms frustules was done by concentrated sulfuric acid and potassium dichromate method of patric and Reimer [20] . The preparation for counting methods of diatoms were followed Furet and Benson – Evans and micro-transect method used for counting [21] . Diatoms were identified according to the following references [22 , 23 . 24] .Four biological indices and NSF-water quqlity 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 this study .

Pollutionindices	References
1- Palmer pollution index	Bellinger and Sigee[25]
2- Trophic diatom index (TDI)	Kelly and Whitton [26]
3- Pollution tolerance idex (PTI)	Lang-Bertalot [27]
4- Shannon diversity index (*H*)	Bellinger and Sigee [25]
5- NSF-Water quality index	BASIN [28]

Results and Discussion :

Physical and Chemical parameters analysis : The measured physic-chemical parameters are show in Table 3 . The average of Air temperatureranged 21.3 in Autumn 2019 and 51.5 C^o in Sumer 2020 . The lowest average value of water temperature was 21.3 in Autumn 2019 and the highest value was 33.5 C^o in summer 2020 (Table 3) . This variation is known in lotic system relation between air and water temperature [29] . Temperature is very important to water quality , and effects the solubility of gases and salts in water and effected on behavior , physiological and distribution of aquatic organisms [30] . The highest average value 28.5 NTU of turbidity wae recorded in Autumn 2019 , wile the lowest value was 1.5 NTU in winter 2019 . The rates of turbidity did not exceed the limits permitted by the World Health Organization (WHO) [31] and the Iraqi standards, where the highest average value were recorded at 28.5 NTU in the autumn 2019 and the lowest Average rates value 1.5 NTU in winter 2020 . You carry it from suspended materials as well as untreated sewage that is directly discharged into the river [16] .The values of total dissolved solid recorded their highest average values in winter 2019 was 754 mg $l^{-1}$and the lowest average value were recorded at 471 mg l^{-1} in summer 2020. Total dissolved solids are a measure of organic, inorganic and other dissolved materials in water [32]. pH of water samples were slightly alkaline , they ranged from 7.5to 7.7 , many studies in Iraqi inland water was recorded the buffer capacity of water such as [33 , 16] . Water salinity ranged 0.4 to 2.4 $g.l^{-1}$, this results revealed that the river was alkaline and oligohaline according to the classification of Reid [34] . The highest average value of electrical conductivity was recorded 1232 µ.s/cm in Autumn 2019 and lowest average value 635 µ.s/cm in Spring 2020 , this high values might be due to the gradual increase in the entry of domestic sewage detergents and waste to the river .

Total hardness recorded for Euphrates river ranges between 253 to 367 mg $CaCO_3$. l^{-1}, the highest values were recorded in the autumn 2020, due to the erosion of the limestone soil nature of the Iraqi lands[35] Ca and Mg have vial importance in plants , which photosynthesis in the aquatic environment , Mg is in the structure of chlorophyll , the concentration of Mg has a great effect on algae growing in lake [36] . All the concentration of calcium were higher than the magnesium

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concentration among most of the study period at all sites , that s probably due to high abilities of calcium ion to react with dioxide carbon more than for magnesium [16] . Dissolved oxygen concentration recorded between 7.9 to 11.9 mg . l^{-1} while biochemical oxygen demand (BOD_5) ranged from 3.8 to 8.3 mg . l^{-1} , these values of BOD_5 were high than permissible limit (5 mg . l^{-1}) proposed by WHO [31] .

Nitrogen and phosphate are tow major nutrients required for algae growth . During the study period , values of nitrate and phosphate elevated at all seasons , this interpreted by increased human activity in agriculture and sewages wastes discharching into study sites . The results of the present study was nitrate concentration recorded between 23.0 to 115.3 mg . l^{-1} and phosphate concentration between 0.129 to 0.198 mg . l^{-1}

Table3 . Means of Physico - chemical factors in Euphrates River during study period .

