Biochem. Cell. Arch. Vol. 22, No. 1, pp. 435-444, 2022 | www.connectjournals.com/bca | *ISSN* 0972-5075
DocID: https://connectjournals.com/03896.2022.22.435 | *eISSN* 0976-1772

USING THE QUANTITATIVE AND QUALITATIVE OF EPIPELIC ALGAE AS BIOINDICATORS TO DETERMINATE THE WATER QUALITY OF AL-HABBANIYAH LAKE, WESTERN IRAQ

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(Received 29 May 2021, Revised 23 July 2021, Accepted 31 July 2021)

ABSTRACT : The current study was conducted in Al-Habbaniyah Lake within the Anbar Governorate, western Iraq for the period from August 2020 to March 2021 for five sites within the waters of the lake. The study included measuring some physical and chemical parameters in the waters of Lake Habbaniyah. The study targeted the community of epipelic algae at the qualitative and quantitative level to use them in determining the quality of the lake water through a set of mathematical indices included in Biological Indices, as well as conducting a Water Quality Index to compare it with the results of physical and chemical parameters and biological indices. All 251 species have been identified belonging to 84 genera of the epipelic algae community, and the different species were distributed in seven classes and their appearance was in varying proportions, as the predominance of the Bacillariophyceae was 44.6%. The physical and chemical parameters agreed with the results of the biological indices and the water quality index to estimate the water quality of Lake Habbaniyah, where it was described as having medium biodiversity according to the Shannon diversity index, where its average values ranged between 2.821-2.012 and the lake water was also described as moderate pollution according to the pollution tolerance index, where its averages ranged between 2.421 - 2.246 and according to Palmer's pollution index, the lake water was described as having medium organic pollution, where its averages ranged between 12.3 - 18.0. The results of the Trophic diatomic index showed that the lake water is of misotrophic , with average values ranging between 67.68 - 35.71. According to the NSF - Water quality index, the lake water was described as of medium quality, with its averages ranging between 57.57-53.32.

Key words : Biological indices, water quality index, Epipelic algae, anthropogenic activities, Al-Habbaniyah lake.

How to cite : Wassan M. M. Al-Hasso and Abdul-Nasir A. M. Al-Tamimi (2022) Using the quantitative and qualitative of Epipelic algae as bioindicators to determinate the water quality of Al-Habbaniyah lake, western Iraq. *Biochem. Cell. Arch.* **22**, 435-444. DocID: https://connectjournals.com/03896.2022.22.435

INTRODUCTION

Biological indices are a group or classes of organisms on which the influence of environmental stresses is clear and shows signs of this effect as a result of human activities or as a result of the destruction of the biological system (Mcgeoch, 1998 and Shahabuddin, 2003). The quality of water greatly affects the quantity and quality of the algae present in it. The types of algae present in waste water differ from those found in clean environments and through the quality of algae present at the bottom of the river, it can be inferred that the presence of pollution is present (UNEP, 1991). Some types of attached algae (Benthic algae) are evidence of water pollution compared to phytoplankton, where attached algae of all kinds are among the basic components of the food web and they also have a role in stabilizing the water body and preparing food for aquatic organisms, because they are relatively stable on the appropriate water body (Blinn and Herbst, 2003). Most of the local studies in the aquatic environment of Epipelic algae focused on their productivity, diagnosis, classification and their relationship to some relevant physical and chemical parameters (Hassan *et al*, 2014 and Al-Ghanimy, 2020). The current study is one of the pioneering studies in evaluating the waters of Lake Habbaniyah using the Epipelic algae as a biological indicators, where most of the studies that have been conducted on Lake Habbaniyah focused on the study of chemical and physical characteristics in order to determine the quality of water and its relationship to the growth of benthic algae and phytoplankton and to determine the prevailing ones in that region (Al-kaisi, 1964; Polservice, 1985; Al-lami *et al*, 1998; Kassim *et al*, 2000).

In a study conducted by Al-Tamimi and Al-Mersomy (2018) in Habbaniyah Lake, planktonic diatoms were used as biological indices of the lake water quality with the study of some physical and chemical factors of the lake. The aim of this study to determine the water quality of Al-Habbaniyah Lake by using quantitative and qualitative of epiphytic algae as bioindicators.

MATERIALS AND METHODS

Lake Habbaniyah is a wide, pear-shaped depression from the surface view in the city of Ramadi, located on the right bank of the Euphrates River, southeast of the city. It was established in 1956 and the purpose of its establishment was to benefit from and store the waters of the Euphrates river to avoid the danger of flooding the Euphrates river, where the capacity of the lake is When it is full (51) meters above the surface of the earth, and the lake is fed by the Al-Warar regulator, which transfers water from the Euphrates River to the lake during the flood season. The area of the lake when it is full is 400 km^2 and accommodates 3.26 billion . m-^{3} to 0.67 billion.m^{-3} (Al-kathily, 2014). Samples were collected from the five selected sites (Fig. 1) for water and mud samples for the period from August 2020 to March 2021 and with a sample rate per month, the geographic latitude and longitude were determined using a geographical device for the sample collection sites, which are shown in Table 1.

