ECOLOGICAL STUDY OF EPIPHYTIC DIATOMS ON TWO SUBMERGED AQUATIC MACROPHYTES IN TIGRIS RIVER, IRAQ

S F. Ali [1*] F M. Hassan[2] R A. Abdul-Jabar[1]
Researcher Prof. Prof.
[1] Dept. of Biology, Coll. of Sci., Tikrit University.
[2] Dept. of Biology, Coll. of Sci. for Women, University of Baghdad.
fikrat@csw.uobaghdad.edu.iq

ABSTRACT

This study was aimed to provide the baseline information of epiphytic diatom communities in the Tigris river within Wasit Province to fill the information gap on the algal distribution. This investigation was conducted on epiphytic diatoms from two macrophytes (*Ceratophyllum demersum and Myriophyllum alterniflorum*) and related physicochemical parameters of the river from June 2015 to May 2016. Three sites were selected along the river (Al-Aziziyah, Zubaidiyah, and Numaniyah). Qualitative and quantitative study of epiphytic diatoms was investigated. A total of 277 species of epiphytic diatoms were identified on both macrophytes, these diatoms belonged to 27 genera for *C. demersum* and 28 genra for *M. alterniflorum*. A total number of diatom species were ranged from 801.8× 10^4 cell.g^{-1} at site 3 to 1159.72 ×10^4 cell.g^{-1} at 1for *C. demersum*, while on *M. alterniflorum* were ranged (87.24 × 10^4 -545.68×10^4 cell.g^{-1}) at site1. The study revealed that diatoms were abundant, reflecting the quality of water and determine the extent of pollution and polluted type.

Keywords: aquatic plants, lotic ecosystem, algae, qualitative and quantitative study.

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دراسة بيئية للدايتومات الملتصقة على اثنين من النباتات المائية الغاطسة في نهر دجلة _العراق

شيماء فاتح علي [1*] فكرت مجيد حسن [2] رياض عباس عبد الجبار [1]
باحث أستاذ أستاذ
[1] قسم علوم الحياة ، كلية العلوم ، جامعة تكريت.
[2] قسم علوم الحياة ، كلية العلوم للبنات، جامعة بغداد

المستخلص

هدفت الدراسة الى توفير المعلومات الأساسية عن المجتمعات الدايتومات الملتصقة في نهر دجلة ضمن محافظة واسط لملء الفجوة في المعلوماتية حول توزيع هذه الطحالب. تناول البحث الدايتومات الملتصقة على اثنين من النباتات المائية (*Ceratophyllum demersum* و *Myriophyllum alterniflorum*) وعلاقتها بالعوامل الفيزيائية والكيميائية للنهر و للمدة من شهرحزيران 2015 الى شهر آيار 2016. تم اختيار ثلاث مواقع على طول النهر (العزيزية، الزبيدية، النعمانية). وتم دراسة كمية ونوعية الدايتومات الملتصقة. سجلت هذه الدراسة 277 نوعاً من الدايتومات الملتصقة على كلا النباتين وتعود هذه الدايتومات الى 27 جنسا بالنسبة لنبات *C. demersum* و28 جنسا لنبات *M. alterniflorum*. تراوح العدد الكلي للدايتومات من 801.8 ×10^4 خلية/غم في الموقع 3 الى 1159.72 × 10^4 خلية/غم في الموقع 1, بينما بلغت الاعداد الكلية لدايتومات الملتصقة على نبات *M. alterniflorum* بين87.24 ×10^4– خلية/غم الى 545.68 ×10^4 خلية/غم في الموقع1. كشفت الدراسة غزارة صنف الدايتومات مما يعكس نوعية المياه وتحديد مدى و نوع التلوث.

الكلمات المفتاحية: الطحالب الملتصقة، النباتات المائية, المياه الجارية, الطحالب، دراسة كمية ونوعية.

* جزء من اطروحة الدكتوراه للباحث الاول.

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INTRODUCTION

Aquatic macrophytes form the specific environment by either suppressing or stimulating aquatic organisms, as well as by enhancing the availability of a large area suitable for colonialism and the attached epiphytic community (3). Epiphytic algae are organisms that attach to aquatic macrophytes by secreting mucilage or colonizing on aquatic macrophyte and sediment surfaces, and constitute heavy carbonate accumulations on plant parts (15). Epiphytes are part of the structured community, which contains primary producers and consumers as well as decomposers. Epiphytic diatoms are play a major role in ecological balance between various macrophytes and their environment. Diatoms may be affected by different factors as macrophyte architecture, water depth, seasonal changes, light intensity, pH, temperature and abundance of macrophytes (4, 9, 18). Epiphytic algae attaches to their hosts in various forms such as encrusting, basal, mucilage, long or short stalk, and pad forms (10). Due to the sensitivity of the benthic algae, they are used as bioindicators to gauge the aquatic environmental conditions (28). The present study aimed to account for epiphytic diatoms on two species of host macrophytes in Tigris River and to fill the knowledge gap in epiphytic diatoms in Wasit province south of Iraq for the first time.

