An Ecological Study of Epiphytic Algae on Two Aquatic Macrophytes in Lotic Ecosystem

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ABSTRACT

The epiphytic algae on some aquatic macrophytes and related physical and chemical properties of Al-Abbasyia-Euphrates river middle of Iraq were studied during the study period from March 2012 to February 2013. Four sites between the Al-Kifil districts extending to the Al-Abbasyia district selected.

The quantitative and qualitative of epiphytic algae on Phragmites australis and Ceratophyllum demersum have studied. In addition to many physical and chemical parameters such as air and water temperature, water flow, transparency, pH, electric conductivity (EC), Salinity (‰), TDS, TSS, dissolved oxygen, BOD5, alkalinity, total hardness, calcium and magnesium. A total of 209 epiphytic algal taxa belonging to Bacillariophyceae (144), Chlorophyceae (39), Cyanophyceae (19) and Euglenophyceae (2) recorded within the present study. Some algal taxa noticed mostly dominant among both the study sites and periods. These were Cymatopleura elliptica, Eunotia arcus, Nitizschia sp., Cymbella sp. and Gomphonema sp. This study revealed the existence of some algal taxa on specific parts of the host macrophytes. Where Sphaerocystis attached on the stem of C. demersum; Actinoptychus sp. attached on the root of P. australis; Chaetoceros capense on the root of P.australus and Thalassiosira fluviatilis on the leaves of P. australis.

Keywords: Epiphytic algae, water quality, aquatic macrophytes, lotic ecosystem, Al-Abbasyia river, euphrates river, Iraq

INTRODUCTION

Algae in the lotic environment tend to attach on the different type of objects. Epiphytic algae are living organisms that play a role in aquatic ecosystems as primary producers (Graham et al. 2009). Many authors focused on its important where aquatic plants are a good shelter to grow algae and tolerance different environment conditions [Gough and Gough, 1981, Laugaste and Reunanen, 2005, Hassan et al. 2007].

The epiphytic algae act as indicators of water pollution as well as being of great importance as primary producers in the food chain in an aquatic system, so several factors determining epiphytic algae abundance and distribution [Mayer and Likens, 1987]. Some environmental factors such as temperature, depth, pH and light penetration determined the density of epiphytic algae on aquatic plants [Scheldon and Boylen, 1975, Moore, 1977]. Grimes et al. (1980) investigated on the living, and dead stems of *P. australis* showed the variance of composition present for diatomic algae although they provide nutrients and stable environmental conditions, while *Gomphonema* preferred the living stems and *Navicula* preferred the dead stems. Distribution and density of epiphytic algae in Nile River were depended on variation of nutrient, temperature, transparency of water and pH [Aboellil and Aboellil, 2012]. Four aquatic plants (*Phragmites australis*, *Typha domengensis*, *Ceratophyllum demersum* and *Potamogeton pectinatus*) were selected in Al- Hawizah marsh

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ISSN: 2186-8476, ISSN: 2186-8468 Print
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- Southern Iraq and identified a total of 229 taxa of epiphytic algae [Al-Hassany and Hassan, 2013]. Many studies deal with the epiphytic algae in some Iraqi aquatic systems such as Euphrates River [Hassan et al. 2007, AL-Fatlawi, 2011]; Diwania river [AL-Ghanimi et al., 2009]; Tigris river [Kassim et al., 2000] and Shatt Al-Arab river [AL –Farhan, 2010]. The study aimed to determine the qualitative and quantitative variation of epiphytic algae on the studied host macrophytes, as well as which parts of host plant will prefer.

MATERIALS AND METHODS

Four sites selected along Al- Abbasyia River. This river lies between two cities in the middle of Iraq (Al-Kifil and Al-Abbasyia) southern holy city of Najaf Al Ashraf (Figure 1). The current study was carried out from March 2012 to February 2013. Physical and chemical properties of the river water were measured according to APHA [2003].