Table 1 : Names of the sampling sites and the GPS values.

No.	Site	Longitude (East)	Latitude (North)
I	Al-Warar Channel	43° 20' 29"	33°21'21"
II	East Ramadi Check point	43° 23' 47"	33°25'33"
III	Al-Thaban channel	43° 32' 33"	33° 21' 05"
IV	Touristic city	43° 34' 03"	33° 14' 20"
V	Al-Mjrra channel	43° 30' 05"	33° 11' 33"

Table 2 : The biological indices and NSF-Water quality index used in the study period (2020–2021).

Indices	References
1- Palmer pollution index (PPI)	Palmer (1969)
2- Trophic diatom index (TDI)	Kelly and Whitton (1995)
3- Pollution tolerance index (PTI)	Lang-Bertalot (1979)
4- Shannon diversity index (*H*)	Bellinger and Sigee (2010)
5- NSF-Water quality index (WQI)	BASIN (2002)

All physical and chemical parameters were determined following Lind (1979) and APHA(2005). Nitrate and nitrite, phosphate and silicate was determined following parson *et al* (1984). Epipelic algae was collected according to Eaton and Moss (1966). Epipelic algae was identified in the laboratory following Prescott (1979) and Germain (1981), the micro transect method was used for the quantitative study determined according to Hadi *et al* (1984). Four biological indicators were tested to estimate water quality, as well as testing the water quality index according to the references shown in Table 2.

Fig. 1 : Map of the study sites in the Al-Habbaniyah lake.

The statistical program Analysis System Statistical-SAS (2012) was used in order to analyze the data to study the effect of different factors (seasons and locations) and the significant differences between the arithmetic means were compared with choosing the least significant difference (LSD). A statistical program was used. Computer ready (SPSS var. 16) in order to extract the values of correlation coefficients between chemical and physical parameters, total number of epipelic algae, biological indices and water quality index.

RESULTS AND DISCUSSION

Environmental condition

The results showed the effect of seasonal and local variations, as well as anthropogenic activities, on the average values of physical and chemical parameters in the water of the lake (Table 3). The average air and water temperatures ranged between 13.4 - 44.2 and 10.4 - 28.6°C, respectively. The lake water was described as oligohaline to Mesohaline, where the average salinity and conductivity ranged between 666.2 - 936.4 µ.s/cm and 0.41-0.57%, respectively (Reid, 1961) and the averages of total dissolved (TDS) exceeded the permissible limits, which ranged between 446.8 - 635.8 mg/l, The highest values of salinity, electrical conductivity and TDS were recorded in the site II because it was affected by sand washing sites and random dumping of wastewater (Salman *et al*, 2013 and Al-Obaidy *et al*, 2015) and chloride concentrations decreased during the summer, where they average ranged between 82.6 - 93.0 mg/l. The pH values showed slight seasonal variations, because the lake water has a high regulating capacity and has a light base, where its averages ranged between 7.52 - 7.30 and 120.8 - 92.8 mg $CaCO_3$/l, respectively (Al-Tamimi and Al-Mersomy, 2018). The lake water was described as hard (APHA, 2005) and within the permissible limits, which ranged its averages ranged between 346.8 - 227.0 mg $CaCO_3$/L, with the calcium element that exceeded the permissible limits overpowering the magnesium element, where its averages ranged between 85.8 - 67.4 mg/L and 32.0 - 21.2 mg/L, respectively. This may be due to the disposal of untreated sewage water loaded with organic materials, which leads to the release of carbon dioxide when decomposing, which in turn reacts with calcium more than magnesium to form calcium carbonate (Boyd, 2000) and the sulfates did not exceed the permissible limits, as their averages ranged between 199.0-170.4 mg/liter. The highest values of sulfate were recorded in the site II because it was affected by human activities, while the lowest values were recorded in the site I (Al- Warar channel) due to the dilution of the Euphrates river water (Hassan *et al*, 2020). The results of the statistical analyzes showed a significant positive correlation between electrical conductivity, salinity, total dissolved solids, chlorine, total hardness, calcium and sulfate ($p<0.01$, r=0.997), ($p<0.01$, r=0.994), ($p<0.01$, r=0.9970) , ($P<0.05$, r=0.896), ($P<0.05$, r=0.959), ($P<0.05$, r=0.927), respectively. The lake water was described as having medium aeration, and its averages recorded above saturation values are limited, as the averages of dissolved oxygen and percentages of oxygen saturation ranged between 9.3 - 7.7 mg/l and 100.69 - 83.17% , respectively, with indicators of organic pollution of the lake water by recording high averages of the values of biological requirement. For oxygen, it ranged between 20.8-10.6 mg/L (Lind, 1979).

