Community Structure of Benthic Algae in a Lotic Ecosystem, Karbala Province-Iraq

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Abstract:

This study focused on benthic algae (epipelic and attached algae on concrete lining stream) in Bani-Hassan stream in Holly Karbala, Iraq. The qualitative and quantitative studies of benthic algae were done by collecting 240 samples from five sites in the study area for the period from December 2012 to November 2013. Also, the environmental variables of the stream were examined in term of temporary and spatial. The results showed that the stream was alkaline, hard, oligohaline and a well aerated. The total nitrogen to the total phosphorus (TN: TP) ratio indicates nitrogen limitation. 129 species of benthic algae belonging to 57 genera were identified. Bacillariophyceae (diatoms) was the predominant taxon (95 species) followed by Chlorophyceae (16 species), Cyanophyceae (14 species), Euglenophyceae (3 species) and Pyrophyceae (one species). Some genera were found throughout the study period: *Nitzschia*, *Navicula*, *Cymbella*, *Gomphonema*, *Surirella*, *Cocconeis*, *Aulacoseira*, *Oscillatoria*, *Lyngbya*, *Spirulina*, and *Scenedesmus*. Site 3 recorded the highest total number of algae in spring 2013, and the lowest total number was at site 5 in Autumn 2013. The chlorophyll-a concentration did not match the total number of algae.

Keywords: Benthic Algae, Epipelic Algae, Concrete lining stream, Lotic Ecosystem.

Introduction:

Algae can be found in all aquatic systems, and are the most diverse assemblage of organisms that can be sampled easily and identified readily to species or varieties [1]. Attached algae has a significant function in aquatic systems that involve stabilization of sediments, regulation of nutrient cycling, and primary production [2]. They are useful as indicators of aspects of water quality, including nutrients, organic enrichment dissolved oxygen and pH [3, 4, 5].

Oeding and Taffs [7] recommended epilithic diatoms as bioindicators of water quality of rivers in Australia and Chessman et al. [8] produced a diatom index to evaluate the effect of human impact on Australian rivers on a broad scale. Taş and Yilmaz [2] used algae as bioindicators in their study of Cimil stream, Turkey. They found that the stream changed from oligosaprobic to β-α-mesosaprobic conditions

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The epipelic algae is defined as free – living in aquatic sediments [9].

The study of epipelic algal ecology was pioneered in freshwater habitats by Round [9, 10, 11, 12, 13]. Bellinger et al. [14] used benthic diatoms as bioindicators in five African tropical streams. This study demonstrated that the benthic algae and diatoms reflect the quality stream status. Leelahakriengkrai and Peerapornpisal [15] showed the relation between some diatomic species and water quality in Ping River, Northern Thailand.

The Epipelic algae species are indicated by their functional groups regarding their tolerance and sensitivity level to different combinations of physicochemical and biological properties of aquatic systems [16]. The diversity of epipelic algae, trophic structure, productivity and nutrient levels are important factors in determining and monitoring the pollution rate in the aquatic systems [17]. Venkatachalapathy and Karthikeyan [18] explained the importance of using diatoms as Biomonitoring in the aquatic river system. Also they reviewed the applications of diatoms in aquatic systems in India and other countries.

There are many previous studies of epipelic algae in Iraq. Kasim [19] studied the southern marshes of Iraq, While Al– Lami [20] studied the

upstream region of the Euphrates River. Al-Saadi [21] worked on the Al –Dagara River, Hassan et al. [22] on the Al-Hilla river, and Salman et al. [23] on the Euphrates River in the middle of Iraq. Moreover, Khadhim et al. [24] studied the spatial and temporal variation of epipelic algae in Neel stream. While Hassan et al. [25] studied Epipelic algae along the Euphrates River between Hindiya and Manathira cites. The diatomic epipelic algae in Al-Shamiyah River were examined by Hassan and Shaawiat [4]. Hassan et al. [26] revealed that the higher number of benthic algae recorded on artificial substrate in the Tigris River. All these studies refer to diatoms as dominant species followed by Chlorophyceae, Cyanophyceae and Euglenophyceae, respectively .

A few years ago studies have been performed on Bani-Hassan stream. These studies are concerned with phytoplankton and physic-chemical variations [25, 27].

There was no environmental basic data on the Bani-Hassan stream before and after concrete lining; this stream is important since it irrigates an area of 194200 acres. The justifications of this study are to fill up the gaps of information on the stream; moreover, to compare the response of benthic algae communities structures gradually from the upstream to the downstream.

Materials and Methods:
Study area :
The study sites are located in the south – western part of the Euphrates River (Fig. 1). The stream is a branch from the right side of the Euphrates River on Al-Hindiya Barrage with length 65km, 44.500 km inside Karbala province. Five sites were selected along the Bani-Hassan stream in the period from December 2012 to October 2013 (Table 1). Site 1 located after Al-Hindia barrage which represented the upstream. Site 2 is over 11.3 km distance from Site1. While, Site 3 and 4 are located on 10km and 19 km from Site 2, respectively. Site 5 represents downstream and located over 7km from Site 4. Only Sites 1and 2 are without concrete lining.

Figure 1. Map of the study sites in the Bani-Hassan stream.

Table 1. Sampling sites GPS values and topography.

Site No.	Longitude (East)	Latitude (North)	Characters of sites
1	44°15'44.20"	32°43'33"	Upstream and agriculture
2	44°13'19.4"	32°37'36.6"	Agricultural and residential
3	44°12'25.5"	32°32'49.7"	Agricultural and residential
4	44°15 ' 49.2"	32°28' 20"	Agricultural and residential
5	44°16 ' 32.5"	32°24'24"	Down stream, agricultural and residential

Physical and chemical properties
Sampling for environmental parameters and benthic algae were collected monthly, from five sites during the period of December 2012 to November 2013. All results were expressed seasonally.