Epiphytic algae were collected from the sampling sites to a qualitative study while a sedimentation technique used for a quantitative study [Zimba and Hopson, 1997]. The micro transects methods used for diatomic algae and hemocytometer methods for non-diatomic algae [Vollenweider, 1974]. Identification of the epiphytic algae has been done by following references [Prescott, 1973, 1982, Sultana et al., 2013, Bellinger and Sigee, 2010 and Al-Hassany and Hassan, 2013].

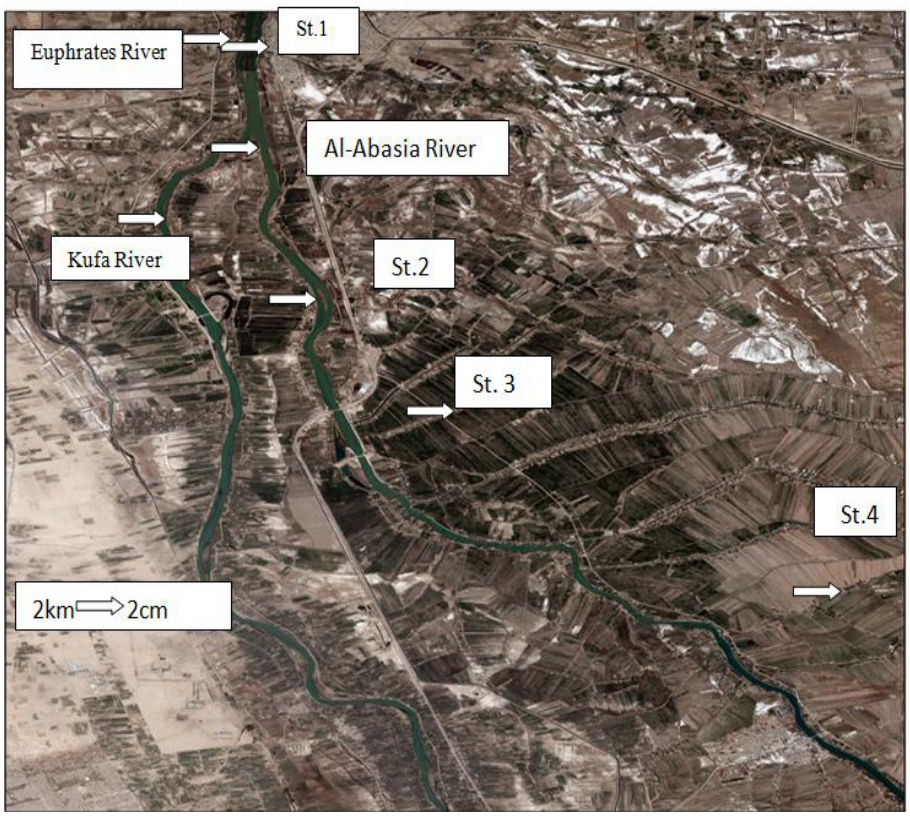

Figure 1. Satellite image of the study sites in Al-Abbasyia River (Euphrates), Iraq

RESULTS AND DISCUSSION

The results of this study showed high values of air and water temperatures in the hot seasons and low values in the cold season. These results were consistent with other studies [Salman, 2006, Hassan et al. 2010, Kassim et al., 2000]. Significant changes recorded in the values of electrical conductivity and salinity compared to previous studies during the winter. Being lower values of E.C. in May 2012 may be due to soil washing by rainwater [McNair and Chow-Fraser 2003] or due to agricultures and domestic uses of water along the river in study area. The results were in consistent with other studies [Gosselain et al., 2005, Salman et al., 2013, Kadhim et al., 2000] while incompatible with another study [Al-Dulaimi, 2013].

The pH was an indicator on the alkalinity and acidity water [US-EPA, 1997]. The results of the present study ranged 6.9-9.13 [Table 1]. It is a common feature in Iraq inland water buffering state due to a high content of calcium bicarbonate [Talling, 1980, Salman et al., 2012].