The concentrations of plant nutrients in the lake water varied, as the concentrations of phosphates and silicates were described as being available, as their averages were higher than the permissible limits and higher than the requirements of diatoms for silicate and their averages ranged between 8.38-3.16 mg/L and 18.8-11.4 mg/L, respectively, while they did not exceed. The results of the statistical analysis showed a significant positive correlation between phosphate and calcium ($P<0.05$, r=0.898) as well as between phosphate and total hardness ($P<0.05$, r=0.918) because there is a relationship between total hardness and phosphate, where phosphate has the ability to form stable compounds with magnesium and calcium in the form of magnesium and calcium carbonate (Reid, 1961). The values of nitrates and nitrites were above the permissible limits, as their averages ranged between 0.7 - 0.4 mg/l and 0.02 - 0.01 mg/l , respectively. The decrease in nitrate and nitrite values in the current study sites may be attributed to better aeration of the lake water (Das *et al*, 2004). The results showed that there was a significant positive correlation of nitrate with total hardness ($P<0.05$, r=0.971).

Algal assemblages

There are 251 species in the current study belonging to 84 genera of the epipelic algae community and the different species were distributed in seven classes and their appearance was in varying proportions, as the dominance of the Bacillariophyceae was 44.6%, that the dominance of the Diatoms over the rest of the algal groups is often characterized by it most of the Iraqi water bodies (Hassan *et al*, 2014; Hassan *et al*, 2017 and Al-Ghafily, 2018) and the results of the current study are in agreement with previous studies conducted in Lake Habbaniyah (Kassim *et al*, 2006; Al-Tamimi and Al-Mersomy, 2018), followed by the Cyanophyceae with 25.9% and then by the Chlorophyceae by 18.2% described the Euglenophyceae with a percentage of 9.2%, while the

Table 3 : Seasonal variation of physical and chemical of water and the total cell numbers of epipelic algae in Al-Habbaniyah Lake during the study period (2020–2021).

	Summer Mean ± SD (Max – min)	**Autumn Mean ±SD (Max – min)**	**Winter Mean ± SD (Max – min)**	**Spring Mean ±SD (Max – min)**	**L.S.D (p > 0.05)**
Air Temperature (C°)	44.2 ± 7.79 33 – 50	44.2 ± 6.14 22 – 38	13.4 ± 3.91 8 - 17	21.8 ± 4.08 15 – 25	*5.08
Water temperature (°C)	29.2 ± 0.83 28 -30	21.0 ± 1.00 20 – 22	10.4 ± 0.89 9 – 11	15.4 ± 0.89 14 – 16	*3.79
EC (μs.cm^{-1})	546 ± 276 72 – 708	936 ± 77 855 – 1060	887 ± 45 814 - 922	887 ± 45 814 – 922	*128.53
Salinity (%)	0.40 ± 0.01 0.38 – 0.43	0.57 ± 0.05 0.51 – 0.65	0.54 ± 0.03 0.50 – 0.03	0.53 ± 0.01 0.52- 0.55	0.188NS
TDS (mg.L^{-1})	362 ± 182 40 - 474	635 ± 55.8 580 – 728	594 ±24 559 – 616	593 ± 15.6 582 – 620	*86.73
pH	7.58 ± 0.46 7.3 – 8.4	7.00 ± 0.25 6.6 – 7.2	7.62 ± 0.21 7.3 – 7.8	7.48 ± 0.13 7.4 – 7.7	*0.559
Alkalinity (mg $CaCO_3$.L^{-1})	92.8 ± 10.1 84 – 110	95.4 ± 10.4 90 – 114	11.8 ± 3.16 114 – 122	12.0 ± 2.86 117 – 124	*22.68
Hardness (mg $CaCO_3$.L^{-1})	227 ±65.7 110 -264	274 ± 24.8 245 – 310	286 ± 10.2 272 – 294	346 ± 10.5 340 – 365	*57.94
Calcium (mg.L^{-1})	67.4 ± 3.64 63 – 72	68.6 ± 11.6 57 ± 88	79.2 ± 3.42 74 – 83	85.8 ± 3.11 83 – 91	*7.88
Magnesium (mg.L^{-1})	21.2 ± 1.92 19 -24	25.4 ± 1.81 23 – 27	22.2 ± 3.11 19 – 26	32.0 ± 1.0 31 – 33	*2.79
Sulphate (mg.L^{-1})	170 ± 11.4 158 – 187	199 ± 23.7 178 – 240	196 ± 4.91 189 – 201	215 ± 12.1 200 – 234	*22.82
Dissolved oxygen (mg. L^{-1})	7.7 ± 1.6 5.5 – 9.5	7.9 ± 0.96 7.0 – 9.5	9.3 ± 0.75 8.5 – 10.0	8.9 ± 0.65 8.0 – 9.5	*1. 32
BOD_5 (mg.L^{-1})	18.4 ± 6.5 13 – 29	20.8 ± 6.72 13 – 31	13.8 ± 2.16 11 – 16	10.6 ± 2.07 8 – 13	*5.39
Phosphate (mg.L^{-1})	5.34 ± 1.95 2.6 – 8.0	8.38 ± 4.55 2.8 – 14.8	6.0 ± 1.55 3.7 – 7.4	3.16 ± 059 2.7 – 4.2	*2.76
Nitrite (mg.L^{-1})	0.01 ± 0.005 0.01 – 0.02	0.02 ± 0.01 0.02 – 0.05	0.02 ± 0.005 0.01 – 0.02	0.01 ± 0.004 0.01 – 0.02	0.011NS
Nitrate (mg.L^{-1})	0.42 ± 0.13 0.3 – 0.5	0.05 ± 0.18 0.2 – 0.7	0.46 ± 0.05 0.4 – 0.5	0.78 ± 0.19 0.5 – 1.0	*0.219
Silicate (mg.L^{-1})	18.1 ± 5.97 12 – 26	17.8 ± 2.16 16 – 21	14.0 ± 1.22 12 – 15	11.4 ± 3.36 9 – 17	*3.61
Total Number Epipelic	25.3 ± 9.6	44.8 ± 26.7	58.8 ± 23.6	32.3 ± 22.1	*7.22
Algae (Cell × 10^3.Cm^2)	9.6 – 34.3	15.15 – 88.2	33.3 – 9.6	10.8 – 60.0	

