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Qualitative and quantitative study of phytoplankton in lotic ecosystems, Iraq

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Abstract

Phytoplankton is the key factor of primary production in streams and other lotic systems. This study focused on phytoplankton in bani- Hassan stream in Karabala province. Five sites were selected along the stream where monthly sampling was carried for 12 months. The physicochemical parameters were studied in addition to diversity, spatial and temporal variation of phytoplankton and biological diversity indices. A total of 136 taxa of phytoplankton were identified which belonged to 65 genera . Where 65, 34, 17, 3 and 1 taxa belonged to Baciallriophyceae, Charophyceae, Cyanophyceae, Dinophyceae and both Euglenophyceae and Cryptophyceae, respectively. Temporal and spatial variations in total number of phytoplankton were noticed in this study. Highest total number was (2.42 cell x 10^3 /l) recorded at site 2 in May 2013 and the lowest was (0.18 cell x 10^3 /l) recorded at site 4 in January 2013. *Cyclotell*, *Aulacoseria*, *Cocconeis*, *Cymatoplerura*, *Nitzschia*, *Cymbella* and *Oscillatoria* were all recorded over study time.

Keywords; Phytoplankton, Lotic Systems, Stream, Temporal Variation, Spatial Variation.

Introduction

Phytoplankton is widely used in freshwater systems as bioindictors [1]. These algae have a notable response to environmental change and water quality alteration [2, 3, 4]. Phytoplankton have a main role as

the main base of an aquatic food chain, the estimation of quality and quantity of these algae important criteria for determining primary production as the main sources of different kinds of aquatic organisms [5].

Many studies have been published on the phytoplankton ecology in the main Euphrates river in its middle region in Iraq. Salman et al. [6] recorded 105 takes of phytoplankton with Bacillariophyceae dominancy in the Euphrates river between two cities (Al-Musayyab and Hindiya). Hassan et al. [7] identified 145 taxa of phytoplankton in the Euphrates river belonged to Bacillariophyceae, Chlorophyceae, Cyanophyceae and other groups. Some other studies concerning phytoplankton compositions in other branches of Euphrates river (In Hilla River [8,9], in Al- Shamiyah river [10], in Al-Hussainya river [11]). The present study aimed to study the diversity of phytoplankton in bani- Hassan stream in Karabala province and to evaluate the water quality.

Materials and methods

Bani- Hassan stream is one of the main branches of the Euphrates river. Its length is 65 km and irrigates an area 114,000 thousand acres within Karabal province[12]. Five sites were selected along the stream[Figure 1). All physical and chemical parameters were measured according to APHA[13), while nitrite, nitrate, phosphate and silicate were determined according to the methods described by Parson et al.[14]. Volenweider[15] method was used to determine chlorophyll-a. For the phytoplankton quantitative study, the sedimention method used with lougle's solution to preserve. Haemeosytometer method was used for phytoplankton total number counting[16]. Phytoplankton was identified following references 17; 18, 19;20]. Two biological biodiversity indices were calculated in this study. Shannon –Weaver Index[21] and Chandler scores[22]. The statistical analysis was used by applying CANOCO program[CAA) to clarify the relationship between the physicochemical parameters and phytoplankton.

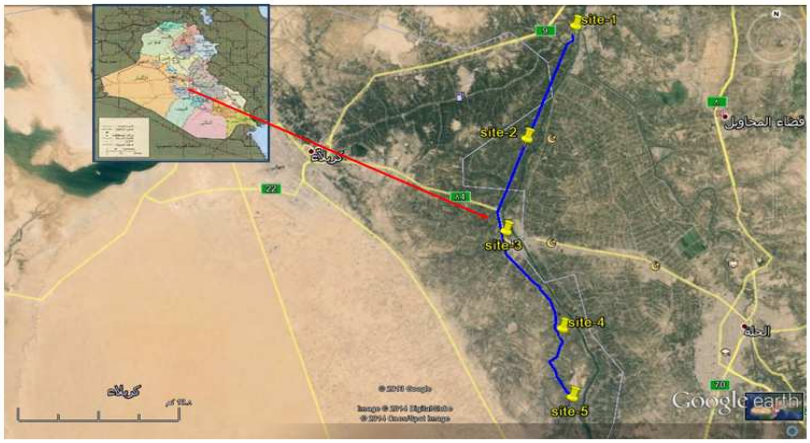

Figure 1. Map of the studied area

Results and discussions

Results of physicochemical parameters were summarized in table 1. The Air and water temperature ranged between 4ºC and 40ºC for air, while 9.5 to 29.8 ºC for water. pH results indicated that the stream was characterized as slightly alkaline as other Iraqi aquatic ecosystems[23, 24]. The stream was