Variation of current velocity has important implications on the biota in lotic ecosystems [Smith, 2004]. The high flow water value recorded in the summer and low values recorded in the winter due to increasing the water levels of river during the period of study. Also, the construction of the barrage may have affected the current velocity [Al- Saadi et al., 1996].

Total dissolved solids and total suspended solids values ranged 277-2114 mg/l and 0.09-37.0 mg/l, respectively. A clear monthly variation in transparency and high values recorded in winter and low values in summer may be due to increased water movement by wind or by boats may be events to increase the turbidity or suspended matters in water column [Kassim.and Al-Saadi, 1995].

The total alkalinity was affected by many factors such as temperature, decomposition of organic matters and concentration of CO_2 [Wetzel, 2001]. The present study showed that the alkalinity values were fluctuating and that water levels have significant impacts on the values of alkalinity [Smith, 2004]. Total hardness were higher than alkalinity values in the present study and the hardness in study area as carbonic type [Lind, 1979].These results have been recorded in other studies [AL-Lami et al., 1999, Alkam et al., 2003, 2009].

Higher concentrations of total hardness recorded in March 2012 may be due to the discharge of waste water into rivers [Salman and Hussain, 2012] or to high precipitation and high soil leaching [Salman 2007, Al-Dulaimi, 2013]. The reason for low total hardness in the summer may be due to the consumption of CO_2 for photosynthesis [Al-Saadi, 2013].

Calcium concentrations were higher than magnesium concentrations in most study periods which may due to the solubility of CO_2 in water and reactions with calcium in contrast to magnesium which tend to precipitate [Goldman and Horne, 1983] .They may also be due to high concentrations of Sulphate ions that precipitate magnesium as magnesium sulphate [Al-Mousawi, 1984]. The lower values of calcium in some study months were attributed to consumption by organisms or to precipitation when they formed compounds dissolved in water [Lind, 1979] which may increase magnesium as a result of the drift of soils or discharges from waste water drainage [Salman et al., 2008, Hassan et al., 2010, Chopra et al., 2013] .

Periphyton organisms are important as primary producers in inland water and frequently contribute a great deal to the energy cycle in such ecosystems [Kassim.and Al-Saadi, 1995].

The high number of Bacillariophyceae (144 species) recorded incorporation with other classes of epiphytic algae. Other studied noticed this dominance of Bacillariophyceae [Hadi and AL- Saboonchi, 1989, Blindow, 1987, Coreltt H and Jones, 2007, Shams et al., 2012].

A clear variation recorded in the number of identified epiphytic algal species among host macrophytes [Table2]. The distribution of algae was depended on the growth form of macrophytes, texture, orientation, area and arrangement of leaves as well as the age of the host plant. The result showed a highest number of species on Ceratophyllum *demersum* in

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site 4. These results were compatible with many studies on submerged macrophytes [Blindow, 1987, Kassim et al. 2000, Hassan et al., 2007, Al-Hassany and Hassan, 2013] and other types of habitat [Messyasz and Kippen, 2006, Longtin et al., 2009].

On the *P. austaralis*, a number of epiphytic algae were affected by many environmental factors such as temperature, dissolved oxygen, alkalinity, Mg and surface area. Also, grazing by herbivores affect the density of attached algae [Graham et al., 2009]. The present study recorded 39, 19 and 2 species belonged to Chlorophyceae, Cyanophyceae and Euglenophyceae, respectively on the studied host macrophytes. These results were compatible with Al-Fatlawi [2011] and Talling [1980]. Euglenophyceae were not recorded on some parts of macrophytes.

Some species of epiphytic algae were found on all parts of certain host plants [Kassim et al., 2000]. These results were recorded in different species of macrophytes [Harlin, 1975, Bell, 1976] because some parts of host plants may provide a good surface to algae during the competition to reduce the light or some materials [Hassan et al., 2007]. The results showed eight species of diatoms on all parts of aquatic plants under study such as *Syndra tenera*, *Fragilaraia capucina* var. *mesolepta*, *Cocconeis placentula*, *Achanthes affinis* , *A .linearis* and *Gomphora parvulwn* on shoot of *P. australis* but *Navicula miniscula* on leaves of *C. demersum* .