Environment variables were measured as follows: temperature, water flow, pH, electric conductivity (EC), salinity, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD_5), Total Alkalinity, Total Hardness, calcium (Ca^{+2}), magnesium (Mg^{+2}), sulfate measured according to APHA [28]. Total nitrogen was measured according to Mackereth et al. [29]. Total phosphorus measured according to Eisenreich et al., [30]. Sediment texture and total organic carbon (TOC) were measured according to [31, 32], respectively.

Benthic Algae:
Due to different substrates of the studied stream, the term of benthic algae is used in this study to express both the epipelic and epilithic algae attached to the concrete lining. The sample of epipelic algae was taken from each site using a spatula for scraping off from the surface of the clay within area $50m^2$ and 3-5 mm. These samples were stored with little of stream water in a polyethylene container and taken away from light in the lab. After 5-6 hours, the sample was mixed after removing the excess water and taking 40g from the sample and transferring into a petri dish. Each petri dish was covered by a lens cleaning tissue and left for 24 hours. Then the tissue was taken off and put in a vial with a few drops of Lugol's iodine for the qualitative and quantitative studied. While for Chlorophyll-a the tissue was put in a vial and kept in -20 °C until determined chlorophyll-a concentration. Epilithic algae was collected by scraping the upper layer of concrete surface which is covered by stream water and their deposit sediment. Then the sample was placed in a clean bottle and added a few drops of Lugol's iodine, another set of bottles without

fixation for chlorophyll-a determination. A total of 180 samples collected from five study sites for benthic algae quantitative and qualitative studies. The counting of algae was done according to Eaton and Moss [33] and identified through several references [34, 35, 36, 37]. Chlorophyll –a concentration was estimated according to Eaton and Moss [33]. The diversity of benthic algae in the study sites was quantified using the Shannon – Weaver index [38], Richness index [39] and the presence of algal species at the study sites was measured according to the method of Chandler [40]. Canonical Correspondence correlation (CCA) [41] was used to illustrate the relationship between benthic algae and environmental variables.

Results and Discussion:

A total of 180 samples was collected monthly for physicochemical parameter study. The results were expressed on a quarterly basis. Table 2 illustrates the range of mean values of the studied parameters and Fig. 2 and 3 show the spatial and seasonal variation of these parameters. The lower values of air and water temperatures were recorded in winter while the higher values were in summer. The lowest water flow in the stream (0.27 m/min) was registered in the summer and the highest value (0.83 m/min) was in winter. Also, a significant spatial and temporal variation were observed in water flow (p<0.05). The results show that the stream water was a high alkalinity with a narrow range of pH value (7.40-8.48). The Iraqi aquatic systems have been characterized by its alkaline and buffer [42, 43, 44, 45, 46, 47]. This narrow range of pH is due to the buffering capacity [48]. Alkalinity was a common feature in Iraqi aquatic systems because of the plentiful of the bicarbonate salts in water, which was affected by many factors such as temperature; CO_2 and waste water [20, 42].

The stream is considered as oligohaline [49] and recorded the highest value of T.D.S and T.S.S as a result of raising water levels in the winter season [5]. The stream was well aerated, very hardness with a high concentration of calcium unlike the magnesium values and this is consistent with other studies [43, 44, 50]. The nutrient concentration ranged as follows: 0.31-092 mg/l, 0.038-0.39 mg/l, 0.47-3.2 mg/l and 131.53-222.11 mg/l for TN, TP, silicate and sulphate, respectively. According to TN: TP values of the stream might be limited by nitrogen [51]. The texture of the stream sediment was silt-clay, and there is a significant relationship between the size of granular deposits with the concentration of total organic carbon. This relationship is observed in this study. The highest

value of organic carbon was recorded on the site 4 which was characterized by texture (silt -clay) possibly due to their large surface area and has an affinity with organic carbon [52].

A total of 129 species of Epipelic algae was identified in the stream. These algae (57 genera) belonged to five classes: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Dinophytceae (Table 3).

Bacillariophyceae was the vast majority and represented (72- 82%) of Benthic algal composition (Figure 4). Chlorophyceae ranged between (6-13 %), and Cyanophyceae were 10-13%, whereas, Euglenophyceae recorded a lower number of species during this study. Although one species was registered for Dinophyta, this is consistent with many of the local studies [24, 25, 44]. No clear differentiation in Benthic algae was recorded due to a different substrate. This result agrees with Winter and Duthic [53] report. They indicated that the composition of the Epilithic, Epiphytic and Epipelic habitat in the studied streams (two tributaries of the Grand River, Ontario, Canada) was not always different.

The dominant classes were Bacillariophyceae with 36 species. The dominance of diatoms might be due to their ability to tolerate the alteration in the environment [54]. Salman et al. [45]) noted the dominance of Epipelic diatoms and followed by Chlorophyceae, Cyanophyceae, and Euglenophyceae. Khadhim et al. [24] reported 56 epipelic algae in one of Euphrates branches. This result was also reported by Hassan et al. [25] in the Euphrates River in a region between two cities. Hassan and Shaawiat [6] noted the dominance of pennate diatom (92.59% of total identified diatoms) in an Al Shamiyah River in Iraq. These results are in agreement with the present study. The high number of the pennate diatom in contrast to the centric is usually recorded in freshwater systems [55], in many Iraqi freshwater systems [23, 42, 46, 56], the dominance of diatom algae also recorded in different river systems [57, 58].

The study results show different genera and species number (Table 4) among the study sites. Site five recorded the lowest number of genera and species (30 genera and 62 species) while Site 4 recorded the highest number of genera and species (43 genera and 84 species). Which might be due to the different sediment texture of each site and also the exposure of these sites to different pollutant, and availability of nutrients and predation by other organisms [59].