rest of the other classes constituted small percentages of the total number of the diagnosed species. The Dinophyceae row constituted 1.2%, while it constituted 0.4% for each of the Xanthophyceae and Chrysophyceae descriptions (Fig. 2). The results showed in the current study on the presence of variations in the number of species of epipelic algae between sites and seasons, as the site I (Al-Warar Channel) was recorded highest number of species (143 species) due to the mitigation of the Euphrates waters, where the rates of pollution are reduced by dilution, which leads to the prosperity of the algae community (Al-Tamimi and Braak, 2019), while the site II recorded (48 species) and the number of species was less in the site I due to an increase in the number of species. Pollutants and industrial and domestic wastes collected at this site from anthropogenic activities leads to a decrease in the biodiversity of the epipelic algae (Hassan and Shaawiat, 2015). The proportions of diatoms in this site are lower than the rest of the sites, as the group of blue-green algae recorded a dominance in this

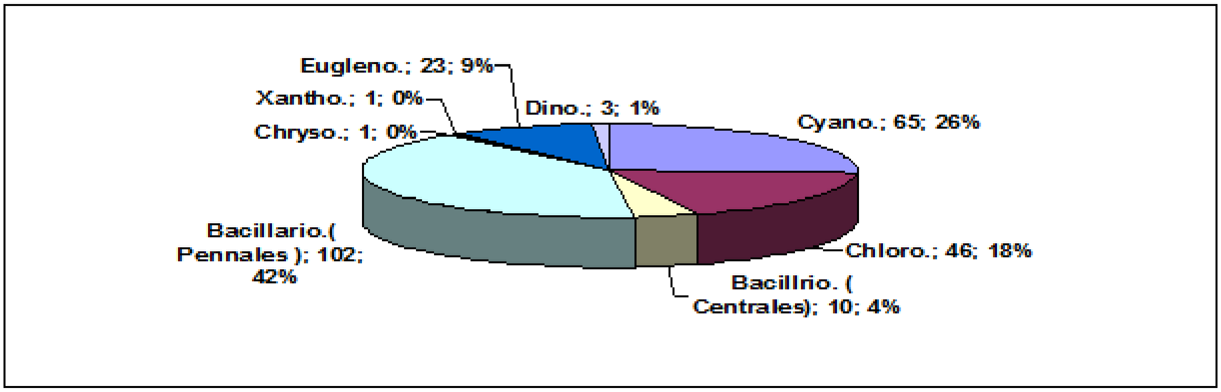

Fig. 2 : Numbers of species and species percentage that recorded at study sites in Al-Habbaniyah Lake during the study period (2020 – 2021).