The higher total cell number recorded on *P. australis* 14237 cell×10^4 ml/g in site 2 may be due to the wide separation of this plant in study area. These results were due to high tolerance of these plants to different environmental conditions [Cronk and Fennessy, 2001, Albay and Aykulu, 2002]. The lower cell numbers of epiphytic algae were recorded on the leaves of *P. australis* 986 cell×10^4 ml/g in site 1, While on leaves of C. *demersum*, the results showed the highest cell number 9505 cell×10^4 ml/g in site 2 and lower cell number 1215 cell×10^4 ml/g in site 1 may be these plants have suitable surface help to growth of algae [Messyasz and Kippen, 2006].

CONCLUSION

This study shows that the temperature, water flow, DO, BOD_5 and growth form of host macrophytes were playing important roles as limited factors for the distribution and density of epiphytic algae. .Epiphytic sampling should be stratified according to the fraction of surface light intensity, macrophytes architecture and seasonal water level variations.

ACKNOWLEDGEMENT

Authors are grateful to Department of Biology, College of Science, University of Babylon and Department of Biology, Faculty of Science, University of Kufa, Iraq for their support to this research.

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Table 1. Range (Mean ± S.D) of some physicochemical properties of AL-Abbasyia River during the study period (March 2012 to February 2013)

Properties	*Site 1*	*Site 2*	*Site 3*	*Site 4*
Air Temperature (Cº)	10.3340.33 (26.72±3.3)	10-45.67 (27.42±5.6)	10.33-37.33 (25.97± 2.3)	11-37 (26.81±2.1)
Water Temperature (Cº)	6.5-33 (20±2.4)	6.67-34 (22±3.2)	7-33 (22±2.75)	7.67-33 (20± 1.9)
Water flow (cm/sec)	80-650 (330± 210)	79-500 (380±150)	90-680 (330± 200)	60-730 (320±130)
Transparency (m)	71.67-300 (121±39.05	65-300 (121±39.05	65-306 (141± 42.67)	29.76 -300 (185.12±49.75)
pH	6.9- 8.1 (7.64±1.3)	7- 8.8 (7.63± 1.6	7- 8.7 (7.65±1.2)	6.97- 9.13 (7.75±9)
Salinity ‰	3.68-23 (13.70±3.2)	5-16 (12.76±2.1)	6.47-17.50 (12.99±1.3)	6.40-18.80 (12.71± 2.9)
Electric Conductivity (µs/cm)	163.3-1083 (780±22.6)	320.67-1076 (829.54±78.9)	419.67-1036 (800.64±180.75)	510-1157 (825.9±241.49)
Dissolved Oxygen (mg/L)	2.50-8.17 (4.52±0.35)	2.33-9.83 (5.13±1.44)	1.83-7 (4.19±1.69)	2.30-12.33 (6.01±1.41)
Biochemical Oxygen Demand (mg/L)	1.5-6.6 (3.2±0.4)	1.7-5.5 (2.8±0.74)	1.4-7.3 (3.57±1.23)	1.5-8 (3.8± 0.56)
Total suspended. solid (mg/L)	0.05-35 (6.12±1.69)	0.05-37 (5.84±3.52)	0.13-22.33 (3.46±0.24)	0.09-24 (3.62± 0.93)
Total dissolved solid (mg/L)	277-510 (41-842.4)	313-2114 (625±50.14	281.67-607.67 (432.27±65.56)	322-550 (451± 72.3)
Alkalinity (mgCaCO3/l)	42.17-810 (342.61±162.)	70-582.17 (329±111.6)	170 - 610.17 (318.51±105.3)	50.50 - 573.40 (315± 163.2)
Total Hardness (mgCaCO3/l)	60-1650 (576.08±105.86)	150-1850 (649.2±87)	150-1500 (400.08±127.7)	200-1489 (580.48± 44.6)
Calcium (mg3/l)	86.48-1429.52 (493±59.4)	124.2-1783.3 (570.4± 26.7)	109.55-1255.86 (572.44±26.5)	200-1489 (580.48±44.6)
Magnesium (mg/l)	8.14-126.94 (35.19± 2.6)	7.63-72.50 (21.33±6.3)	11.07-268 (61.59±2.6)	6.70-206 (57.33±3.1)