Table 2. Range of mean values of physicochemical parameters during the study period in Bani-Hassan stream.

| Parameters	Sites				
	1	**2**	**3**	**4**	**5**
Air temperature (°C)	12.33 -27 (19.67±2.04)	15-29.67 22.67±2.21)	16.67-31.33 (24.33±2.08)	18-34.33.18 (26.92±2019)	18.5-37.67 (28.79±20.57)
Water temperature (°C)	12.67-28.5 (21.10±1.87)	12.83-28.36 (20.99± 1.83)	13.33-28.6 (21.47± 1.81)	13.46 -28.9 (21.72± 1.83)	13.37-29 (220.04± 1.81)
Electric Conductivity (EC) (μS/cm)	1087-1299 (1173.58±32.61)	1060-1333 (1174.72 ±36.19)	1067-1269 (1151.94 ±32.46)	1079-1272 (1168.61 ± 28.34)	1062-1291 (1163.33±32.83)
Salinity ‰	0.67-0.80 (0.73 ±0.02)	0.66-0.83 (0.74±0.021)	0.68-0.79 (0.72±0.019)	0.68-.079 (0.73±0.017)	0.67-0.79 (0.72±0.021)
pH	7.44-8.06 (7.75±0.08)	7.57-8.14 (7.8±0.08)	7.64-8.38 (7.9±0.09)	7.64-8.47 (8.03±0.11)	7.33-8.48 (8.07±0.11)
Total dissolved solid TDS(mg/l)	530-636 (573.33±15.88)	527-656 (577.78±17.28)	521-624 (564.44±16.26)	534 - 640 (578.89 ±15.45)	536 - 643 (573.33±16.36)
Total suspended solids TSS(mg/l)	11.2 - 33.29 (20.56± 4.61)	8.02 - 37.71 (23.17± 4.65)	4.96- 37.15 (22.66±5.96)	2.9 - 33.83 (19.78 ± 6.06)	3.75 - 38.76 (19.02 ±7.01)
Water flow (m/sec.)	1 – 0.4 (0.66 ± 0.03)	0.7 – 0.2 (0.93±0.02)	0.7 – 0.1 (0.83±0.38)	0.7 – 0.1 (0.35±0.14)	0.6 – 0.3 (0.63±0.02)
Dissolved oxygen (mg/l)	6.67-11.44 (8.37 ±0.61)	6.31-11.24 (8.14 ±0.63)	6.9 - 12 (8.5 ± 0.66)	6.52- 12.43 (8.31 ± 0.65)	6.48-12.43 (8.61± 0.75)
Biochemical Oxygen Demands BOD5 (mg/l)	1.52- 4.1 (2.71± 0.36)	0.84- 3.97 (2.6 ± 0.4)	1.48- 4.02 (2.4 ± 0.34)	1.45- 2.53 (2.12 ± 0.21)	1.21- 3.56 (2.42 ± 0.31)
Total alkalinity (mg CaCo3/L)	112.44- 131.56 (122.44 ±3.43)	100.89-129.89 (120.11 ±3.80)	106.33-131.33 (121.25 ±3.56)	101-128.56 (119.11 ±3.39)	100.89-130.89 (119.19 ±3.62)
Total Hardness (mg CaCo3/L)	331.11-355.22 (344.75 ± 11.47)	337.33-356.11 (344.16 ± 10.71)	332- 366.67 (347.25 ±9.84)	327.35- 383 (342.98 ±15.33)	282-361.78 (334.03±11.10)