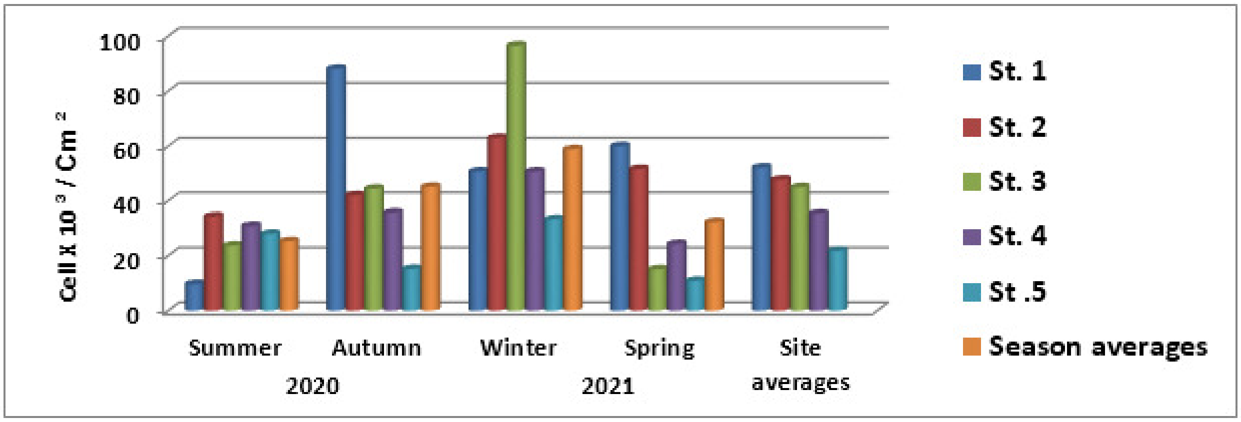

Fig. 3 : Seasonal and local variations of the total number of epipelic algal cells at the sampling sites in Lake Habbaniyah during the study period (2020-2021).

site over the rest of the algal groups. Where this site is one of the sites that contain the most euglenophyceae , which confirms the presence of percentages of organic pollution in this site (Palmer, 1980), that the number of species identified for the class of blue-green algae (26%) is higher than the proportion of the number of species for the class of green algae, which gives an impression that the lake water contains percentages of salt (Talling, 1980).

The results of the quantitative study of epipelic algae showed that there were significant differences between seasons and between sites ($p<0.05$) (Fig. 3), where the highest average number of cells of epipelic algae was recorded in winter (58.86×10^3 cell / m^2) and this increase is attributed to the drift Some components of the soil when it rains, and consequently, the increase of nutrients in the water of the lake, because it contains organic residues, minerals and agricultural fertilizers, in addition to what the Al-Warar Channel adds from the organic matter due to the household waste dumped in it (Al-Ghafily, 2018). Epipelic algae cells in the summer (25.3×10^3 cell/m^2) due to the high temperature and the increase in the concentration of salts, which in turn negatively affect the growth of algae (Ali *et al*, 2018) and the site I (Alwarar Channel) recorded the highest the average number of the total number cells of epipelic algae (52.13×10^3 cell/ m^2) due to the abundance of organic nutrients in this site from the household organic waste dumped in it and the site V (Al-majera Regulator) recorded the lowest average of the values of the total cell number of epipelic algae, which amounted to (21.81×10^3 cell /m^2), due to the nature of the clay soil in that area and the lack of human activities (Boyd, 2000). There was a significant positive correlation between the total cell number of epipelic algae and air temperature ($P<0.01$, $r=0.993$) and a significant positive correlation with water temperature ($P<0.01$, $r=0.988$).

A group of species indicative of the state of the water body were recorded at the sampling site, where the presence of *Oscillatoria princeps* and *Euglena* sp. percentages (5.18% and 10.36 %), respectively in site I, where this alga is one of the indicators of the richness of water in organic matter (Palmer, 1980) (Table 4).

Bioindicators indices

The highest average values of Shannon's Diversity Index (*H*) were recorded in the winter (2.821) (Fig. 4 A), due to the rainy season and the erosion of nutrients from neighboring soils, which leads to an increase in nutrients that lead to algal diversity and similar values were recorded less than in other seasons. The highest average values of Shannon's diversity index were recorded in the site I of the Al-Warar regulator (2.608). These high values recorded are evidence that the site of the Al-Warar Canal has good biodiversity and this may be due to the availability of natural conditions, since the water of the channel is running, which makes the water quality suitable for increasing diversity due to the wide range of suitable growth conditions for increasing diversity (Jonge, 1995) and the opposite occurs in difficult conditions and this may explain the recording of the lowest average Shannon index values in the site II (2.246), which suffers from pollution of its waters affected by anthropogenic activities (Hassan *et al*, 2020). According to the results of the current study, the waters of Lake Habbaniyah are of medium biodiversity and of medium water quality.