oligohaline according to Reid classification in which the present results of the electric conductivity (EC) and salinity (S‰) ranged 989-1440 µS /cm and 0.62-0.88‰, respectively. The statistical analysis showed a positive correlation between EC, S‰ and total dissolved solids and this agreed with another study[25]. The values of both total dissolved solids and total suspend solids ranged as follows 480-703 mg/l and 0.28-81.03 mg/l, respectively. Both values were increased in December 2013 that may be due to eroding the large amount of mud from the surrounding lands. Light penetration and water flow ranged between 30 - 215m and 0.1-1 m/Sec. No anoxia recorded in this study, the stream has a good aeration and oxygen concentration levels were above 5mg/l and up to 12 mg/l during the study period. Biochemical oxygen demand (BOD5) ranged 0.56-4.80 mg/l. Total alkalinity values (95-137 mg CaCO3/l) indicated that the stream was slightly alkaline and belonged to bicarbonate ions and this results noticed in Iraqi aquatic ecosystems[23;26;27]. According to Lind[28) the stream considered as hard water. Hardness concentrations ranged 138-493 mg CaCO3/l. calcium and magnesium values ranged 41-182 mg/l and 9-86 mg/l, respectively.. Only one time the magnesium concentration over calcium concretion, may be due to the consumption of calcium ion by phytoplankton also combined with other ions to produce dissolved compounds in water[26; 29] and this result agrees with another Study[30].

The surface water nutrient levels ranged as follows: 0.03-17.03 µg/l, ND-5.05 µg/l, 2.6-97.90 µg/l for phosphate, nitrite and nitrate respectively, while the silicate ranged 0.01-5.03 mg/l. The highest value of N: P recorded in April 2013, while the lowest value recorded in November 2013.The highest concentration of nutrients might be due to discharge of agro-industrial and municipal discharge[31].

Table 1. Range (Mean±SD) of physicochemial and biological parameters of Bani-Hssan stream during the study period.

Parameters	**Sites**				
	1	**2**	**3**	**4**	**5**
Air temperature (°C)	**4-29 (20.16±1.12)**	**11-34 (23.25±1.12)**	**12-34 (23.97±1.26)**	**12-37 (26.83±(1.21)**	**13 -40 (29.22±(1.47)**
Water temperature (°C)	**9.5 - 29.4(12.28±1.05)**	**9.7 -29.1 (21.09±1.02)**	**10.4 -29.2 (21.86±1.04)**	**10.5 -29.7(21.79±1.02)**	**10.7 -29.8 (22.19± 1)**
pH	**7.3-8.3 (7.75±0.05)**	**8.4- 7.4(7.8±0.05)**	**8.5 -7.5 (7.89±0.05)**	**8.6 – 7.5 (8.03±0.06)**	**8.6 – 7.4 (8.06±0.06)**
ElectricConductivity (µS/cm)	**990 – 1386 (1173.61±18.4)**	**990 -1440 (1178.06± 19.8)**	**996 - 1380 (1115.2±18.23)**	**1040 -1350 (1169.17±16.02)**	**1003 – 1380 (1163.8±19.04)**
Salinity ‰	**0.63 – 0.88 (0.73±0.01)**	**0.63 – 0.9 (0.73±0.13)**	**0.63 - 0.8 (0.72 ±0.01)**	**0.88 - 0.7 (0.73±0.01)**	**0.88 - 0.6 (0.71± 0.02)**