MATERIALS AND METHODS

Three sites selected along Tigris River in Wasit province (Al-Aziziyah, Zubaidiyah and Numaniyah). The present study was carried out from July 2015 to May 2016 and the results presented seasonally (Fig. 1, Table1). All physicochemical parameters of water were measured according to APHA (13) nitrite, nitrate and phosphate (32) and silicate (26). The aquatic plants were collected from each site and preserved by using (3ml) of the formalin 4% as a preservative for a while back to the laboratory. Then the algae separated from the leaves, stems and roots (if it found) of aquatic plant hosts, shaking with scrape to separate the algae from host plant (19), then scrape the surfaces of aquatic plants by brush to ensure the separation of the largest number of algae. Calculated diatom cells by light microscope using an oily compound lens 100X following the Microtransect method for counting the epiphytic diatom cells (17).

Figure 1. Map of study areas (Used Arc-GIS Map program)

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

Sites	Longitude (eastwards)	Latitudes (northward)
St.1: Al-Aziziyah	38°.1835′	54°.9050′
St.2: Zubaidiyah	35°.9799′	55°.8840′
St.3: Numaniyah	35°.9611′	57°.7080′

RESULTS AND DISCUSSION

The results of this study recorded water temperature ranged from 12 ºC to 34 ºC. The highest temperatures were recorded in the summer (August 2016) at sites 1 and 3, and the lowest temperature in the winter (February 2016) at sites 1 and 3 (Table 2).

Table 2. Range, average of physicohemical in the Tigris River during the study period 2015-2016

Parameters	Sites		
	S1	S1	S1
Water Temp. C°	12.00-34.00 22.62	12.5-33.0 22.95	12.0-34.0 23.41
pH	6.7-8.2 7.25	6.7-8.3 7.19	6.7-8.2 7.25
Dissolved oxygen mg.L^{-1}	5.2-11.2 8.0	5.6-11.2 8.18	5.2-11.6 8.38
BOD_5 mg.L^{-1}	0.4-2.3 1.4	0.4-2.5 1.36	0.3-2.3 1.27
Total Hardness mg $CaCO_3$.L^{-1}	600-1100 848.3	600-1000 795	600-1040 840
Calcium mg $CaCO_3$.L^{-1}	350-740 515	380-725 472.5	370-770 496.2
Magnesium mg $CaCO_3$.L^{-1}	100-585 332.8	75-475 330	100-500 350
Alkalinity mg $CaCO_3$.L^{-1}	120-148 134.3	114-148 129.3	114-150 130.8
Nitrite mg.L^{-1}	0.176- 9.76 2.37	0.134-7.667 2.13	0.153-3.078 1.04
Nitrate mg.L^{-1}	0.7-26.2 17.04	0.735-26.17 16.63	11.88-26.37 18.07
Phosphate mg.L^{-1}	0.039-0.975 0.552	0.026-0.884 0.535	0.052-0.884 0.566
Silicate mg.L^{-1}	11.94-35.51 25.64	11.63-35.81 25.74	11.63-34.4 25.64
Sulphate mg.L^{-1}	138.4-166.1 158	116.7-222.6 155.7	119-300 162.07