The seasonal variations in the pollution tolerance index (PTI) values did not show significant differences between the seasons, as all the mean values were close during the seasons and ranged between (2.246-2.421), while the local variations showed a significant variation (P<0.05) (Fig. 4B). Where the highest value was recorded in the site V (2.695), as it is not affected by human activities, and the lowest value was recorded in the site II (2.071), as it suffers from the growth of many human activities (Lang, 1979), according to the results of the current study. Habbaniyah Lake is medium pollution, where the pollution tolerance index values did not exceed (3.000), where the results of the current study are consistent with the results of the physicochemical parameters of the study sites and also correspond to what was diagnosed for some types of diatoms with medium tolerance, which is evidence that the water is moderately polluted, namely; *Nitzschia acicularis*; *N.dissipata*; *Naviculla cryptocephala*; *N. Gregaria Cocconeis placentula* (Wang *et al*, 2014). The results of the statistical analysis showed a significant negative correlation between pollution tolerance index and air temperature (r = -0.879, p < 0.05) and also a significant negative correlation with water temperature (p < 0.05, r = -0.884).

The results of the Palmer's pollution index (PPI) showed that there were significant differences between seasons as well as between sites (P<0.05) (Fig. 4 C). The highest average of PPI values was recorded in the winter (17.6) and the lowest average was recorded in the spring (13.0) and the local variations showed a clear contrast, where the site I recorded the highest average of PPI values (18.0), which indicates the possibility of high organic pollution due to Domestic and industrial waste dumped in the site of Al-Warar Channel (Al-Ghafily, 2018), while the lowest average values of evidence were recorded in site III (12.3) and this indicates the presence of little organic pollution due to the dilution of the Euphrates River water (Al-Tamimi and Al-Mersomy, 2018). According to the PPI values, the waters of Lake Habbaniyah are of moderate organic pollution, as their seasonal and local averages did not exceed the values up to 20, that the registration of 11 genera of the approved genera in extracting the values of PPI, which totaled 20 genera within Palmer's table (Palmer, 1969) thus gives an impression of the quality of the lake water with medium organic pollution. These genera are: *Chlamydomonas*, *Chlorella*, *Closterium*, *Cyclotella, Gomphonema*, *Melosira, Navicula, Nitzschia, Oscilllstoria, Scendesmus* and *Synedra.* The results of the statistical analyzes showed that there was a significant positive correlation between Palmer's pollution index and magnesium (P<0.05, r = 0.923).

The results of the Trophic diatomic index (TDI) showed that there were significant differences between sites as well as between seasons (P<0.05) (Fig. 4D), where the seasonal variations showed a variance in their averages, where the highest mean of the TDI was recorded in the summer (67.68) due to the high temperature and low Water levels as a result of evaporation, which leads to an increase in the concentration of essential nutrients (Hassan and Shaawiat, 2015 and Ali *et al*, 2018), while the lowest average was recorded in the winter season (35.71) due to rain that leads to an increase in the water level and a decrease in evaporation rates. The concentration of nutrients in water decreases (Hassan *et al*, 2020) and the local variations showed a marked variance, where the highest average was recorded in the site III (57.94), which may be attributed to the abundance of nutrients due to human activities in this site, and similar values were also recorded in the site I (Al-Warar Channel) (56.17) due to the flow of water from the Euphrates River and the movement of water that leads to the circulation of nutrients from the bottom and banks (Ali *et al*, 2018), while the lowest average was recorded in the site V (41.17) because of the lack of coverage. The vegetation in the area and the absence of human activities from factories or factories close to the site, which in turn add to the water organic materials or household or industrial waste, where the presence or lack of plant nutrients in the water is evidence of its cleanliness or pollution (Kelly and Whitton, 1995). According to the results of the current study, the waters of Lake Habbaniyah are of medium pollution and mesotrophic (Vasiljevic *et al*, 2014; Kelly and Whitton,

Table 4 : Total number of Epephytic algae species (Cell × 10^3. Cm^{-2}) occurring in more 5% of the samples from Al-Habbaniah Lake during the study period (2020–2021).