Total dissolved solid TDS(mg/l)	**480 - 670 (574.5±8.7)**	**480-700 (577.5±9.73)**	490 -680 (568±9.04	**510 - 690 (579.2±8.65)**	**510 -680 (573.8±9.17)**
Total suspended solids TSS(mg/l)	**7.14 - 50.4 (20.55±2.6)**	**1.9 - 50.0 (23.05±2.69)**	**0.28-70.9 (22.64±3.35)**	**0.56 -68.6 (29.02±10.3)**	**0.57-81.03 (19.02±3.9)**
Light transmittance (cm)	**60- 80 (69.11±0.92)**	**37- 215 (86.66±7.71)**	**38 -190 (107.13±9.78)**	**30-170 (102.43±7.45)**	**30 -120 (86.03±4.79)**
Water flow (m/sec.)	**0.4-1.0 (0.66±0.03)**	**0.2-0.7 (0.93±0.02)**	**0.1-0.7 (0.83±0.38)**	**0.1-0.7 (0.35±0.14)**	**0.3 -0.6 (0.63±0.02)**
Dissolved oxygen (mg/l)	**6.0-12.7 (8.35±0.35)**	**5.4 -12.6 (8.32±0.37)**	**5.8-12.3 (8.44±0.36)**	**5.6 -11.9 (8.12±0.34)**	**5.8-12.8 (8.86±0.29)**
BOD_5mg/l	**0.7–4.5 (2.730.71)**	**0.6–4.8(3.25±0.37)**	**1–4.2 (2.99±0.35)**	**1.2 – 3.5(2.50±0.24)**	**0.8–4.6 (2.86±0.29)**
Total alkalinity (mg CaCo3/L)	**97.3 -135.6 (122.58±2.02)**	**95.6-132.3 (120.11±2.19)**	**97.0-136.0 (121.3±2.19)**	**99.6-137.0 (119.27±1.97)**	**99.0-133.3 (119.3±2.18)**
Total Hardness (mg CaCo3/L)	**172-460 (342.7±10.22)**	**182-466.6 (344.03±11.26)**	**162.6 -453.3 (384.7±11.89)**	**138.6-493.3 (347.03±14.31)**	**143.3-418.6 (336.97±10.45)**
Calcium (mg3/L)	**41.9-180.0 (117.5±5.17)**	**59.03-165.3 (115.5±4.26)**	**63.5-165.3 (116.14±5.02)**	**71.5-182.6 (111.28±5.09)**	**70.4-166.6 (111.71±4.91)**
Magnesium (mg /L)	**16.574.4 (56.11±1.75)**	**9.4 -82.5 (57.43±1.90)**	**9.4 -76.4 (60.16±1.99)**	**29.8-86.4 (60.27±2.47)**	**28.2-75.7 (56.3±1.94)**
Phosphate (µg/L)	**0.15-16.46 (5.89±1.12)**	**0.05-17.03 (4.87±1.12)**	**N.D-15.26 (5.27±1.0)**	**N.D -15.96 (5.54±1.07)**	**N.D-16.46 (4.94±1.07)**
Nitrite (µg/l)	**0.46-5.06 (1.90±0.25)**	**0.22-4.6 (1.32±0.21)**	**N.D -3.9 (0.98±0.19)**	**N.D-3.9 (1.19±0.18)**	**N.D-205 (0.76±0.12)**
Nitrate (µg/L)	**9.13- 97.4 (37.07±4.29)**	**2.62 -86.6 (32.43± 6.6)**	**3.53 -95.5 (33.38±4.65)**	**5.63 -76.93 (28.64±3.66)**	**5.23-97.93 (28.60±4.37)**
Silicate (µg/L)	**0.23-1.83 (0.23±0.09)**	**0.09-3.56 (1.29±0.17)**	**0.4 -3.13 (1.37±0.15)**	**0.01 -3.56 (1.29±0.16)**	**0.02-5.03 (1.37±0.25)**
Chlorophyll –a ((µg/L)	**0.01-3.7(1.82±0.33)**	**0.18-7.3 (1.69±0.34)**	**N.D -4.0 (1.40±0.25)**	**N.D-7.7 (1.17±0.39)**	**N.D-1. (0.71±0.12)**
Phyophyten ((µg/L)	**N.D-3.7 (1.41±0.27)**	**N.D-3.5 (1.48±0.29)**	**0.26--4.2 (1.92±0.03)**	**0.33-4.13 (1.83±0.29)**	**N.D-3.6 (1.07±0.24)**
Total No.	**1512.4-**	**2420.6- 252.06**	**905.2- 200.8**	**975.9- 181.2**	**673.53-185.9**

Phytoplankton cell.103/ L)	**253.4(750.89±65.90)**	**(749.18±155.66)**	**(507.99±39.18**	**(543.11±38.27)**	**(350.35±24.43)**

A total of 136 species of phytoplankton belonged to 65 genera were identified throughout the sampling period. Six classes of phytoplankton noticed in this study, where the Bacillariophyceae was the dominant class among the other classes (Table 2). The Bacillariophyceae was represented as 79 species belonged to 29 genera, 9 species of centric diatoms and the rest was to pennate diatoms. Other classes were represented as follows: 34, 17, 2, 3,1 and 1 for Chlorophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae and Cryptophyaceae, respectively (Figure 2).

Table 2. Number of species (S) and genus (G) of identifying phytoplankton in each studied sites.