These results were consistent with other studies (12, 20). The results of pH in the present study ranged 6.7-8.3 (Table 2). The pH values of Iraq inland water tend to be alkaline in most cases and due to the presence of carbonates and bicarbonates in abundant natural water (27), also the results asymptotic to the study of Al-Janabi (6). The results showed that DO values ranged between 5.2 mg.l^{-1} at sites 1 in June, September2015 and site3 in July, and 11.6 mg.l^{-1} at sites3 in February2016. The values of dissolved oxygen were higher than those of some studies on the Tigris River, such as the study of Al-Janabi (6) and Al-Bayati (2). In the present study the water is classified as (clean - very clean) according to the common classification used for water pollution in the UK based on the Biological Oxygen Demand (25)**.** The total alkalinity was affected by many factors such as temperature, decomposition of organic matters and concentration of CO_2 (35). The present study showed that the alkalinity values ranged from 114 mg.l^{-1} at site 2 and 3 in August2015 and May2016 to 150 mg.l^{-1} at site 3 in February 2015.Total hardness were higher than alkalinity values in in the Tigris River and the water in the present study was characterized by its high density and was classified as (33) in terms of hardness as very hardness. This is more common in river water, which is due to the nature of the rock and soil in Iraq (8).This result is higher than that recorded (2, 11) Calcium concentrations were higher than magnesium concentrations in the most study periods which may due to the calcium can be attributed to the nature of the land in which the river passes, in which limestone rocks form a large proportion (14). Magnesium tends to precipitate more calcium (20). This is consistent with other studies on the Tigris River that recorded calcium superiority on magnesium, such as (2, 6). Calcium values were higher than recorded (11). The nitrite values were recorded 0.134-9.76 mg.l^{-1} at site 2 in December 2015 and site1 in July2015 respectively. The decrease in nitrite concentrations may be due to increased consumption by algae and aquatic plants, or due to the lack of polluted flows containing nitrogenous substances and increased rainfall that lead to higher levels of water that led to mitigate. While nitrate ranged 0.71-26.37 mg.l^{-1} at site 1 in November2015 and site 3 in April 2016. The highest concentration of nitrates is due to excessive irrigation after the fertilization of the agricultural lands (7). Phosphorus concentrations showed a significant increase that may be a result of high water levels (31). Iraq waters are characterized by high concentrations of silicate. This is due to the geological nature of the land in which Tigris and Euphrates Rivers flow, and they are of great importance for diatoms as they are needed for building of their siliceous skeletons (16, 29). And decrease of sulphate concentrations due to their consumption by algae and aquatic plants or to the mitigation factor resulting from high water levels (22). The results of quantitative and qualitative of epiphytic diatoms on two species of macrophyta (*C. demersum* and *M. Alterniflorum*) were shown in Table 3 and 4. Aquatic plants act as a key ecological role by providing shelter, substrate, and nutrient source for epiphytic algae, which are dominants isolates in lotic systems (9). The distribution of algae may be affected by different factors as macrophyte morphology, water depth, seasonal changes, light intensity, pH, temperature and abundance of macrophytes as well as the age of the host plant (18). The study was recorded 227 species of epiphytic diatoms on both macrophytic species in this study. The result showed a number of epiphytic diatoms on *Ceratophyllum demersum* diagnosed during the study on the Tigris River in three sites 127 species belonging to 27 genera, where the number of central diatoms 11 species belong to 5 genera by (8.66%) of the total species. The number pinnate diatom has reached 116 species belong to 22 genera by (91.33%) of the total species (Table 3, 4). The number of epiphytic species classified in site1 is 114 species, the site2 is 119 species, and the site 3 is 115 species (Table 3). Diatoms are dependent on a variety of different adhesions of different species, such as: *Rhicosphenia* and *Gomphonema* have a long and short stalk that helps them to stick. *Bacillaria paxillifer* cell are joined by mucus produced by the raphe groove, and the genus *Synedra* contains Mucilage pads form, while the genera of *Navicula* and *Nitzschia* bind cell together in a mucous membrane, mucilaginous tube form (5).

Table3. Number of genera and species of diatoms algae and the percentage of epiphytic diatoms on (*Ceratophyllum demersum)* diagnosed during the study period in the Tigris River

Types of Diatoms	Sites					
	S1		S2		S3	
	C	P	C	P	C	P
Species	11	103	12	107	11	104
Genus	5	18	5	22	5	24
Percentage of Species %	8.87	90.35	10.08	89.91	9.56	90.4
Total number of Species	114		119		115	
Total number of Genus	23		27		29	

C= Centric diatom, P=Pennate diatom The species *Navicula, Nitzschia, Cymbella* and *Surirella* have the most variety of species, with different sites and seasons. Most of these diatoms are adherent to the aquatic plants (9), As well as the dominance of the pinnate diatoms on the central diatoms. The results agree with (5, 11, 30)

Table 4. List of epiphytic diatom (*Ceratophyllum demersum* & *Myriophyllum alterniflor* and its total number (cell × 10^4. L^{-1}) during the study period. (-) = Type does not exist