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Table 2. List and total number (Cell*10^4) of identified epiphytic algae in the present study

Epiphytic Algae	*Phragmytus Austaralus*			*Ceratophylum Demarsum*	
CYANOPHYTA	*Leaves*	*Shoot*	*Root*	*Shoot*	*Leaves*
Anabaena cylindrical Lemm.	0.0604	0.0621	-	-	0.0061
Anabaena doliolum Bhara.	-	0.0303	0.0315	-	0.017
Anabaena sp.	-	0.39	-	-	0.0127
Anacystis nidulans (Rich) Dro.and Dai.	-	-	-	0.0735	-
Aphanocapsa elachista West and west	0.0531	-	0.0118	-	-
Chrococcus leminticus Lemm.	0.055	-	-	0.0611	0.041
C. disperus (Keissle.) Lemm.	-	-	-	-	0.061
C.turgidus (Kütz.)Näg	-	0.0453	-	0.0431	-
Cylidrospermum .sp	-	-	-	-	0.0882
Enteromorpha intestinalis (L.) Grev.	-	0.075	-	0.0632	-
Gleocpsasp sp	0.023	-	-	-	-
Gleotheca sp	0.042	-	0.09	-	-
Gleotrictia sp	-	-	-	0.092	-
Gomphorspaeria sp.	-	-	-	-	0.017
Lyngba aestuarii Lemm.	0.032	-	0.088	-	0.0329
Microcystis aeruginosa (Kütz)	-	0.0321	-	0.037	0.341
Phormidum ambigun Gom	-	-	-	-	0.092
Schizothrix tinctoria Gom	0.0361	-	0.0421	-	0.017
Acrosiphonia arcta (Dillw) Ag.	-	-	-	0.0543	0.0543
CHLOROPHYTA					
Batophora aerstedii Ag	-	0.0431	-	-	-
Bulbochaete insignis Pri.	0.007	-	-	-	-
Cladophora golmerata (L.) kütz.	0.0431	0.09	-	0.087	-
Closteriopsis longissima Lemm.	0.082				0.0831
Cosmacladium tuberculatum Pres.	0.022	-	-	-	0.0312
Cosmarium botrytis Men.& Raf.	0.0231	0.044	0.043	-	-
C. leaven Rab.	-	-	-	0.0765	-
Crucigenia tetrapedia (Kirch.)West	0.0291	0.0881	-	0.039	-
Dimorphococcus lanatus Bra.	-	-	0.0653	0.0546	-
Draparnaldia judayi Pres.	0.0542	-	-	0.0542	0.0556
Hyalotheca dissiliens Smi.	-	-	0.0321	-	-