Sites / **Classes**	**1**		**2**		**3**		**4**		**5**	
	S	**G**	**S**	**G**	**S**	**G**	**S**	**G**	**S**	**G**
Bacillariophyceae	55	24	65	24	66	23	46	22	30	17
Centrales	8	3	7	3	7	3	5	3	4	2
Pennales	47	18	58	21	59	20	41	19	26	15
Chlorophyceae	25	15	26	18	21	15	19	15	25	18
Cyanophyceae	12	8	15	10	10	8	9	8	10	8
Euglenophyceae	2	2	0	0	0	0	2	2	0	0
Dinophyceae	3	3	3	3	1	1	2	2	2	2
Cryptophyceae	1	1	1	1	1	1	0	0	1	1
Total	98	50	110	56	99	48	78	49	68	46

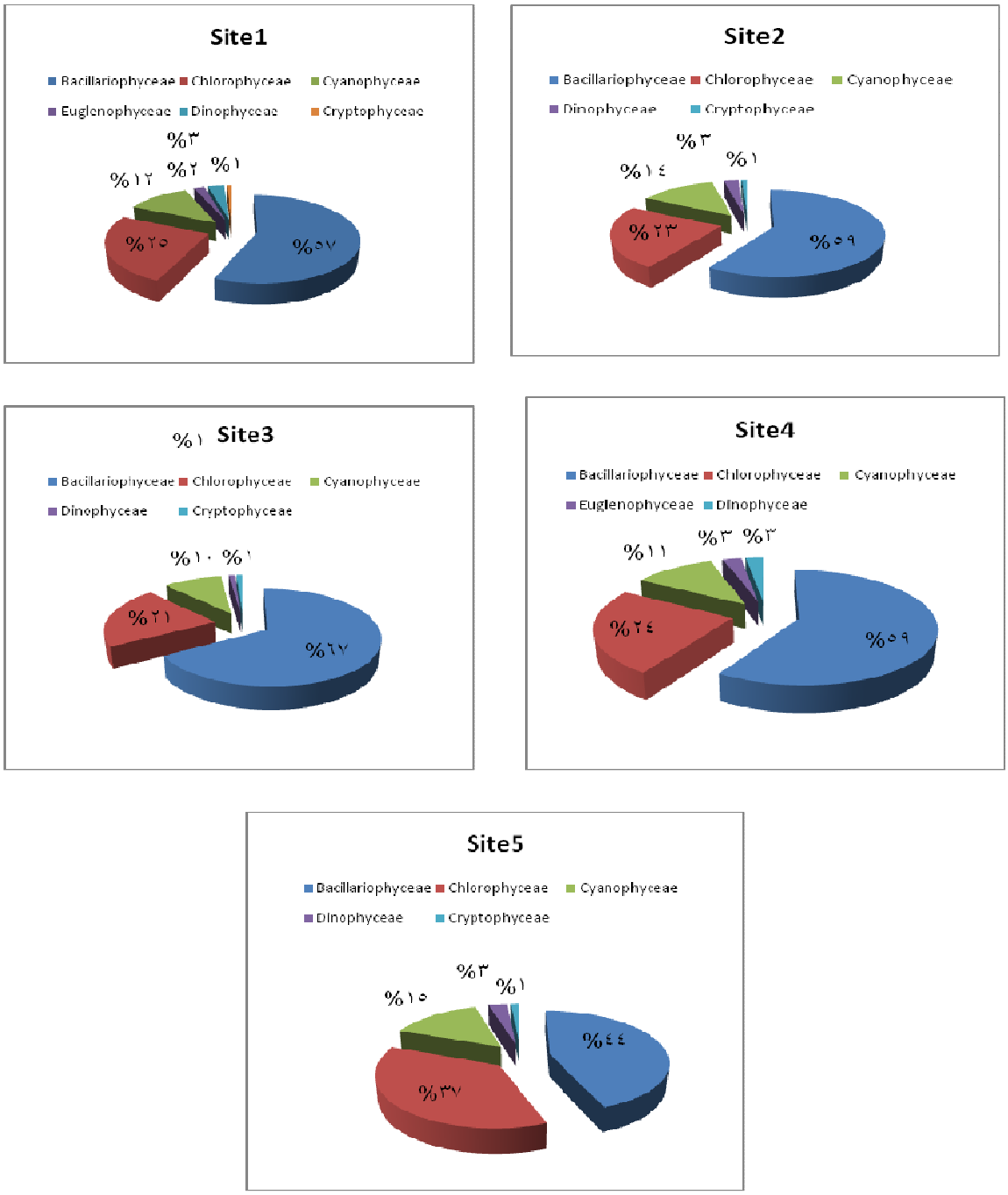

Figure 2. Percent of phytoplankton classes in the studied sites.