Diatoms	*C. demersum*			*M. alterniflorum*		
	Sites					
	S1	S2	S3	S1	S2	S3
Centrales						
Aulacoseira granulata (Ehr.) Simonsen	0.12	0.5	0.55	0.39	0.91	28.46
A. italica (Ehr.) Simonsen	0.4	0.12	0.08	0.08	0.05	0.23
Coscinodiscus granii L.F.Gough	1.02	2.69	0.13	3.14	6.2	0.07
Cyclotella atomus Hustedt	0.19	0.27	0.29	0.1	2.28	1.22
C. comta Kützing	0.26	0.34	-	19.46	0.31	8.85
C. meneghiniana Kützing	2.43	0.95	2.29	13.73	2.94	0.08
C. ocellata Pantocsek	0.32	0.11	0.04	2.19	-	-
Melosira granulate (Ehr.) Ralfs	0.28	1.42	1.04	0.97	4.2	36.1
M. italica (Ehr.) Kützing	0.06	0.08	2.09	1.75	2.12	1.28
M. varians Agardh	0.5	3.78	3.67	15.01	1.97	51.5
Thalassiosira baltica (Grunow) Ostenfeld	0.22	0.2	0.63	0.36	1.8	1.28
Total of Centrales	5.8	11.3	10.81	57.18	22.78	129.07
Pennales						
A. minutissima var. affinis (Grunow) Lange-Bertalot	6.73	19.33	0.78	22.94	35.92	10.05
A. acutiuscula Kützing	-	-	-	-	-	-
Amphora elliptica (Agardh) Kützing	-	-	-	-	1.3	-
A. bioculata Cleve	1.03	0.31	0.44	4.85	10.9	33.17

A. ovalis (Kütz) Kützing	21.47	0.17	3.79	0.17	28.5	27.6
A. pediculus (Kütz) Grunow ex A.Schmidt	0.11	-	0.4	-	0.38	0.21
A. robusta Gregory	3.3	-	7.17	0.06	0.15	4.44
Pennales						
Achnanthes affinis Grunow	13.58	15.89	1.59	6.48	1.57	2.56
A. linearis (W. Smith) Grunow	0.31	0.51	0.35	0.07	1.52	0.47
A. minutissima	25.41	-	0.31	-	0.1	4.54
B. paxillifera (O.F.Müller) T.Marsson		7.08	0.26	4.7	2.42	0.54
Caloneis amphisbaena(Bory.) Cleve	103.18	73.6	70.6	33.6	69.2	55
C. amphisbaena var. subsalina (Donkin) Cleve	75	79.9	31.5	33.2	22.04	50.3
C. bacillum (Grunow) Cleve	0.28	0.91	0.13	1.73	23.38	5.07
Cocconeis pediculus Ehrenberg	27.7	20.77	2.17	19.1	0.08	5.96
C. placentula Ehrenberg	59.97	83.4	71.7	55.43	0.81	58.1
C. placentula var. *euglypta* (Ehr.) Cleve	49.66	94.2	88.54	38.66	30.26	51

Table 4. Continuum

Diatoms	*C. demersum*		Sites		*M. alterniflorum*	
Centrales	S1	S2	S1	S2	S1	S2
Cymatopleura elliptica (Brébisson) W.Smith	-	0.25	-	-	9.54	-
C. solea (Breb.) W.Smith	4.6	7.82	0.06	20.85	5.27	1.25
Cymbella affinis Kützing	42.23	10.76	0.42	18.37	6.09	32.6
C. aspera (Ehr.) Cleve	11.67	22.2	0.42	0.32	3.25	2.3
C. cistula(Hemp.) Grunow	0.32	22	1.45	8.26	-	0.1
C. cymbiformis C.Agardh	0.2	0.95	0.1	-	10.9	0.19
C. lanceolata (C.Agardh) Kirchner	26.92	0.25	0.1	7.13	-	17.9
C. lange-bertalotii Krammer	0.41	1.1	0.24	-	-	2.74
C. prostrate (Berk.) Cleve	2.71	16.43	-	2.35	-	-
C. tumida (Breb.) Van.Heurck	20.64	0.91	11.01	-	10.79	0.18
C. turgida (Greg.) Cieve	-	6.58	-	11.34	1.86	7.36
Diatoma vulgare Bory	0.53	0.17	3.68	2.8	29.13	1.62
D. moniliforme Kützing	0.08	0.08	0.21	0.2	9.1	0.66
Encyonema silesiacum (Bleisch) D.G.Mann	0.02	1.63	0.19	0.13	15.82	11.7
Eunotia exigua (Brébisson ex Kütz.) Rabenhorst	7.53	0.35	0.12	0.14	0.14	0.22
E. fallax A.Cleve	-	-	0.1	-	-	0.09
E. minor (Kütz.) Grunow	0.08	0.68	0.37	2.2	0.14	2.4
Fragilaria biceps Ehrenberg	0.86	0.04	2.83	10.78	2.78	2.72
F. capucina Desmazieres	1.48	0.96	-	0.89	12.39	-
F. capucina var. rumpens (Kütz.) Lange-Bertalot ex Bukhtiyarova	0.08	2.52	0.2	0.34	4.64	0.06
F. construens (Ehr.) Grunow	0.18	0.24	4.5	0.41	16.7	0.32
F. construens f. binodis (Ehr.) Hustedt	2.58	7.98	2.7	0.22	0.2	0.58
F. crotonensis Kitton	0.57	0.33	0.35	2.34	31.3	0.24