Calcium (mg3/L)	84.14- 125.67 (114.31 ±8.00)	97.57- 125.67 (111.84 ± 6.06)	93.56-122.97 (112.96 ± 7.81)	94.22- 129.44 (108.15 ±7.28)	95 - 121.46 (108.20 ± 7.41)
Magnesium (mg /L)	50.33- 61.97 (55.64 ±2.03)	52.44- 62.63 (56.38 ±2.57)	54- 61.44 (58.89 ± 2.58)	47.89-65.39 (57.1 ± 3.77)	4.022-61.44 (54.71 ±3.34)
Sulphate (mg /L)	154.05- 197.22 (177.21 ±10.07)	145.58- 222.11 (183.02±12.74)	143.96- 207.61 (187.32±10.29)	147.13- 212.56 (184.56±10.76)	131.35- 213.56 (185.25 ±10.86)
Total Phosphours (TP) (μg/L)	0.12-0.39 (0.2± 0.05)	0.05- 0.37 (0.16 ± 0.05)	0.04-0.32 (0.13 ± 0.05)	0.038- 0.33 (0.13± 0.05)	0.05- 0.31 (0.13 ± 0 .045)
Total Nitrogen (TN) (μg/L)	0.38- 0.92 (0.66 ± 0.09)	0.31- 0.9 (0.62± 0.1)	0.44- 0.87 (0.65 ± 0.08)	0.38- 0.89 (0.66 ± 0.08)	0.32- 0.81 (0.59 ± 0.07)
TN:TP	2.33:1- 8.1:1 (4.72 ± 0.69)	2.21:1- 11.74:1 (6.54± 0.96)	4.16- 20.21 (12.1 ± 1.91)	4.09- 32.13 (18.2 ± 3.66)	2.68- 15.62 (8.1 ± 1.14)
Silicate (mg/L)	0.6-1.14 (1.15±0.09)	0.64 – 2.66 (1.39±0.28)	0.55 – 2.04 (1.26±0.23)	0.47 -2.3 (1.3±0.29)	0.49 – 3.2 (1.58±0.44)
Soil pH	7.08-7.36 (7.23±0.06)	6.94 – 7.48 (7.18±0.08)	6.78 – 7.47 (7.21±0.12)	6.96 -7.42 (7.14±0.08)	7.01 – 7.29 (7.18±0.06)
Soil EC (μS/cm)	1089-2403 (1734±345.26)	722 – 978 (864±54.46)	786 – 1649 (1047±163.3)	906 -1634 1189±171.71)	773– 1704 (1325±136.13)
Total Organic Carbon %	0.59-1.19 (0.88±0.16)	0.58 – 0.98 (0.77±0.16)	0.45 – 1.04 (0.74±0.13)	0.75 -1.39 (1.7±0.16)	0.78 – 1.13 (0.17±0.1)
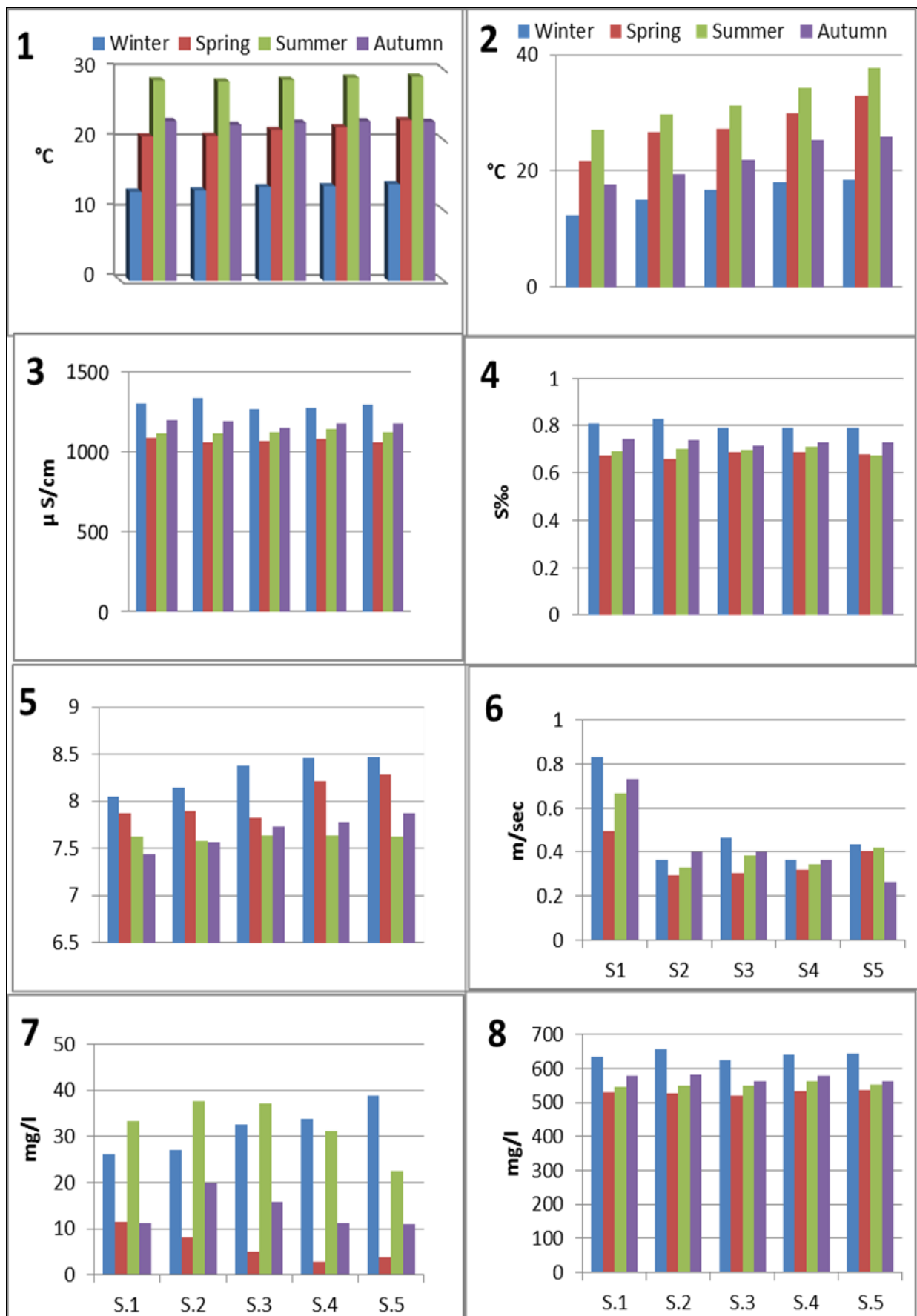
Figure 2. Seasonal variations of the following parameters: 1: air temperature 2: water temperature 3: conductivity 4: Salinity 5: pH 6: Alkalinity 7: Total suspended solids 8: Total dissolved Solids.
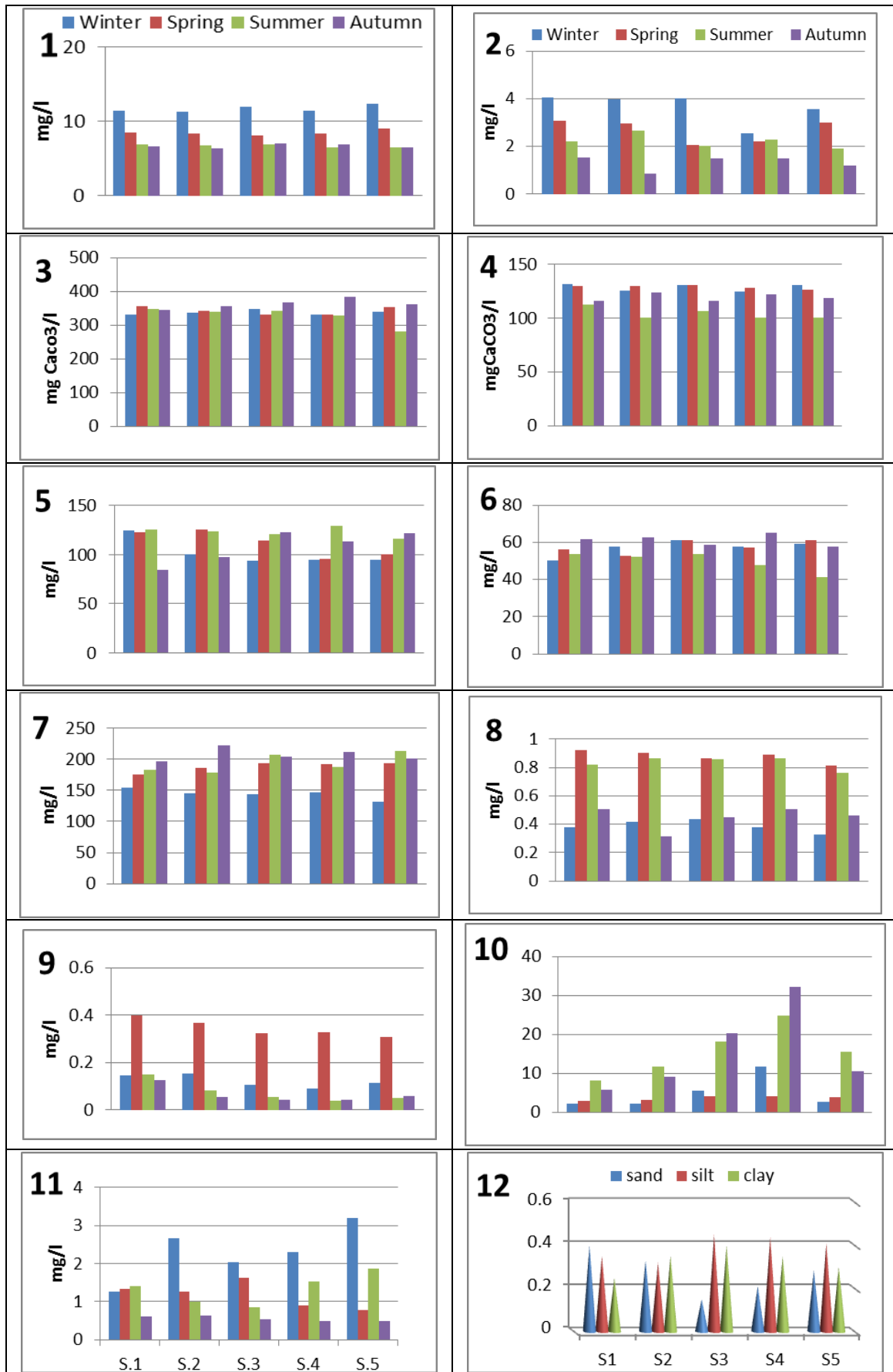
Figure 3. Seasonal variations of the following parameters: 1: Dissolved Oxygen 2: Biochemical Oxygen demand 3: total Hardness 4: Total Alkilinity 5: Calcium 6: Megnesium 7: Sulphate 8: Total Nitrogen 9: Total Phosphurs 10: TN:TP 11: Silcate 12: Soil texture.