ISSN: 2186-8476, ISSN: 2186-8468 Print
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Euastrum dubium Näg.	0.0653	-	-	0.439	-
Gleocystis ampla (Kütz.)Lag	-	0.023	0.0542	-	0.0129
Mesotaenium kramstia Lemm.	-	-	-	0.0654	0.043
Monostroma groenlandicu. Ag.	-	-	0.0061	0.065	-
Mougeeotia sp.	0.0432	0.0931	-	0.091	-
Netrium digitus var .lamellosum (Brébisson ex Kützing) Grönblad	0.439	0.0448	0.0654	-	-
Nitella sp.	-	-	-	0.0113	-
Oedogonium cardiacum (Hass.) Witt.	-	0.0688	0.0453	0.439	-
Palmella miniata Lei.	-	0.02x3	-	-	0.43
Palmellococcus miniatus (Kütz.) Chod.	-	0.0221	-	0.0543	-
Palmodictyon sp	0.0912	0.0654	0.311	0.0667	-
Pediastrum boryanum (Turp.) Men.	0.0021	0.081	-	-	0.087
P.simplex (Mayen) Lemm.	-	-	-	0.0354	-
Prasiola calophylla (Garm.et Grev.)	0.0935	-	0.0661	0.09	+
Pyramimonas cirolanae Pennick	0.0329	0.0432	-	0.0326	-
P. tetrahynchus Scha.	-	0.0552	0.0559	-	-
Scenedesmus quadricauda (Turp.)Brĕb.	-	0.0542	0.0021	0.091	-
S. bijuga (Turp.) Lag.	0.0632	-	-	0.0881	-
S. dimorphus (Turp.) Kütz.	-	-	-	0.0021	-
Selenastrum bibraianum Rei.	-	0.09	0.03	-	-
Sphaerocystis sp.	0.0556	-	-	-	-
Stigoclonium sp.	-	0.0501	-	-	-
Tetraspora cylindrical (Whal) Agardah	-	0.0401	-	-	-
Treubaria setigerum (Archer) Sm.	-	0.031	0.017		-
Trochiscia reticularis (Reins) Han.	-	0.0735	-	-	-
Ulothrix aequals Kütz.	-	-	0.643	-	-
Volvox sp.	-	-	-	-	0.09
Zygnema sp.	0.017	-	0.041	-	-
EUGLENOPHYTA					
Euglena sp.	-	0.027	-	0.091	-
Phacus triqueter (Ehr.) Duj	-	0.04	-	-	-
BACILLARIOPHYTA (Centrals)					
Actinoptychus splendens (Shad.) Raflsex Pritch.	-	-	-	-	0.49

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Auliscus sp.	-	-	0.29	-	-
Biddulphia laevis (Ehr.) Hust	-	-	-	0.6	-
Chaetoceros capense Karsten	-	-	-	-	0.71
Coscinodiscus granii Gough	-	0.22	-	-	-
C. lacustris Grunow	-	-	0.22	-	-
Coscinodiscus stellaris Roper	-	-	-	0.33	-
Cyclotella bodanica var .michiganensis Skv	-	0.9	-	0.74	0.17
C. comensis K Rüh.	0.42	0.22	-	0.58	-
C. meneghiniana Kütz.	-	0.91	0.59	-	-
Ditylum brightwelli (West) Grunow	-	0.22	0.29	-	-
Hyalodiscus sp.	-	2.2	-	-	-
Guinardia delicatula (Cleve) Hasle	-	-	0.15	-	-
Licmophora ehrenbergii(kütz Grunow	0.33	-	-	0.76	-
M. jurgensi Ag.	-	-	-	-	1.5
M.cf. spaerica Setch.ex Gard.	-	1.2	-	1.04	-
Rhizosolenia. imbricata Brig.	-	-	-	1.3	-
Stephanodiscus astraea var. intermedia Fri.	3.3	-	0.77	-	-
S. hantzshii Gru.	-	-	-	-	0.6
S. niagarae Ehr.	-	-	-	1.8	-
S. tenuis Hust.	0.6		-	-	-
S. turris (Grev.)Rafls	-	3.4	2.7	-	-
Thalassiosira anguste-lineata (Schm.) Fryx .ex Hasle	0.6	-	-	-	1.1
T.eccentrica (Ehr.) Cleve	-	-	-	0.8	-
T. decipiens (Grun.) Joørg.	-	-	1.2	-	-
T. eccentrica (Ehr.) Cleve.	-	-	-	1.2	-
Thalassiosira fluviatilis Hustedt	-	1.3	2.2	-	-
Thalassiosira sp	-	0.33	-	-	1.2
BACILLARIOPHYTA (Penales)					
Achnanthes affinis Grunow	-	2.9	4.7	-	-
A. exigua Grun	1.5	-	6.8	-	-
A. hungarica Gru.	-	-	-	2.2	-
A. lanceolatade Br.	-	0.9	3.1	-	1.5