F. elliptica Schumann	-	0.83	9.12	4.53	0.74	0.17
F. intermedia Grunow	0.21	7.22	0.18	0.08	9.02	0.11
F. ulna (Nitzsch) Lange-Bertalot	-	91.6	0.63	24.1	0.17	21.92
F.ulna var. acus (Kütz.) Lange-Bertalot	-	16.6	34.48	57.1	77.8	37.2
*F. ulna var. biceps (*Kütz.) Compère	0.07	64.8	0.34	0.14	0.08	0.07

Table 4. Continuum

Diatoms	*C. demersum*			*M. alterniflorum*		
			Sites			
	S1	S2	S1	S2	S1	S2
Centrales						
Gomphoneis olivecum (Horne) P.Dawson ex. Ross et Simith	32.34	1.9	0.35	21.23	37.4	4.48
Gomphonema acuminatum Ehrenberg	6.38	1.78	31	38.7	5.97	1.87
G. affine Kützing	12.7	2.29	28.98	-	-	0.41
G. exilissimum (Grunow) Lange-Bertalot & E.Reichardt	0.07	0.54	0.62	-	0.22	0.27
G.geminatum (Lyngbye) C.Agardh	13.23	33.5	13.23	-	0.14	-
G. insignaffine E.Reichardt	46	1.22	46.92	29.06	58.77	1.95
G. lagenula Kützing	0.07	-	0.5	-	-	0.08
G. minuta P.Fusey	4.92	2.5	7.82	3.7	36.5	25.3
G. minutum (C.Agardh) C.Agardh	21.6	0.16	2.88	29.64	63.7	19.38
G. olivaceum (Hornemann) Brébisson	11.54		-	0.43	29.43	60.4
G. parvulum (Kütz.) Kützing	44.42	27.6	20.26	12.22	55.9	12.03
G. parvulum var exilissimum Grunow	0.21	0.06	-	0.54	1.83	2.23
G. pumilum var. elegans E.Reichardt & Lange-Bertalot	0.26	1.74	0.04	0.08	0.52	-
G. rhombicum Fricke	0.02	0.15	0.11	3.27	0.07	-
G. truncatum Ehrenberg	5.26	7.93	2.32	7.04	8.95	0.33
Gyrosigma acuminatum (Kütz.) Rabenhorst	1.77	0.24	0.19	7.96	10.57	2.02
G. attenuatum (Kütz.) Rabenhorst	0.26	1.59	0.2	2.14	20.05	0.56
G. fasciola (Ehr.) J.W.Griffith & Henfrey	0.17	-	3.55	-	0.13	0.19
Hantzschia amphioxys (Ehr.) Grunow	-	-	-	3.9	-	-
0.12	0.58	2.25	0.1	0.05	2.31	
Navicula ambigua Ehrenberg	-	0.47	0.46	1.29	1.3	5.04
N. capitata var. hungarica (Grunow) R.Ross	0.11	0.22	0.11	-	-	-
N. cryptocephala Kützing	21.45	1.79	0.21	0.03	-	-
N. cuspidata (Kutz.) Kutzing	30.78	52.5	7.33	4.32	0.06	0.08
N. gregaria Donkin	60.5	25.83	26.36	14.05	0.07	7.4
N. halophila (Grun.) Cleve	38.9	40.98	25.41	53.3	101.1	66.64
N. lanceolata Ehrenberg	1.7	11.17	0.14	49.53	118.3	75.2
N. protracta Grunow	0.07	-	0.06	0.72	0.26	1.25
N. pygmaea Kützing	1.32	0.15	0.08	3.6	-	-
N. radiosa Kützing	21.47	73.4	-	5.8	0.03	0.08
N. rhynchocephala Kützing	0.49	0.08	23.6	55.34	106.49	41.33
N. tripunctata (O.F.Müller) Bory	0.09	0.22		0.06	0.05	0.08
N. veneta Kützing	22.91	0.44	1.15	0.04	0.06	0.2
N. viridis (Nitzsch) Ehrenberg	0.3	38.57	45.06	0.22	25.28	14.99
Nitzschia acicularis (Kütz.) W.Smith	0.68	1.68	0.3	11.58	105.05	42.6
N. amphibia Grunow	0.05	5.62	0.3	9	22.03	12.7
N. capitellata Hustedt	0.15	0.06	-	1.81	1.45	0.08
N. commutate Grunow	-	-	-	0.05	0.29	0.04
N. constricta (Gregory) Grunow	7.62	2.57	0.34	2.37	0.21	-