Table 3. Identified Benthic algae in Bani-Hassan stream during the study period.Symboles: P= 1-2, F=3-10, C=11-50, A=51-100, V= 100-Up according to Chandler's scores (Chandler, 1970).

Taxa	1	2	3	4	5
Cyanophyceae					
Anabaena sp.	-	P	F	P	P
Chroococcus limneticus Lemmermann	P	-	-	-	-
Gomphosphaeria aponina Kützing	-	p	-	-	-
Lyngbya aestuarii Lemmermann	C	C	A	A	P
Lyngbya limnetica Lemmermann	P	P	C	F	F
Lyngbya perelgeaus Lemmermann	-	-	F	C	-
Lyngbya sp.	-	P	P	F	P
Merismopedia glauca (Ehr.) Nägeli	P	-	P	P	-
Nostoc sp.	-	-	P	P	-
Oscillatoria. limnetica Lemmermann	C	C	C	F	F
O. tenuis Agardh	P	-	-	-	-
O. priceps W.west & G.S.west	-	p	-	-	-
O.splendid	C	-	P	-	-
Spirulina major Kützing	P	p	F	F	P
Chlorophyceae					
Actinastrium hantzschii Lagerheim	-	-	P	-	-
Chlamydomonas sp.	-	-	-	P	-
Chlorella vulgaris Bejerinck	p		-	-	-
Coelastrum microporum Nägeli	P	P	F	P	P
Coelastrum reticulatum P.A.Dangeard	P	p	P	P	P
Cosmarium botrytis Meneghinii	-	-	-	P	-
C.formosulum Hoff	-	-	-	P	-
C. granatum De Brébisson	-	-	-	P	-
C.subcostatum Nordstedt	-	-	-	P	-
Cosmarium sp.	-	p	-	-	-

Taxa					
Pediastrum boryanum (Turp.) Meneghinii	P	-	-	-	-
Scenedesmus bijuga (Turp.) Lagerheim	P	p	P	P	P
S. quadricauda (Turp.) De Brébisson	P	-	P	P	P
Staurstrum aradoxum Meyen ex ralfs	-	-	-	p	-
Tetraëdron minimum (A. Braun) Hansgirg	-	-	P	P	-
Euglenophyceae					
Euglena sp.	P	P	P	P	-
Trachelomonas sp.	-	-	P	P	-
Lepocinclis sp.	-		-	P	-
Dinophyceae					
Peridinium sp.	F	P	P	P	F
Bacillariophyceae					
Order(1) Centrales					
Aulacoseira granulate (Ehr.) Ralfs	C	C	C	C	C
A.varians Agradh	F	-	-	-	-
Coscinodiscus lacutirs Grunow	P	P	P	p	P
Cyclotell comta (Ehr.) Kützing	-	-	p	-	-
C. meneghiniana Kützing	C	C	C	P	F
C.ocellata Pantocsek	F	F	F	F	P
C.striata (Kütz.) Grunow	-	-	P	F	-
C. stelligera (Cl.Et.Gran)Van Heurck	-	-	p	-	-
Stephaenodicus hantzschii Grunow	-	P	-	-	P
Order(2) Pennales					
Achnanthes gibberula Grunow	P	-	-	P	-
A. lanccolata (Bréb.) Grunow	-	P	-	P	P
Amphipleura pellucida (Kützing) Kützing	P	-	-	-	P