A. minutissima Kütz.	-	1.7	-	-	+
A. saxonica Kras.&Hust	-	-	1.1	-	-
Amphipora alata Kütz.	1.5	-	-	-	-
Amphora bullatoides Hohn et Grun	-	3.3	3.2	-	-
A. holsatica Husted	0.9	-	-	-	-
A. ovalis kütz.	-	-	0.6	-	-
A. veneta Kütz.	-	-	-	11	-
Amphora sp.	2.9	-	-	-	-
Asterionella Formosa Hass.	3.4	-	-	-	7.1
Caloneis amphisbaena (Bory) Cl.	1.2	-	11.2	-	-
C. bacillum (Grun.) Cl.	-	-	-	-	3.3
C. bacillaric var. thermlic (Grun) Cl.	1.8	-	-	-	-
Campylodiscus noricus var .hibernica (Her.) Grun	-	1.5	4.4	-	-
C. solea (Breb.et Godey) Sm.	5.2	-	-	-	1.9
C. placentula Ehr.	-	-	5.9	-	-
Cymatoplurea solea (Berb.) Sm.	-	1.2	-	1.2	-
Cymbella cistula (Ehren.) Ki.	0.4	-	4.4	-	-
C. delicatula Kütz.	-	-	-	3.3	-
C. helvetic Kütz.	0.5	-	-	1.1	-
C. microcephala var .crasa Reimer	0.9	_	-	9.7	-
C. minuta His.&Rab.	-	1.5	-	-	1.2
C. parva (W.Smith) Ki.	-	-	0.6	-	-
Cymatopleura elliptica (Brĕb.) Smith	-	_	3.6	-	-
Gyrosigma sp.	_	2.2	1.2	-	-
Diatoma elongatum (lyngb) Ag.	-	-	6.6	-	-
D. vulgar Bory	_	_	-	-	2.2
Diploneis puella (Schum) Cl.	_	2.2	8.4	-	-
D .smiti (Berb.) Ce.	1.2	-	2.9	-	-
Didymosphenia sp.	-	_	-	-	0.3
Encyonema sp.	_	_	1.6	-	-
Epithemia adnata var. porcellus (Kütz.) Patra	-	6.9	7.2	-	-
E. sorer Kütz.	0.5	0.6	0.7	-	-
Eunotia arcus (Ehr.)) Kuetz	_	_	12.4	-	-

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E. serra Ehr.	_	_	2.7	-	-
E. curvata (Kütz) Larg.	0.32	0.22	-	-	-
E .pectinalis (Rafl.) Ra.	0.61	_	0.6	-	-
Fragilaria bervistriata Gru.	_	0.52	-	-	-
F. capunica Desm.	_	_	0.9	-	-
F.crotonensis Kiton	0.53	_	-	-	-
Fragilaria sp.	_	0.66	2.9	-	3.9
Gomphonema acuminatum Her	_	_	0.6	-	-
G. augur (Ehr.)	_	_	1.1	-	-
Gyrosigema attenuatum (Kütz.)	0.28	0.53	-	-	-
M.smithii Thw.ex.W.Sm	0.79	0.65	-	-	-
Melosira varians Ag.	_	_	1.4	-	-
Melosira sp	_	_	5.7	-	-
Navicula atomus (Kuetzing) Grunow	0.87	0.49	-	5.7	-
N. bacillum Ehrenberg	_	_	1	-	-
N. cryptocephala kütz	0.74	_	-	-	1.4
N .cuspidate (Kütz) Kütz.	_	0.59	3.7	-	6
N. decussis Oestrup	+	_	2.4	-	-
N. dicephala W.Smith	_	0.81	2.9	-	-
N. gastrum (Ehr.) Kuetzing	_	_	-	1.3	-
N. gracilis Her	0.59	_	-	0.7	-
N. halophila (Grun.) Cleve.	_	_	-	1.2	-
N. jarnefeltii Hust.	0.4	0.78	-	-	-
N. lanceolata (Ag.) Küetzing	_	_	1.5	0.9	-
N. minuscule Grunow	_	_	2.2	-	-
N. parva (Ehr.)Ra.	0.4	0.65	0.9	1	-
N. pseudotuscula Hust.	_	_	1.7	-	-
N.reinhardtii Grun.	_	_	1.8	-	-
N.seminulum Grun.	0.59	0.31	-	6.8	-
Neidium affanis (Her.) Pf.	_	_	2	-	-
N. irids (Ehr) Cl.	_	0.71	-	9.7	-
N. affine (Ehr.) Pf.	0.65	_	6	2.4	-
N. acicularis (kütz.) Sm.	_	0.65	-	-	-
Ntichiata angustata (W.Sm.) Grunow	_	+	2.2	1.3	-