Some genera were predominating throughout the study period, such as: *Cyclotella*, *Aulacoseira, Cocconeis*, *Cymatopleura*, *Nitzschia*, *Cymbella*,*and Oscillatoria.*

Spatial and temporal variation of total number of phytoplankton noticed during the present study (Figure 3). The total number of phytoplankton recorded the lowest and highest values (0.18 x 10^3 and 2.42 x 10^3 individual/l) at sites4 and 2in January 2012 and May 2013, respectively (Figure 3). Two peaks of total number of phytoplankton noticed during the spring and autumn months of the study period. These results might be due to an increased nutrient concentrations in consistent with agricultural activities in spring in Iraq[32]. Chlorophyll-a, and phaeophytin ranged 0.02-7.70 µg/l and 0.01-4.20 µg/l, respectively. The chlorophyll-a concentration result indicated that the stream was considered as oligo-mesotrophic according to Felfôldy[33]. In this study noticed an incompatibility of chlorophyll-a with the total number of phytoplankton and perhaps the reason was the dominance of Bacillariophyceae[34]. Spatial variation in identifying phytoplankton (table 2 and 3) where different species (genera) recorded in the studied sites as follows: 98 species (50 genera), 110 species (56 genera), 99 species (48 genera), 78 species (49 genera) and 68 species (48 genera) in sites 1, 2, 3, 4 and 5, respectively (Table 3).

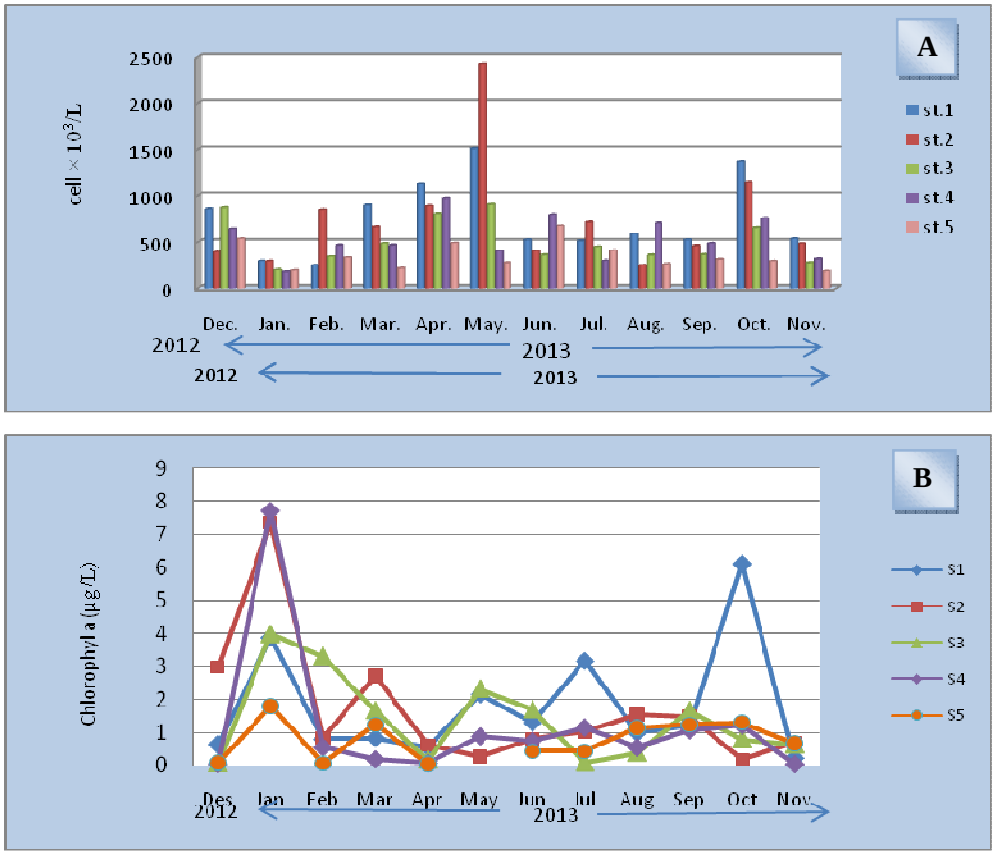

Figure 3. Monthly variation of total number of phytoplankton (A) and its Chlorophyll-a (B) in the studied sites.

Table 3. Identified phytoplankton with Chandler's signsin Bani-Hasssann stream during the study period. Present: P, Frequent: F, Common: C, Abundant: A, very abundant: V (followed Chandler, 1970).

Sites / **Taxa**	1	2	3	4	5
CYANOPHYCEAE					
Anabaena sp.	P	P	P	P	P
Aphanocapsa sp.	F	P	P	-	-
Chroococcus limnaticus var. elegans G.M.Smith	F	F	P	F	P
C. turgidus (Ktz.)Naegeli	-	F	-	-	-
Lyngbya Perelegans	-	P	P	p	P
Gomphosphaeria aponina ((Kutzing)	P	P	P	p	P
Merismopedia elegans	-	P	-	p	-
M. glauca(Ehr.) Naegeli	F		P		P
M.tenuissima lemmermannn	P	P	-	-	-
Microcystis aeruginosa Kützing	P	P	P	F	P
Nostok sp.					
Oscillatoria amoena (Ktz.) Gomont	-	F	-	P	P
O. limnetica Lemmermann	-	C	F	C	F
O.limosa Roth Agardh	F	F	-	-	-
*O.miuima (*Gicklhorn*)*	C	F		-	-
Oscillatoria sp.	F	-	-	-	F
Spirulina Laxa G.M.Smith	P	P	P	-	-
Chlorophyceae					
Actinastrum hantzschii Lagerhein	P	F	p	F	P
A.falcatus (Corda) Ralfs	C	-	-	F	F