Parameters	Autumn 2019	Winter 2020	Spring 2020	Summer 2020
Air Temperature (C°)	21.3	16.5	28.3	51.5
Water Temperature (C°)	21.3	15.2	22.0	33.5
Turbidity (NTU)	28.5	1.5	3.3	2.3
T.D.S (mg l^{-1})	754	484	617	471
pH	7.7	7.7	7.6	7.5
Total Alkalinity (mg $CaCO_3$ l^{-1})	133.6	163.2	142.6	140.2
E.C (µs cm^{-1})	1232	692	635	657
Salinity (‰)	0.5	0.8	0.4	2.4
Total Hardness (mg $CaCO_3$ l^{-1})	367	260	280	253
Calcium (mg l^{-1})	69.0	57.6	57.3	61.6
Magnesium (mg l^{-1})	31.3	28.6	32.6	23.8
Dissolved Oxygen (mg l^{-1})	7.9	11.9	8.3	8.3
DO %	109	118	117	163
BOD (mg l^{-1})	3.9	3.8	4.1	8.3
Nitrate (mg l^{-1})	83.3	14.2	115.3	23.0
Phosphate (mg l^{-1})	0.198	0.177	0.129	0.154

A total of 177 taxon of diatoms was identification on *C. demersum*which these taxa belonged to

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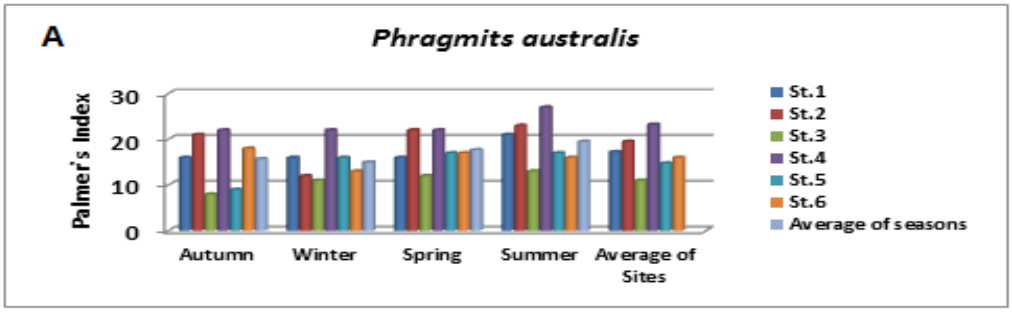
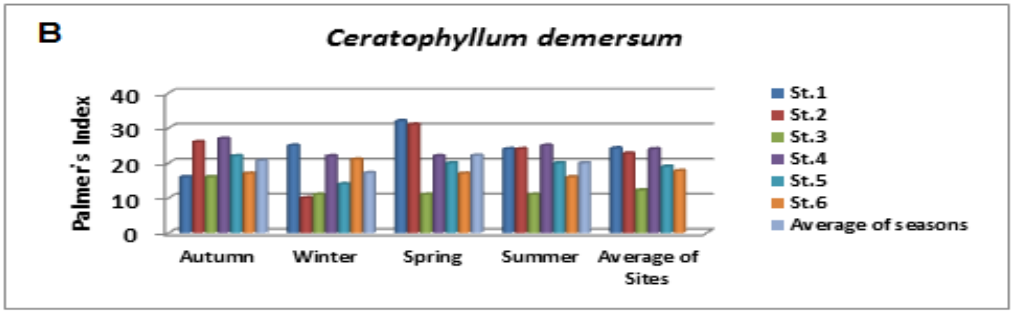
28 genera . The centric diatoms were represented about 7.14 % of the total identification diatoms by 2 species belonged to 6 genera . While pennate diatoms was 96.61 % by 171 species belonged to 26 genera .

Palmer index values for epiphytic diatoms on *P. australis* ranged from 15.00 in autumn 2020 to 19.50 in summer 2020 , but in *C . demersum*from 17.17 in Autumn 2020 to 22.17 in spring 2020 (fig . 2 . A and B) . The results of the statistical analysis showed significant differences between seasons and sites ($p \leq 0.05$) . The values of the palmer index more than 15 were considered as drift in mesotrophic to Eutrophic status [37] . The results of the palmer index according to epiphytic diatoms to *C . demersum*more than values to *P. australis*. Eleven genera were identified from a total of twenty genera that were used to extract Palmer's index values in the current study: *AulacosiraCyclotella, Euglena,GomphonemaNavicula,NitzschiaOscillatoria, Pandorina, Phormidium, Synedra, Stigeocolonium*[37] . The results of Palmer's index according to the epiphytic algae to the*C . demersum*plant showed higher values than the values extracted according to the epiphytic ditoms to the *P. australis*plant , and showed that the Euphrates river of study sites is consistent with the organic pollution manual , which shows that the water ranges from moderate to high pollution (Table 4) .