Table 1. Continuing

Species						Species					
Amphora coffeaeformis (Ag.) Kützing	P	-	-	-	-	*D. ovalis* F. Fricke	p	-	P	P	P
A.ovalis (Kütz.) Kützing	p	P	P	P	P	*Epithema sorex* Kützing	F	-	-	-	P
Asterionella formosa	-	-	-	P	-	*Epithema* sp.	-	-	-	p	-
Bacillaria paxillifer Gmelin	p	C	P	P	-	*Eutonia arcus* Ehrr.	-	-	p	P	-
Caloneis amphisbaena (Bory)Cleve	-	P	-	-	-	*Fragilaria. crotonensis* Kitton	-	P	P	-	-
C.permagna (Bail.) Cleve	P	P	P	-	-	*F. intermedia* Grunow	P	-	p	P	-
Cocconeis pediculus Ehernberg	F	F	F	C	C	*F. vaucheria* (Kut) petersen	P	-	-	p	-
C. placentula var. *euglypta* (Her.) Cleve	P	F	F	F	F	*Gomphoneis olivaceae* (Horne)P.Dawson ex Ross et Sims	P	P	F	F	-
C.placentula Ehernberg	F	C	C	-	C	*Gomphonema. Angustatum* (Kütz.)Rabenhorst	F	P	F	C	P
Cymatopleura elliptica (Bérb.)W.Smith	P	P	-	P	-	*G. constrictum* Ehernberg	-	P	-	-	-
C. solea (Bérb.)W.Smith	P	P	F	F	P	*G. lanceolatum* Ehrenberg	-	P	-	-	P
Cymbella affinis Kützing	F	-	P	F	P	*Gyrosigma acuminatum* (Kütz.) Rabenhorst	P	-	F	P	P
C. caepitosa Kützing	-	P	F	C	P	*G. spenceri* (W. Smith) Cleve	P	P	P	P	P
C. cistula (Her.)Kirchn	C	P	F	C	C	*Hantzschia amphioxys*(Her.) Grunow	-	P	-	P	-
C. tumidula Grunow	P	-	-	-	-	*Mastogloia braunii* Grunow	F	-	P	F	P
C. obtusiucula Kützing	P	P	p	P	P	*M. smithii* var. *amphicephala* Grunow	P	-	-	-	-
C. pusilla Grunow	F	F	F	P	F	*Merdion* sp.	-	F	P	P	-
C.sinuata W.Gregory	-	-	p	p	-	*Navicual anglica* Ralfs	P	P	-	-	-
C.tumida (Bérb.) van Heurck	P	-	-	P	P	*N.bacillium* Ehrenberg	-	P	p	P	-
C. ventricosa Kützing	P	P	P	C	P	*N. cincta* Ehrenberg	A	C	F	C	C
Denticula sp.	F	P	-	-	P	*N. gracilis* Ehrenberg	C	P	C	C	F
Diatoma elongatum (Lyngb.) Agradh	-	P	-	-	P	*N. alophile* (Grun.)Cleve	-	P	-	P	-
D. hiemale (Roth.)Heiberg	P	-	-	-	P	*N. pygmaea* Kützing	-	-	-	-	P
D. vulgare Bory	F	F	P	P	F	*N. radiosa* Kützing	P	-	-	-	P
N. trivalis lang- Bertalot	F	C	F	P	C	*Surirella ovalis* De Brébisson	F	P	P	P	P
N.schroeteri F.Meister	F	P	P	-	-	*S. ovate* Kützing	-	-	-	P	-
Neidium affine (Ehr.) Pfitz	-	P	-	-	-	*S. robusta* Ehrenberg	-	-	p	P	P
Nitzschia.apiculata (Greg.) Grunow	P	F	F	C	F	*Synedra capitata* Ehrenberg	-	-	-	P	-
N.angustata var.*acut* Grunow	p	P	P	P	-	*Synedra acus* var. *radians* Kützing	P	-	-	-	-
N. dissipata (Kütz.) Grunow	-	P	-	-	-	*S. ulna* (Nitzs.) Ehrenberg	F	P	P	-	F
N. fasciculate (Grun.) Grunow	P	P	P	P	P	*S. ulna* var. *oxyrynchus* (Kütz.) Van Heurck	P	P	P	P	-
N. filiformis(W.Smith) van Heurck	P	-	-	-	-	*S.pulchella* Kützing	P	-	-	-	-
N. granulate Grunow	P	-	-	P	P	*Tabellaria* sp.	-	P	-	-	-
N.hungarica Grunow	P	P	P	-	-						
N. linearis W.Smith	F	-	F	P	P						
N. longissima (Bérb.) Ralfs	P	P	F	P	-						
N. lorenziana Grunow	C	-	F	F	P						
N.obtusa W.Smith	F	P	F	P	P						
N. palea (Kütz.) W.Smith	F	-	P	P	P						
N. punctata (W. Smith) Grunow	P	P	P	P	P						

N. recta Hantzsch ex Rabenh.	P	P	P	p	-
N. romana Grunow	-	P	p	P	-
N.sigmoidea (Ehr.)W.Smith	F	P	P	P	P
N. tryblionella Hantzsch	P	P	P	P	P
Pleurosigma salinarum Grunow	P	P	P	P	P
Pinnularia gibba Ehrenberg	-	P	-	-	-
Rhoicosphenia curvata(Kütz.) Grunow	P	P	F	F	P
Rhopalodia gibba (Ehr.)O.Müller	P	-	P	-	-
R. gibberula (Ehr.)O.Müller	-	-	P	-	-
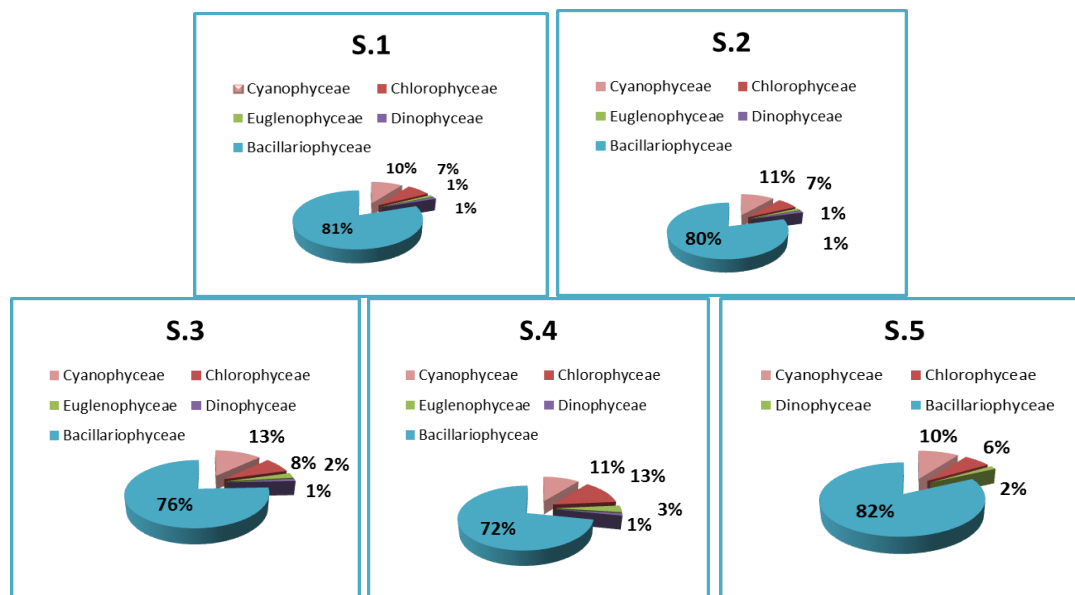
Figure 4. Percent of identifying Classes of Benthic Algae in the studied sites