Table 4. Continuum

Diatoms	*C. demersum*				*M. alterniflorum*	
	Sites					
Centrales	S1	S2	S1	S2	S1	S2
N. dissipata (Kütz) Grunow	4.53	0.95	3.54	0.21	0.1	0.2
N. filiformis (W.Sm.) Hust	31.38	8.93	7.98	10.25	0.08	4.23
N. fruticosa Hustedt	-	-	9.9	22.4	15.71	0.04
N. linearis W. Smith	2.45	0.15	-	-	-	-
N. nana Grunow	0.02	0.09	-	20.44	0.12	0.29
N. obtusa W.Smith	3.26	4.5	0.97	0.02	0.22	0.26
N .palea (Kütz .) W.Smith	17.7	22.83	19.54	2.02	-	11.74
N. reversa W.Smith	2.09	0.4	0.11	21.2	83.15	14.28
N. rectilonga Takano	0.6	0.09	1.61	66.7	0.94	0.16
N. scalaris (Ehr.) W.Smith	0.3	8.77	0.21	12.27	3.32	1.42
N. sigma (Kütz .) W.Smith	0.56	-	4.65	2.41	2.95	2.76
N. sigmoidea (Ehr.) W.Smith	0.34	0.29	6.07	9.8	-	1.16
N. thermalis (Ehr.) Auerswald	0.08	0.43	2.81	6.67	18.58	0.1
N. vidovichii (Grunow) Grunow	0.89	-	0.05	0.26	0.15	1.37
Pinnularia dactylus Ehrenberg	0.07	0.15	1.56	0.22	0.2	0.44
P. viridis(Nitzs.) Ehrenberg	0.08	0.19	0.25	0.05	0.05	0.1
Pleurosigma elongatum W.Smith		0.1	0.09	2.45	0.15	0.02
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot	1.22	4.93	0.45	5	0.04	0.14
R. curvata(Kütz .) Grunow	0.45	0.14	6.72	11.68	38.87	0.39
Surirella brebissonii Krammer & Lange-Bertalot	-	0.23	-	20.22	11.39	29
S. capronii Brébisson & Kitton	6.89	-	3.4	3.04	1.47	-
S. minuta Brébisson ex Kützing	7.1	-	14.35	1.54	0.5	1.79
S. ovalis Berbisson	17.25	-	1.76	0.23	0.08	1.64
S. robusta Ehrenberg	26.6	-	23	4.08	92.1	1.19
Synedra acus Kützing	0.22		0.73	1.59	26	0.3
S. capitata Ehrenberg	0.14	2.26	0.07	1.53	56.18	0.18
S. delicatissima W.Smith	0.17	-	0.18	0.14	0.16	0.09
S.fasciculata (C.Agardh) Kützing		30.32		0.02	-	1.69
S. rumpens Kützing	22.8	0.48	10.2	15.14	102.4	18.58

Table 4. Continuum

Diatoms	*C. demersum*				*M. alterniflorum*	
			Sites			
Centrales	S1	S2	S1	S2	S1	S2
S. ulna **(Nitzs.) Ehrenberg**	**6.87**	**4.59**	**5.5**	**3.62**	**38.1**	**0.1**
S. ulna var. biceps **(Kütz.) Schönfeldt**	**0.55**	**0.1**	**0.21**	**0.55**	**0.09**	**4.33**
Total of Pennales	**1153.92**	**1109.73**	**801.8**	**1056.36**	**1841.5**	**980.49**
Total (Cell × 10^4 /cm^2)	**1159.72**	**1121.03**	**812.61**	**1113.54**	**1864.28**	**1109.56**

There was a variation in the number of epiphytic diatoms species on *Ceratophyllum demersum* of the study sites because of the different nature of the influences that are subject to each site. Whereas the number of epiphytic diatoms on *Myriophyllum alterniflorum* diagnosed 117 species belonging to 28 genera, where the number of central diatoms 11 species belong to 5 genera by (9.40%) of the total species. The number pinnate diatom has reached 106 species belong to 23 genera by (90.59%) of the total species (Table 5). The number of species classified in site1 is 124 species, the site 2 is 113 species, the site 3 is 113 species as show in Table 4 and 5. Lowe (24) pointed out that these diatoms are present in large numbers in basal water and rich in the concentration of nutrients, and the decrease of diatoms may be due to the increased deposition of calcium carbonate ($CaCO_3$) on the leaves of aquatic plants due to high temperature (36). Total number of epiphytic diatoms species on *Ceratophyllum demersum* with different sites and seasons ranged 801.8× 10^4 cell.gm^{-1} -1159.72 ×10^4 cell.gm^{-1} in sites 3 and site1 respectively (Table 4). Seasonal variation of the total number of epiphytic daitoms species was observed in this study. For centric diatoms ranged 0.33 –28.11 × 10^4 cell.gm^{-1} at site1 in winter2016 and Autum2015 respectively.