Pollution tolerance index (PTI) determine the pollution by using diatoms to assess the health of aquatic ecosystems such as rivers [38] . this index values ranged from 2.563 in spring 2020 to 2.843 in autumn 2019 according to the epiphytic diatoms results to *P. australis* but values ranged 2.527 in summer 2020 to 2.861 in autumn 2019 according to the epiphytic diatoms in *C . demersum* (fig.2 C and D) , The results of the statistical analysis did not show a significant difference between the seasons well as between the sites . These results indicated that the Euphrates river was moderately polluted water according to classification of water pollution by Lange-Bertalot [27] (Table . 4) ,this classification revealed that values of PTI were ranged from 1 to 4 , the 1 indicate most polluted water while the 3 , 2 numbers indicated moderately polluted water and 1 number indicated least polluted water . The dominants of some diatoms to indicated moderately polluted water , which is *Cocconeisplacentula* and *Cyclotellameneghiniana*[39]. The results of the PTI extracted according to epiphytic diatoms to the host plants (*C . demersum* and *P. australis*) were converged in the current study.





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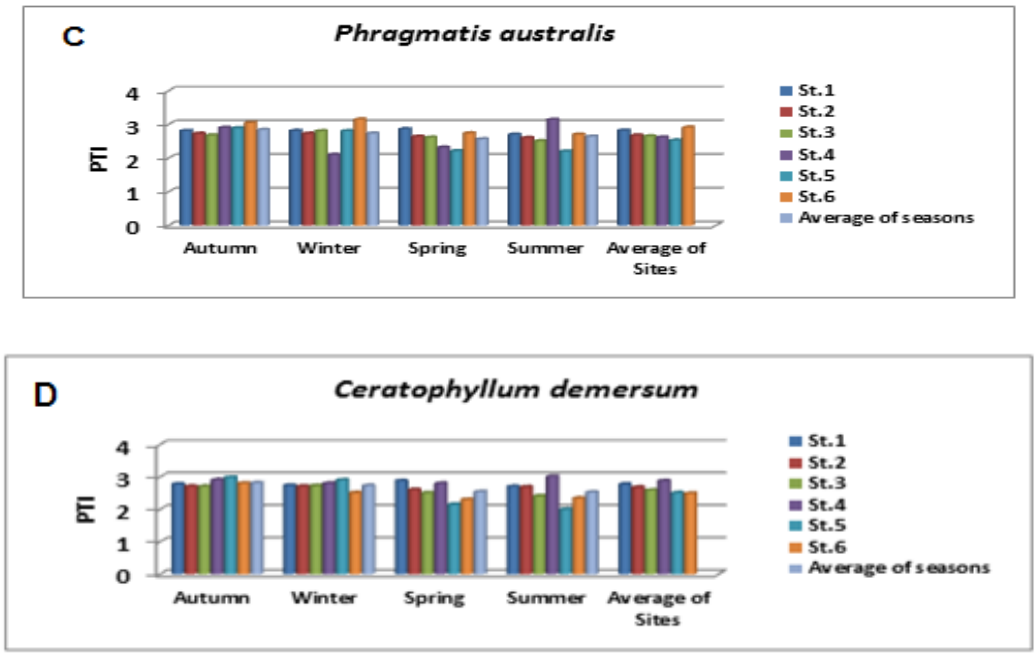

Figure 2 : seasonal variation in studied indices on tow Macrophytes plants (A and B) Palmeŕ s index , (C and D) Pollution tolerance index in Euphrates River during the study period .

Trophic Diatomic index (TDI) is a good tool for monitoring river , diatoms community are liable to alter of factors that not related to nutrients [26] . The present study results of TDI mean values ranged from 63.23 in Autumn 2019 to 68.11 in spring 2020 according to the epiphytic diatoms in *P* . *australis*, but values ranged 66.43 in winter 2020 to 71.35 in summer 2020 according to the epiphytic diatoms in *C* . *demersum*(fig. 3 A and B) . The results of the statistical analysis show a significant difference between the seasons well as between the sites(P ≤0.05) . According to this index the Euphrates River was tended to be mesotrophic to eutrophic , this might be confirmed by existence of *Cocconeispediculus*at most study sites, this species found in mesotrophic River [40].

In the present study the Shannon – Weaver index (*H*) recorded average values above 3 in the study period . The *H* average ranged values from 3.391 in autumn 2020 to 3.999 in summer 2020 according to epiphytic diatoms in *P* . *australis* but the *H* values according to the epiphytic diatoms in *C* . *demersum*exceeded 4 where its average values ranged 3.816 in autumn 2020 to 4.486 in summer 2020 (fig . 3 c and D) . The results of the statistical analysis show a significant difference between the seasons well as between the sites . These findings confirmed the *H* index results which emphasize that the Euphrates River has high biodiversity (epiphytic diatoms)(Table . 4) and also meant that no dominancy for certain species of epiphytic diatoms in the study river . There was a similar species composition al all studied sites with some differences due to the nature of each site and type of macrophyteson which epiphytic diatoms grow such as *P* . *australis and C* . *demersum* . These macrophytes lead to suitable condition of algal growth [41 , 42] . This high values of *H* index were indicative of good water quality of Euphrates River [43 , 44 , 16] .The results of the *H* extracted according to epiphytic diatoms to the host plants (*P* . *australis and C* . *demersum*) in the current study were converged.