N.capitellata Hust	_	_	4.3	-	-
N. commonis Rabh	+	_	-	9.7	-
N. denticula Grun	_	+	6.8	6.9	-
N. dissipata (Küetzing) Grunow	_	0. 86	-	-	-
N. dubia W.Smith	0.75	_	-	-	-
N. fasciculate Grunow	_	0.74	3.9	-	-
N.fonticola Grunow	_	_	4.2	-	-
N. frustulum (Kütz)	_	0.41	-	2.2	-
N. heufleriana Grunow	0.64	2.8	0.6	-	-
N. hungarica Grun	0.53	_	1.2	_	_
N. intermedia Hantzsch ex Cleve & Grunow	_	4.3	-	12.1	-
N. kutzingiana Hils.	_	1.9	3.4	-	-
N. linearis Sm.	0.21	_	-	30	-
N. lorenziana Grunow	0.51	1.8	-	-	-
N. micrcephala Grun.	_	_	1.5	-	-
N. obtusa W.smith	_	1.9	-	1.8	-
N. palea (Kuetzing)W.Smith	1.8	2.1	6	-	-
N. recta Hant.& Rab.	1.6	_	-	0.7	-
N. rostellate Hust.	_	2.8	5.7	-	-
N. sigmoidea (Ehr.) Smith	+	_	1.7	1.4	-
N. tryblionella Hantsch	_	3.01	-	4.7	-
N. vermicularis (Kütz.) Grun.	_	0.9	2.9	-	-
N. vitera Nor.	0.23	_	5.7	-	-
Peronia sp.	_	0.87	-	-	-
Pinularia acrosphaeriade B.	_	_	0.6	-	-
P. divergenis Her	_	_	-	2.9	-
Pinularia sp.	1.9	3.06	-	0.9	-
Rhoicosphenia curvata (Kütz) Gru.	0.39	0.38	1.2	-	-
Rhopalodia gibba (Her.) Mul.	_	_	-	0.7	-
Semiorbis sp.	_	0.91	-	1.6	-
Stenopterobia sp.	0.89	_	0.9	-	-
Stephanodiscus niagarae Ehr.	_	0.75	5.7	0.8	-
Stephanopyxis palmeriana Grev.	1.7	_	-	-	-
Surirella elegens Her.	_	2.3	-	-	-

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S.ovata kütz.	_	2.1	1.5	-	-
S .robusta Her.	0.52	0.72	13	-	-
S.rumpens Kg.	_	__	6.8	-	-
Synedra vaoucheria Kütz	0.31	0.58	-	20.6	-
S .acus Kütz.	0.93	+	-	3.6	-
S. pulchella (Ralfs) Kütz.	1.2	_	2	-	-
S. rumpens Kg.	_	1.2	2.9	-	-
S. tabulate (Ag) Kütz	_	1.2	2.4	-	-
S.ulna (Nitz.) Ehr.	1.2	_	0.9	3.9	-
Tetracyclus sp.	_	_	2.9	-	-
Thalassiosira weissflogii (Grunow) G.Fryxell & Hasle	0.89	1.8	1.3	-	-
Tryblionella coarctata (Grun.) Mann.	_	_	2.9	4.3	-
T .levidensis Smith	_	_	-	6.5	-

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