Summer	*Anabaena osillarioides*	*Cymbella cistula*	*Euglina* sp.	*Navicula gregaria*	*Navicula* sp.	*Nitzschia dissipata*	*Nitzschia* sp.	*Oscillatoria actissima*	*O. brevis*	*O. curviceps*	*O. princeps*	*O. subbrevis*	*O.minima*	*Phormdium* sp.	*Pinularia microstauron*	*Pinularia* sp.	*Spirulina major*
Site I	-	-	-	-	0.9	-	0.9	2.1	-	-	0.3	-	-	-	-	-	-
Site II	-	-	-	-	-	-	-	-	6.6	-	-	-	-	0.9	-	-	12.0
Site III	-	-	-	5.4	-	-	1.5	7.5	-	-	-	-	-	-	-	-	0.9
Site IV	-	-	-	-	1.2	-	3.9	-	3.6	-	0.6	-	-	-	-	-	-
Site V	-	-	-	-	-	-	1.2	10.8	4.5	-	-	-	-	-	-	1.2	-
Autumn																	
Site I	-	-	-	1.8	1.2	-	0.9	6.3	-	-	8.6	0.3	15.9	1.2	-	-	8.1
Site II	-	-	-	-	2.4	-	0.6	-	1.5	-	-	5.4	-	-	-	-	-
Site III	-	-	-	-	6.0	-	0.9	0.6	2.7	-	3.3	1.8	-	0.6	-	0.9	-
Site IV	0.6	-	-	-	1.5	-	1.2	0.3	3.9	-	0.6	-	-	-	-	1.2	0.3
Site V	-	-	-	-	-	-	1.5	-	3.0	-	-	-	-	-	-	-	-
Winter																	
Site I	-	-	4.8	4.2	6.0	-	-	3.0	2.4	-	-	-	-	0.6	2..1	-	-
Site II	-	-	-	9.0	-	-	2.1	3.9	1.2	-	-	-	-	-	1.8	-	-
Site III	2.1	-	-	-	6.0	-	-	-	9.5	9.0	0.6	-	-	12.0	2.4	9.0	-
Site IV	0.9	-	-	-	5.1	-	4.5	-	-	-	-	-	-	-	3.0	-	-
Site V	-	3.6	-	-	-	-	-	1.5	-	-	-	-	-	-	2.7	-	-
Spring																	
Site I	-	-	11.4	-	3.9	7.5	-	15.0	-	-	-	-	-	-	-	-	-
Site II	-	6.3	-	4.5	-	-	2.1	5.1	-	-	-	-	-	-	-	-	0.9
Site III	-	2.1	-	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Site IV	-	-	-	-	6.6	-	2.1	-	-	-	-	-	2.4	-	-	-	-
Site V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