The mean values of National Sanitation Foundation – Water quality Index (NSF- WQI) ranged from 51.83 in summer 2020 to 62.12 in winter 2020 (fig .3 E) . These results showed that the

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studied river was Unsuitable to Mediumwater quality (Table . 4) . The results of the statistical analysis show a significant difference between the seasons ($P \leq 0.05$) However , no significant differences were found between the sites . These values of NSF – WQI were identical to the values of most physical and chemical parameters at low values of the BOD , T. Alkalinity , TDS , EC , Salinity , N , P and high concentration of dissolved oxygen [45] .

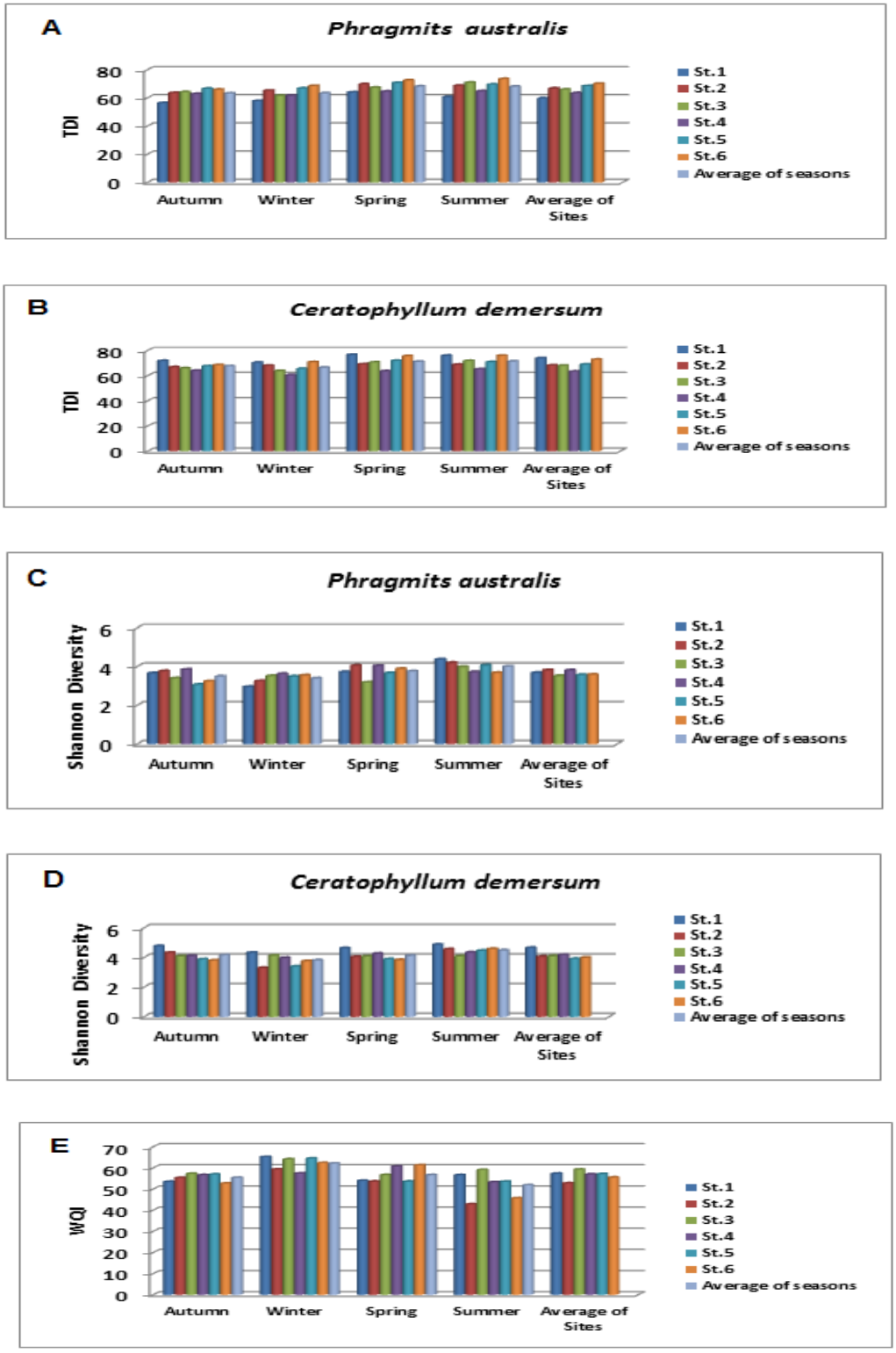

Figure 3 : seasonal variation in studied indices on tow Macrophytes plants (A and B) Trophic diatomic index , (C and D) Shannon diversity index and NSF – Water

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quality index (E) in Euphrates River during the study period .