A.*sp*	P	-	P	P	P
Botryococcus protuberans	C	F	F	P	F
Chlamydomonas sp.	F	F	-	-	P
Chlorella vulgaris Bejerinck	C	F	F	C	F
Chlorococcum humicola Naeg.	-	P	p	-	P
Coelastrum microporum (Nageli)	F	F	F	-	P
C. reticulum (Dang.) Senn	P	F	p	P	P
Coelastrum sp	F	F	-	F	-
Cosmarium granutum	P	P	F	F	P
C. leave Rabenhorst	P	P	-	-	-
Cosmarium sp	F	p	-	P	-
*Crucigenia tetrapedia(*Kirchner)	F	P	F	F	P
Dictosphaerium pulchulum	F	P	p	F	-
Micractinium pusillum (Fresenius)	P	-	-	-	P
Mogeotia sp.	F	F	p	F	F
Kirchnersella obesa	F	F	-	-	-
Large hemiacitiata	F	P	P	P	P
Oocystis sp	F	F	P	P	P
Pandorina morum (Muell)Bory	-	-	P	F	P
Pediastrum simplex Meyen	-	-	P	-	F
Scenedesmus acuminatus (Lag.) Chodat	F	F	P	F	-
*S. acuminatus*var.tetradesmoides	P	-	P	-	-
S. arcuatus Lemm	P	p	-	-	P
S.bijuga (Turb.)Lagher	C	F	F	-	F
S.dimorphus (Turb.)*Ktz.*	F	P	-	-	P
S. intermedius Chodat	-	-	-	P	-

S. quadricauda (Chodat)	C	C	C	-	F
Scenedesmus sp.	-	F	-	-	P
Selanastrum sp.	-	P	P	-	-
Spirogyra subsalsa	-	P	-	P	P
Staurastrum sp.	-	P	-	-	P
Tetraedron minimum Hansgirg	-	-	P	P	P
Euglenophyceae					
Euglena sp.	P	-	-	p	-
Trachelomonas sp.	P	-	-	p	-
Dinophyceae					
Dinobryon sertularia(Ehrenberg)	P	p	-	F	p
Glenodinium quadriden	P	p	-	-	p
Peridinium sp.	F	F	P	F	-
Cryptophyceae					
Chroomonas sp	C	C	F	-	-
Bacillariophyceae					
Centrales					
Aulacoseira granulate (Ehrenb.) Simonsen	A	A	C	A	C
Melosira. varians Agardh	C	P	F	-	P
Cosinodiscus sp.	-	-	-	F	-
Cyclotella atomus Hustedt	F	F	P	-	-

C. comta(Ehrenb.) Kütz.	P	-	-	P	-
C. kuetzingiana Thwaites	C	F	F	-	-
C. meneghiniana Kütz	A	C	C	C	C
C.ocellata Pant	V	V	A	C	C
Stephanodiscus dubius (Fricke) Hustedt	F	F	F	-	-
Pennales					
Acanthoceras zachariasi Brun.Simonsen	-	-	-	P	P
Achananthes affinis Grunow	P	F	F	P	-
A. hungarica (Grunow) Grunow	P	P	P	-	F
*Amphora ovalis (*Kütz) Kütz	-	P	P	F	-
Amphora veneta Kütz.	-	F	-	P	-
Amphora sp.	-	P	F	F	P
Anomoeoneis exilis Kütz.	-	P	-	-	-
Asterionella Formosa Hass.	F	P	P	-	F
Bacillaria paradoxa Gmelin	P	-	P	P	P
Caloneis ventricosa (Ehr.) Meister	-	P	P	-	-
Cocconema cistula Hempr.	P	F	F	F	-
Cocconeis pediculus Ehernb.	C	C	P	A	F
C. placentula var. *euglypta* (Ehr.) Grunow	C	C	C	C	C
Cymbella caespitosa (Kützing) Brun	-	P	P	P	-
C. gracilis (Rabenh.) Cleve	F	P	F	P	-
C. leptoceros (Ehrenb.) Kütz.	F	F	P	C	-
C. prostrata (berk.) Cleve	F	F	F	-	-
C. parva (W.Sm) Wolle	P	F	F	P	F
C. stomatophora Grunow	F	F	P	F	F
Cocconema fusidium Ehrenb.	P	C	P	C	-