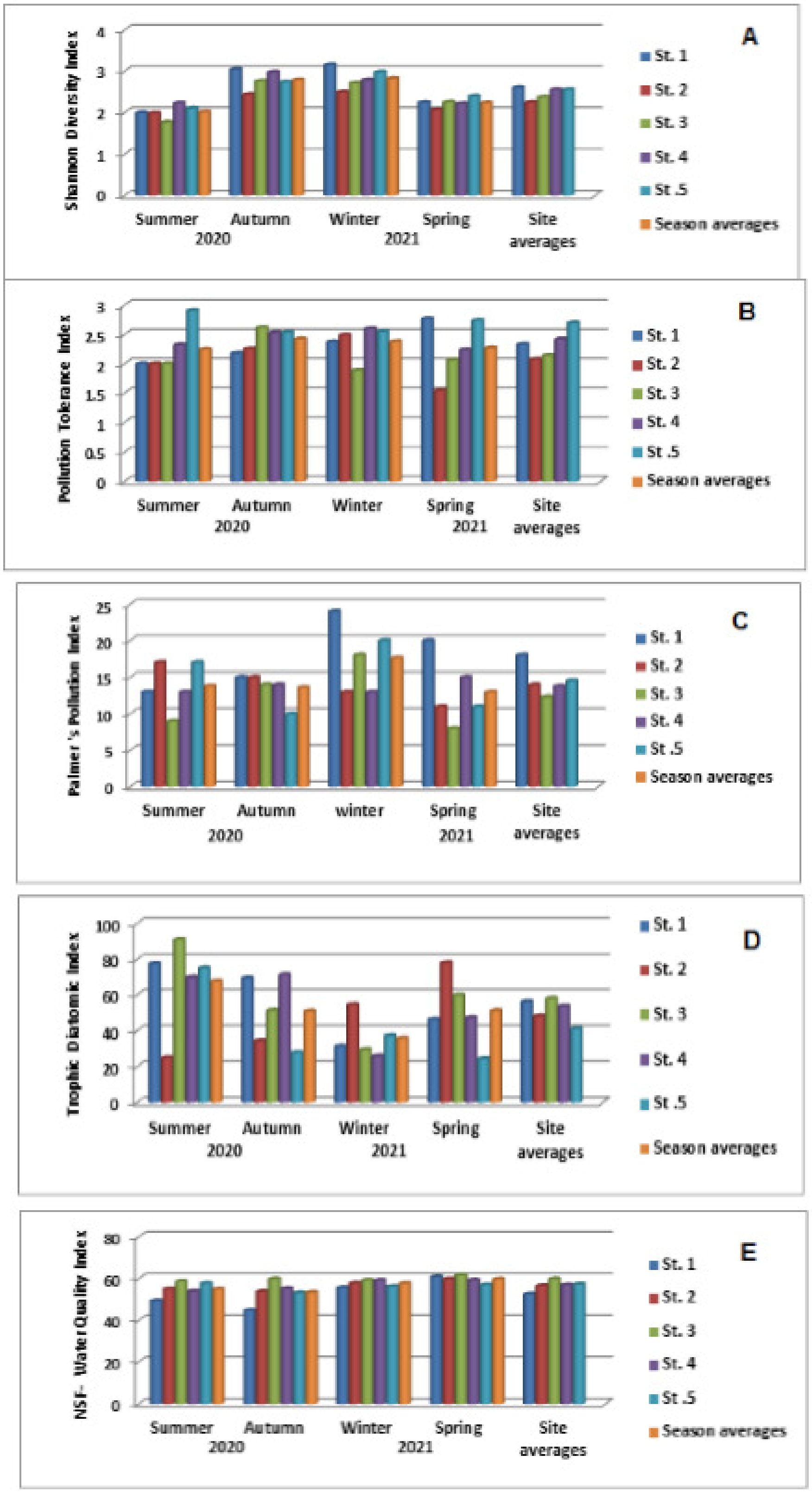

Fig. 4 : Values of the locational and seasonal variations of the biological indices for the epipelic spices of the sample analysis and NSF- Water quality index from Al-Habbaniah Lake during the study period (2020–2021).

1995) and this result agreed with the results of physical and chemical parameters recorded in the water of the sampling sites. The registration of many species indicative of the state of the mesotrophic water body in the Lake Habbaniyah, which confirms the results of the current study of the TDI. The recorded species are *Cocconeis*

Table 5 : Classification of the water quality of Lake Habbaniyah according to the results of biological indices and NSF- water quality index in the sampling sites during the study period (2020 – 2021).

Indices	References	Mean values	Classification of water
Shannon Diversity Index	Shannon and Weaver (1949)	2.012 – 2.821	Medium biodiversity
Tolerance Pollution Index	Lang-Bertalot (1979)	2.071 – 2.695	Moderate pollution
Palmer's Pollution Index	Palmer (1969)	12.3 - 18.0	Moderate organic pollution
Trophic Diatomic Index	Kelly and Whitton (1995)	35.71 – 67.68	Misotrophic
Water Quality Index	BASIN (2002)	52.58 – 59.79	Medium water quality

placentula, *Cymbella affinis, Diatoma vulgare, Fragilaria capunica*, *Gomphonema angustum*, *Melosira tripunctata*, *Nitzschia dissipata*. Whereas, only two species with high nutrient tolerance were recorded, namely *Nitzschia acicularis and N. Palea* (Kelly and Whitton, 1995) .

Water quality index

The results of the water quality index (WQI) showed that there were significant differences in the water quality index between seasons as well as between sites ($P<0.05$) (Fig. 4 E), where the highest average values were recorded in the spring (57.57) and the lowest average values were in the autumn (53.32). Notable in its averages, where the highest average values were recorded in the site III (61.56), while the lowest average values were recorded in the site V (Al-Majarra Channel) (56.89). According to the averages of the seasonal and local water quality index, which did not exceed (60.00), so it is considered to be of medium water quality (BASIN, 2002). Through this indicator, we can know the extent of the impact of human activities on the water surface and the extent of the use of this water (Vasiljevic *et al*, 2014). The results of the current study did not correspond to the study of Al-Tamimi and Al-Mersomy (2018) in Lake Habbaniyah, which recorded values higher than the values recorded in the current study, which ranging between (67.8-78.7) and this indicates a decline in the quality of the lake's water. The results of the analyzes showed there was a statistically significant negative correlation between water quality index and magnesium ($P<0.05$, $r=-0.947$).

CONCLUSION

The lake water is exposed to many external influences and this is reflected on the overall environmental parameters of the lake water, in terms of low water levels due to drought and lack of rain in the winter, as well as its overlap with anthropogenic activities, which is reflected on the life of the epipelic algae community in the current study. The study is the extent of the impact of the nature of the sites on the physical and chemical characteristics, which was reflected in the qualitative and quantitative estimation of the epipelic algae, and this was evident in the site I affected by the water of theAl- Warar Channel, the site II affected by sand washing sites and anthropogenic activities and the site III affected by its confluence with the Euphrates River through the Sin Al Dhuban channel.

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