Table 4. Classification of water quality according to means diatomic indices values in studied sites .

Pollution indices	*Phragmitsaustralis*	*Ceratophyllumdemersium*	Water quality	reference
Palmer's Index	16.95	20.00	Moderate – High pollution	Palmer (1969) [37]
Pollution Tolerance Index (PTI)	2.70	2.65	Moderate	Lang-Bertalot (1979) [27]
Trophic Diatomic Index (TDI)	65.73	69.13	Mesotrophic -Eutrophic	Van Dam *et al.* (1994) [46]
Shannon Diversity Index (*H*)	3.66	4.14	High Biodiversity	Shannon-weaver (1949)[47]
NSF-Water quality Index	56.48		Unsuitable - Medium	Basin (2002) [28]

There were no clear differences in the values of all sites for the biological indices both Palmer's Index , Pollution Tolerance Index , Trophic Diatomic Index , Shannon – Weaver Diversity Index and NSF-Water quality Index for estimating the water quality of the Euphrates River in the current study, which was conducted through the quantity and quality of the epiphytic diatoms to both aquatic plants (Macrophytes) , both *P . australis and C . demersum*(Figure 4) .

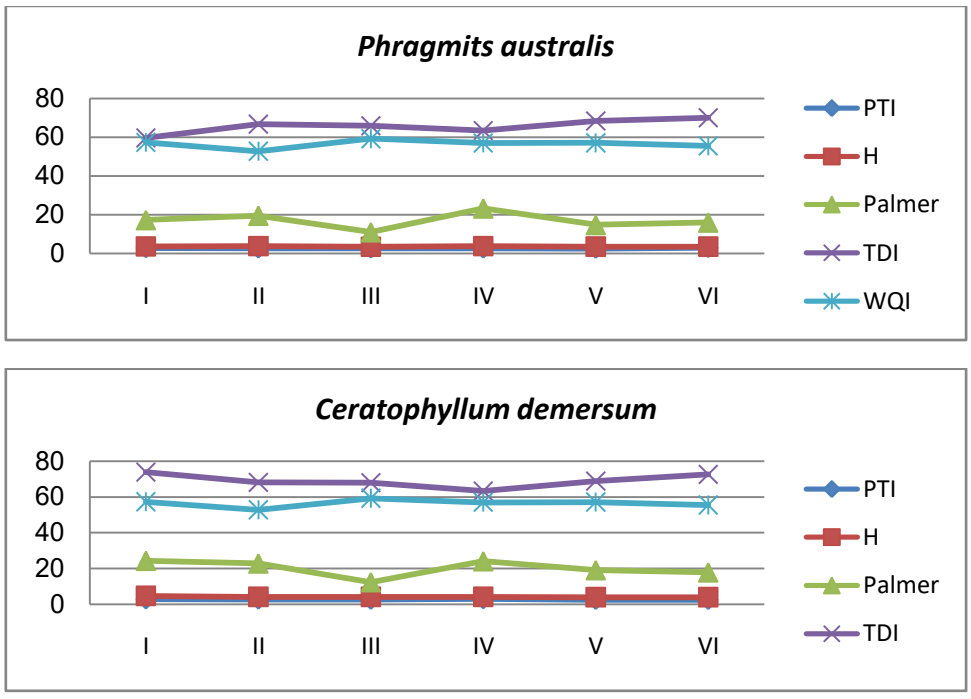

Figure 4 . The Water quality change of epiphytic diatoms on Macrophytes plants

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accordingto sites .

Conclusion :

It can be concluded that most of the studied indices the status of the water quality of Euphrates River which was moderately to high polluted , mesotrophic and high diversity of epiphytic diatoms due to discharge of organic and other pollutant being dumped into the river during river passing in the major cities and small villages located on the river basin .All the results of the biological indicators of the quality of the water of the Euphrates River extracted according to the Epiphytic algae attached to the host plants were converged, except for the values of the Palmer's index on the*C . demersum*plant, which was higher than the values recorded on the *P . australis*plant.

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