Diatoma hiemale (Roth)Heib.	-	-	P	-	-
D. vulgare Bory	C	C	C	C	F
Diploneis ovalis(Hilse)Cleve	P	F	P	-	-
Eunotia curvata (Kütz.) Largerst.	-	F	-	F	-
Eunoia sp.	-	P	P	-	-
Fragilaria crotonensis Kitton	-	F	F	P	-
Fragilaria sp.	P	-	P	-	-
Gomphonema olivaceum (Hornemann) Brébisson	F	F	C	P	-
G. angustatum var. productum Grunow	-	F	F	F	F
G.gracile Ehernberg	P	-	F	p	-
G.intricatum Kuetzing	P	-	P	-	-
G. constrictum Ehrenberg	-	P	P	-	P
Gomphonema sp	P	-	P	F	P
Gyrosigma acuminatum (*Kütz.*) Rabenh.	P	P	F	F	-
G. scalproides (Rabenhorst) Cleve	F	P	P	-	-
Gyrosigma sp.	-		P	P	-
Hantzschia amphioxys(Ehr.) Grunow	P	-	P	-	-
Mastogloia elliptica (Ag.) Cleve	P	-	-	-	P
Navicula gracilis Ehrenb.	P	F	P	p	-
N. gibbula Cleve	F	P	F	P	-
*N.cuspidata (*Kütz) Kütz	-	P	P	-	-
Navicula sp.	F	F	P	F	-
N. halophila (Grun.) Cleve	P	P	F	P	P
N. parva Ralfs	-	P	-	-	-
N. radiosa Kütz.	-	-	P	P	-
N.tuscula Ehrenb.	-	F	-	p	P

Neidium affine (Ehr.)Pfitz	-	P	F	-	-
Nitzschia acicularis (ktz.)W.Sm.	F	P	-	-	-
N amphibia Grunow	F	F	P	P	P
N. gracilis Hantzsch	F	P	P	C	F
N.hungarica Grunow	-	P	F	F	-
N.intermedia Hantzsch	F	P	P	-	-
N. longissima (Berb.)Ralfs	F	F	F	F	C
N. obtusa W. Sm.	-	P	P	-	-
N. palea (Kütz) W. Sm	F	F	C	-	-
N. romana Grunow	P	P	F	F	-
N. sigma (Kütz) W.Sm.	F	F	F	p	-
N. sigmoidea (nitzsch)W.Sm.	P	F	F	-	P
Nitzschia sp .	F	-	F	C	C
Pinnularia sp.	P	P	P	-	-
Rhoicosphenia curvata (kütz.) Grunow	P	F	-	-	-
Rhopalodia gibba (Ehrenb.) O. Müll.	-	-	P	P	-
Sphinctocystis librilis (Ehrenb.) Hassal	C	C	F	C	F
Surirella ovalis Bréb.	P	C	P	F	F
Synedra affinis Kütz.	P	P	-	-	F
S. acus Kütz.	F	F	F	F	F
S. capitata Ehrenb.	P	-	-	-	-
S. ulna (Nitz.) Ehrenb.	C	C	C	F	F
S. pulchella Ralfs	F	P	P	-	-
Syandra sp.	F	-	P	-	-

Cyclotella ocellata and *C. meneghiniana* predominate species during the study period . *C. ocellata* found in alkaline aquatic ecosystems and considered as bio-indictors for olighotrophic aquatic ecosystems

[35, 36]. The presence of some genera such as *Oscillatoria* , *Lyngbya* and *Euglena* might be indication of organic pollution[1).

Four biological diversity indices were used in this study and ranged as follows:(3.4 -3.90),(2.90 -3.80), (61% - 36%)for richness, Shannon and Jaccard similarity indices, also the Chandler score was used.

The CCA analysis showed the effect of environmental parameters on phytoplankton diversity. This study will discuss only the main phytoplankton group (Baciallariohyceae). In figure 4 explain that *Cyclotella kuetzingiana* (Cycl.K) was affected highly significantly by temperature and water flow. *Aulacoseira granulate,Cyclotella.ocellata*, *Nitzschia.hungarica,Diatoma vulgar* and *Gyrosigma scalpriode*have positive correlation with calcium while *C. meneghiniana* showed a positive correlation with total hardness, total alkalinity and pH. The following species *Cymbella cistula*, *Cymbella affinis*, *Diatoma hiemale*, *Navicula gracilis*, *Nitzschia sp* have a positive correlation with nitrate and temperature and a negative correlation with total hardness. Other species (*Asterionella Formosa*, *Surirella ovalis,Fragilaria affinis,Gymphoneis olivaceum*) showed a positive correlation with nitrate, phosphate, silicate and temperature. While the following species; *Diatoma vulgare*, *Gyrosigmascalpriodes* and *Nitzschia.hungarica* were correlated positively with water temperature and water flow while a negative correlation with total alkalinity and total dissolved solids. Light penetration, dissolved oxygen, BOD5 and total dissolved solids with *Navicula sp* and *Bacillaria faxillifer*, while a negative correlation noticed with water flow. *Nitzschia longissima*, *Navicula gracilis,Achnanthes hungarica*, *Cymatopleura solea*, and *Gyrosigma sp* have a positive correlation with total dissolved solids, salinity (S‰) and total hardness while a negative correlation noticed with nitrate, chlorophyll-a and total suspended solids. Synedra sp showed a positive correlation with total hardness.