Table 4. Number of genera and species of recorded Benthic algae at the studied sites in Bani-Hassan stream during the study period.

Classes	Sites									
	1		2		3		4		5	
	G	S	G	S	G	S	G	S	G	S
Cyanophyceae	5	8	5	8	6	10	6	9	4	6
Chlorophyceae	3	6	3	5	4	6	4	6	2	4
Euglenophyceae	1	1	1	1	2	2	3	3		
Dinophyceae	1	1	1	1	1	1	1	1	1	1
Bacillariophyceae										
Centrals	3	5	4	5	3	7	3	5	4	6
Pennales	24	61	24	53	22	52	22	56	19	46
Total	37	82	38	73	38	78	39	80	30	63

Some algal species were recorded at all study sites such as *Nitzschia*, *Navicual*, *Cymbella*, *Gomphonema*, *Surirella*, *Cocconeis*, and *Aulacoseira*. The genus Nitzschia recorded (17) species and nine species were registered for each of *Navicual* and *Cymbella*. The other genus such as *Gomphonema*, *Surirella* and *Cocconeis* have included three species for each and two species of genus *Aulacoseira*. These genera have played significant environmental roles in the ecosystem such as primary productivity and bio-indicator of

environmental changes such as increased of nutrients and salinity [23, 25, 60].

The quantitative study of Benthic algae ranged from 23.26×10^4 in Site three during the spring to $1.1.4 \times 10^4$ at site 2 in autumn (Figure 5). The decline was due to the water reservation at the second site, as a result of streamlining which leads to a lack of concentration of nutrients as a result of the mitigation quotient of high water levels and prevent the growth of algae on the bottom operations as well [61].

Chlorophyll-a values of Benthic algae do not match with the total number of cells during the period of study (Figure 5). Chlorophyll-a values ranging from undetectable during autumn to higher values during the winter (6.68 μg/ cm2). These values may be due to the amount of chlorophyll - a in larger species cells that are not equal to small-sized species cells [22, 62].
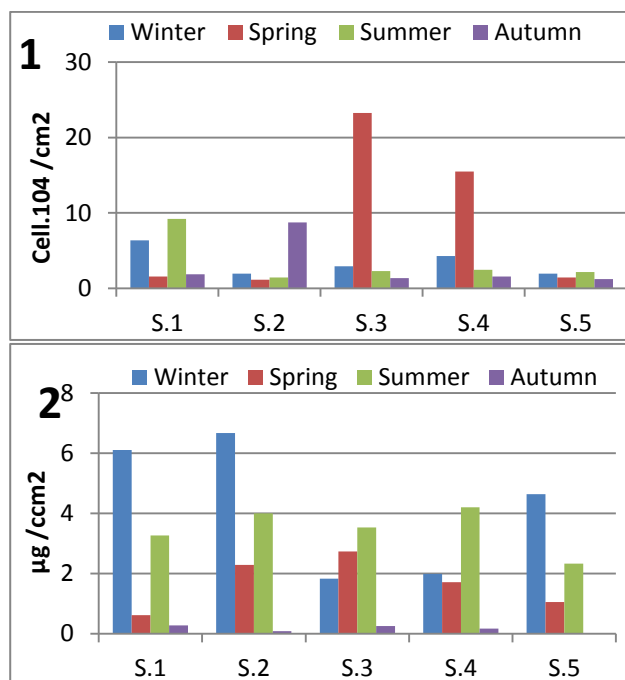
Figure 5. seasonal variations of the total number (1) and chlorophyll-a (2) of attached algae during the study period.

The results of this study show that the highest values of diversity by Shannon -Weaver was (3.65) bit/ind at Site 3in summer. These results of index attributed to the influence of environmental factors on the diversity of algae conjoined in this season. These environmental factors were temperature, light transmittance, and concentration of nutrients [25, 42]. The lowest value of the index was (1.70) in Site five during the autumn season and might be due to the effect of the pollution caused by human activities or environmental stress [47].

The CCA results show a positive and negative correlation between environmental parameters and pennate diatoms (Figures 6 and 7). The left side of the CCA map in figure 6 explained that some environmental parameters have a positive correlation with pennate diatoms such as both Cymbella cistula and with soil conductivity, while a negative correlation with air temperature, and sulphate (SO4). *Nitzschia* spp showed varying response to the environmental parameters; *N. palea* has a positive correlation with calcium, and negatively with total dissolved solids (TDS), total suspended solids (TSS), water flow (WF) and

conductivity (EC). *N. angustata* is positively with total hardness (TH) and negatively with both air temperature and pH, the same result with *Gomphonema lanceolatum. N. longissima* is negatively with air temperature and sulphate. The right side of Figure 6 Show both *N. lorenziana* and *N. duissipata* not affected by all studied environmental parameters. Navicula spp also show a different correlation; N. schroeteri and N. accumninatum are positive with total hardness and both total suspended solids and magnesium, respectively. Both species; N. bacillium and N. radiosa have a weak positive correlation with environmental parameters. N. gracilis has shown no correlation with all the studied parameters, the same with Gomphonema olivaceae. Cymbella affinis has a positive relationship with both total suspended solids and magnesium .