Table 5. Number of genera and species of diatoms algae and the percentage of epiphytic diatoms (*Myriophyllum alterniflorum)* diagnosed during the study period in the three sites in the Tigris River

Sites	S1		S2		S3	
Types of Diatoms	**Central diatoms**	**Pinnate diatoms**	**Central diatoms**	**Pinnate diatoms**	**Central diatoms**	**Pinnate diatoms**
Species	**11**	**113**	**10**	**103**	**10**	**103**
Genus	**5**	**22**	**5**	**22**	**5**	**21**
Percentage of Species %	**8.87**	**91.12**	**8.84**	**91.15**	**8.84**	**91.15**
Total number of Species	**124**		**113**		**113**	
Total number of Genus	**27**		**27**		**26**	

While the total number of pinnate diatoms ranged 57.79-434.8 × 10^4 cell.gm^{-1} at site 1 in winter 2016 and summer 2015 respectively. Whereas the total number of epiphytic diatoms species on *Myriophyllum alterniflorum* ranged 87.24×10^4 -545.68×10^4 cell.gm^{-1} at site1 in winter2016 (Table 4). The total number of central diatoms among the sites ranged 0.45 – 45.26 × 10^4 cell.gm^{-1}at sites3 and1 in spring2016 and summer2015 respectively, and pinnate diatoms ranged 84.99-542.16×10^4 cell.gm^{-1} at sites 1 and 2 in winter2016 and summer2015 respectively. Some species of pinnate diatoms were characterized by the highest number of individuals between sites of the study such as the genus of *Navicula radiosa* (0.98 × 10^4 - 36.7 × 10^4 cell.gm^{-1}) at site2 in summer2015 and winter2016. While *Navicula halophile* recorded (9.8 × 10^4-36.4 cell× 10^4 cell.gm^{-1}) in site2 in summer2015 and winter2016 respectively. Also Some species of central diatoms were characterized by the highest number of individuals between sites of the study such as the genus of *Melosira varians* (2.3 × 10^4-17.7 × 10^4 cell.gm^{-1}) at site3 in spring2016 and the winter2016. While *Melosira granulata* recorded 6.3 × 10^4-12.2 × 10^4 cell.gm^{-1}) at site3 in summer2015 and in summer2016 respectively. The decrease in the rate of algae is due to several factors, such as grazing rate and flow velocity, turbidity causing insufficient light access to photosynthesis (21, 34) or due to the lack of nutrient concentrations as a result of the reduction of high water levels, which prevents the growth of algae on the bottom well (1). CCA analysis (Fig.2) shows effect of different environmental factors in the aquatic environment is heterogeneous in the distribution and spread of epiphytic diatoms on *Ceratophyllum demersum* as results revealed a positive correlation among some epiphytic diatoms *N.reversa*, *A.veneta*, *C.amphisbaena F.ulna*, *C.tumida ,S.robusta* and environmental factors Ph, Ca^{+2}, Mg^{+2}, DO, T. Kalinity and SiO_3^-. While these species are negatively correlated with the environmental factors of Water temperature and BOD_5. Whereas *Cocconeis placentula*, *Cocconeis placentula var.euglyptra*, *N.halophila*, *N. gregaria F. ulna var acus*, *M.varians*, *A. bioculata*, *A. veneta A. ovalis and C.affinis* have positive correlation with SO_4^{-2} and NO_3^-, and negative with other studied factors. Whereas *N.radiosa*, *N.palea*, *A. A.minutissima*, *G.minutum* and *S.acus* have positive correlation with Water temperature and BOD_5 negative with other studied factors. And the genera of *F.ulna var acus*, *C. tumida*, *S. rumpens S.ovalis* and *G.paravulum* have positive correlation with NO_2^- and $PO_{4-}^{3}$and negative with other studied factors.