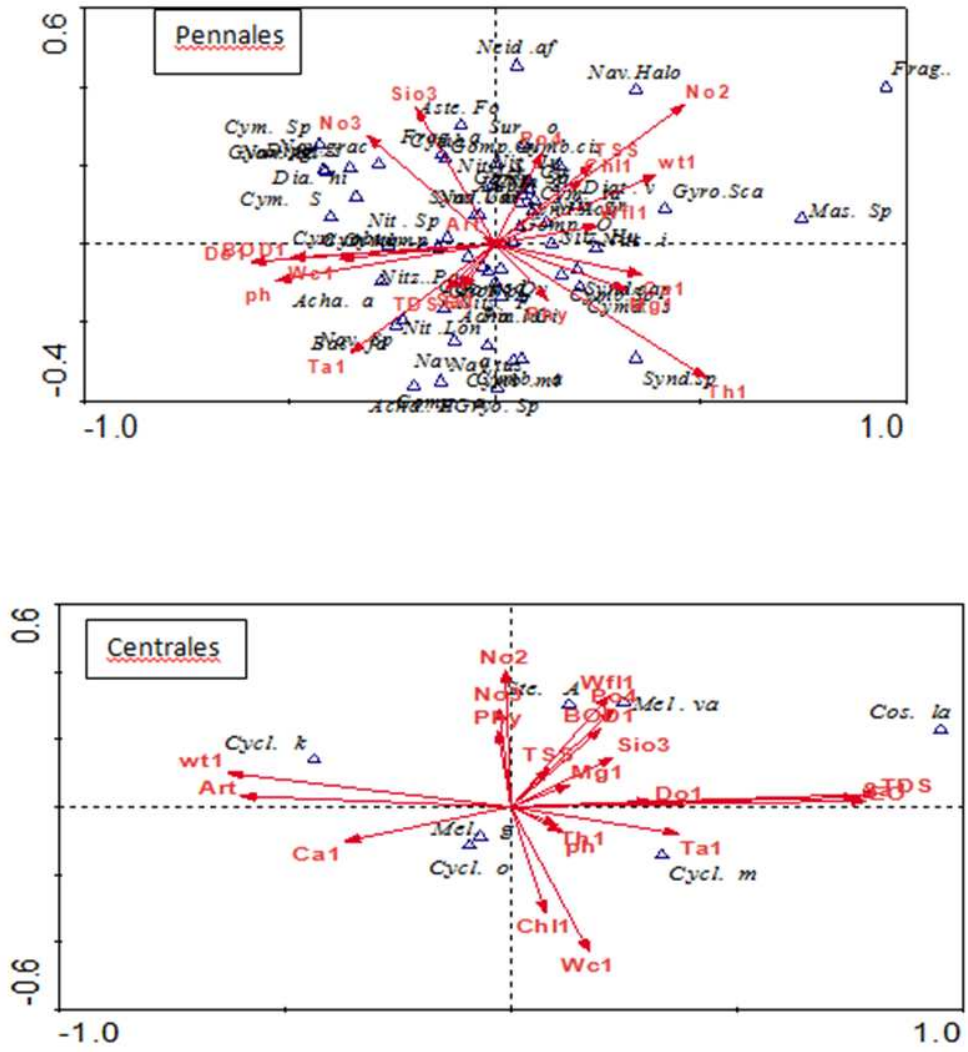

Figure 4: CAA analysis of effect of environmental parameters and Bacillariophyceae. Ph: pH, EC : Electric Conductivity, TDS: Total Dissolved Solids , TSS: Total Suspended Solids, Art: Air Temperature, wt1 :Water Temperature , Do1: Dissolved Oxygen, BOD1 : Biochemical Oxygen Demand, Ta1 : Total Alkalinity, Th1: Total Hardness, Ca1: Calcium, Mg1: Magnesium, Sa1 : Salinity, Wfl1 : Water Flow, Wc1: Light penetration, Po4: Phosphate, No2: Nitrite , No3 : Nitrate , Sio3: Silicate ,Chl1 : Chlorophyll-a, Phy: Phytoplankton Total Number. Other abbreviations are the initials of algae species.

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