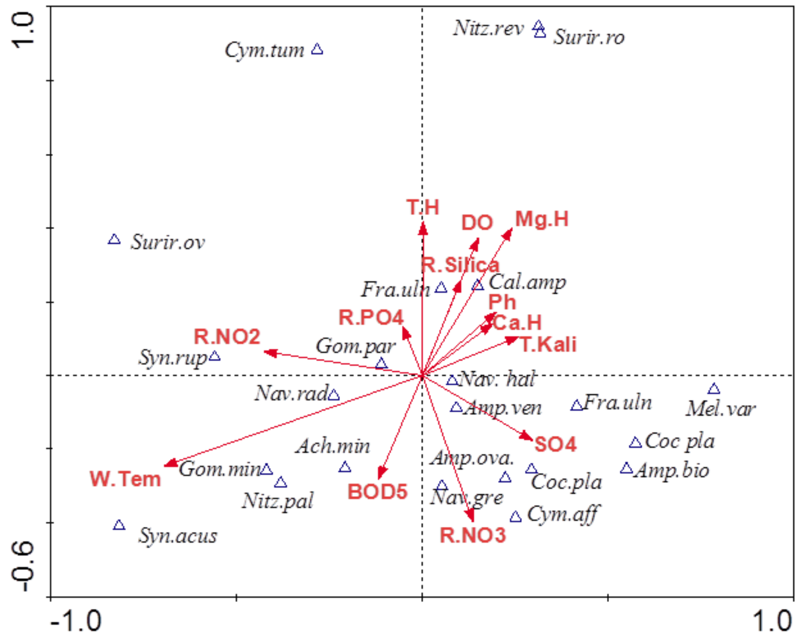

Figure 2. CCA analysis of epiphytic diatoms on (*Ceratophyllum demersum*) and the environmental correlations during the study period of the Tigris river

While CCA analysis (Fig. 3) of epiphytic diatoms on *Myriophyllum alterniflorum* as results showed positive correlation among epiphytic diatoms *C. placentula*, *C.meneghiniana*, *S. rumpens*, *A.affinis* and environmental factors T. hardness, SO_4^{-2} and NO_2^-. While these species are negatively correlated with the environmental factors of pH and PO_4^{-3} .Whereas *N.palea*, *N. filiformis*, *N. gregaria*, *A. ovalis* and *S.robusta* have positive correlation with water temperature, NO_3^-, BOD_5 and Total Alkalinity and negative with other studied factors. And *A. bioculata*, *N. halophile*, *F. ulna and C. amphisbaena* have positive correlation with pH and PO_4^{-3}. Whereas *C. tumida* and *G. olivaceum* positive correlation with Ca^{+2}, Mg^{+2}, DO and SiO_3^-. The studied physicochemical parameters confirmed that effect of different environmental factors for distribution and spread of epiphytic diatoms on two submerged macrophyte plants of the study sites (23), also seasonal water level variations were playing important roles as limited factors for the distribution and density of epiphytic diatoms

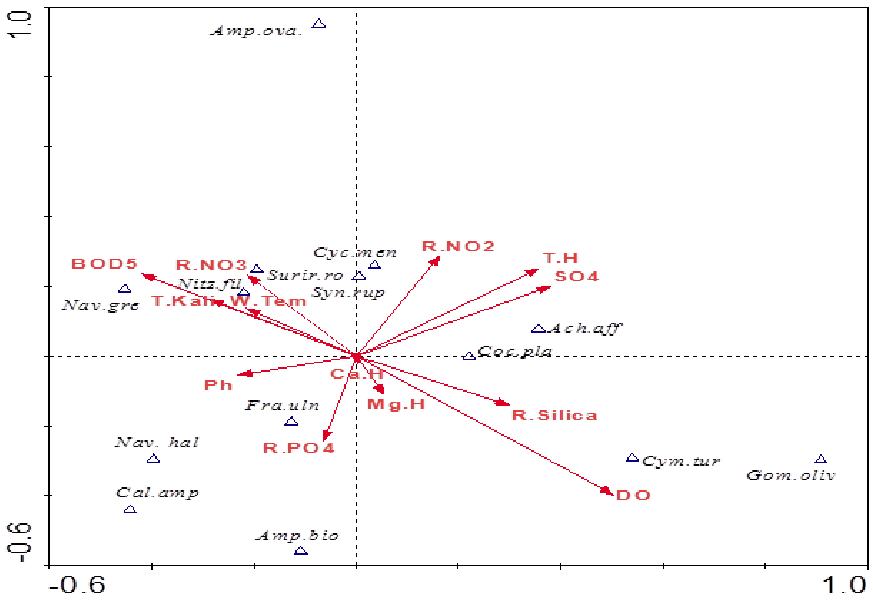

Figure 3. CCA analysis of epiphytic diatoms on (*Myriophyllum alterniflorum)*) and the environmental correlations during the study period of the Tigris river

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