Centric diatoms have a different correlation with the studied parameters (figure 6/). Cyclotella comta and Aulacoseria vrians have no correlated with the studied environmental parameters. While Cyclotella ocellata, C. meneghiniana and Aulacoseria granulata have a positive correlation with water temperature (WT), TSS, pH-soil, total alkalinity (TA), and WF while Coscinodiscus lacustris and Stephaenodiscus hantzschii have negatively with these parameters .

The CCA results showed a positive and negative correlation between some species and environmental parameters (Figure 7). These species were Chroococcus limneticus and WF; Oscillatoria limnetica and calcium; Lyngbya aestuarii and chlorophyll-a; Lyngbya sp and pH; Nostoc sp and Anabaena sp with WT; Lyngbya perelgenus and total organic carbon (TOC); and Lyngbya limnetica and total phosphorus (TP). While other species (Merismopedia glauca, Spriulina major, Oscillatoria splendid, O. priceps, and O. tenuis show no correlation between them and the studied parameters. In the upper left part of Figure7 showed a positive relationship between some species (Tetraedron minimum, Coelastrum microporum and Pedistrum boryanum) and some parameters (calcium (ca), Chlorophyll-a (chlo), WF, EC, and EC-soil). Cosmarium spp (C.formosulum, C. subcostatum and C. sp.) have a correlation with TK, WF, and SO4 .

Conclusion:
There were no differences in the composition of attached algae between not lining and concrete lining stream, but there were quantitative differences between them. The diatom is the predominant group in the stream.
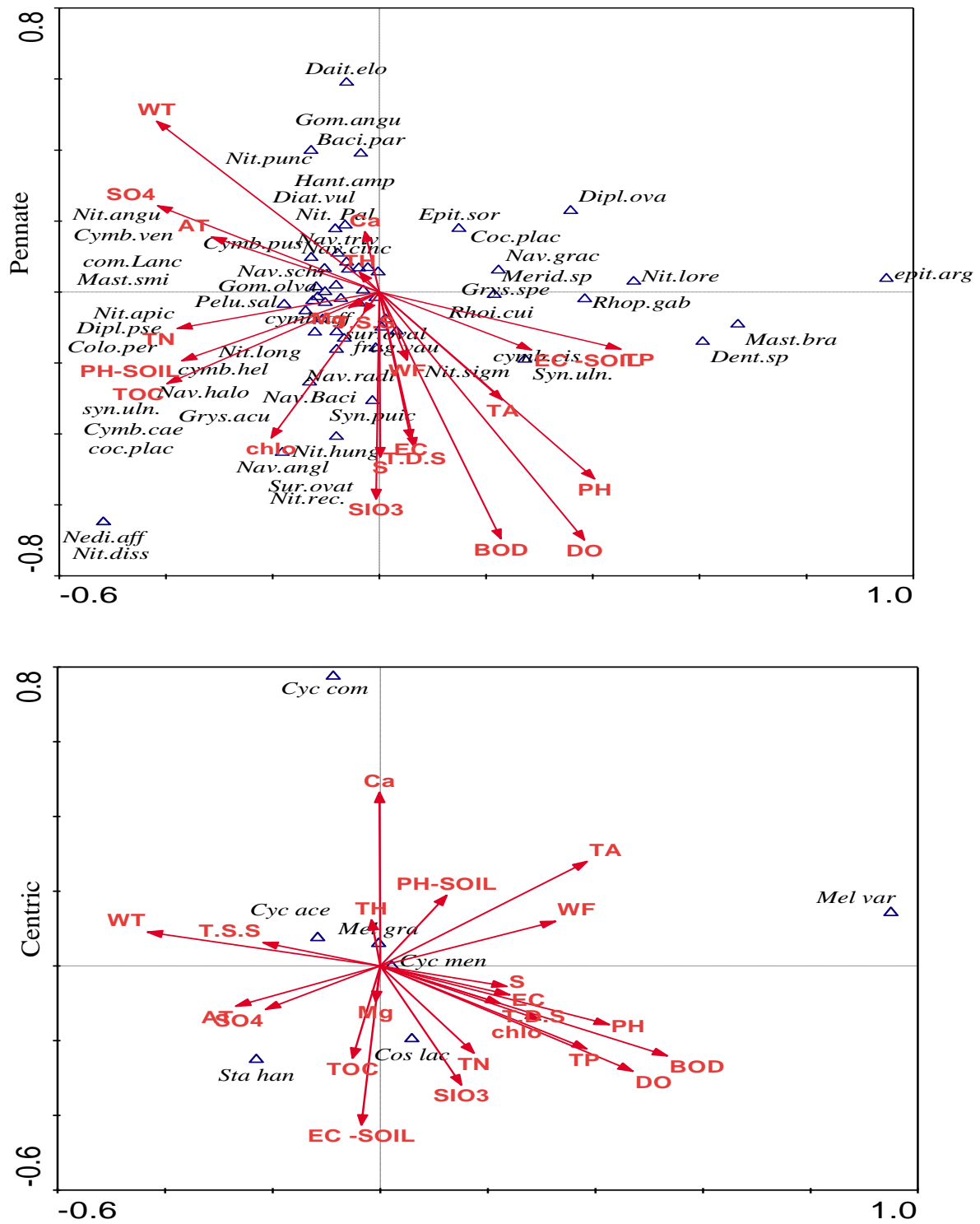
Figure 6. CCA of of environmental parameters and Bacillariophyceae (pennate and centric diatom) the abbreviation is noted in the text.
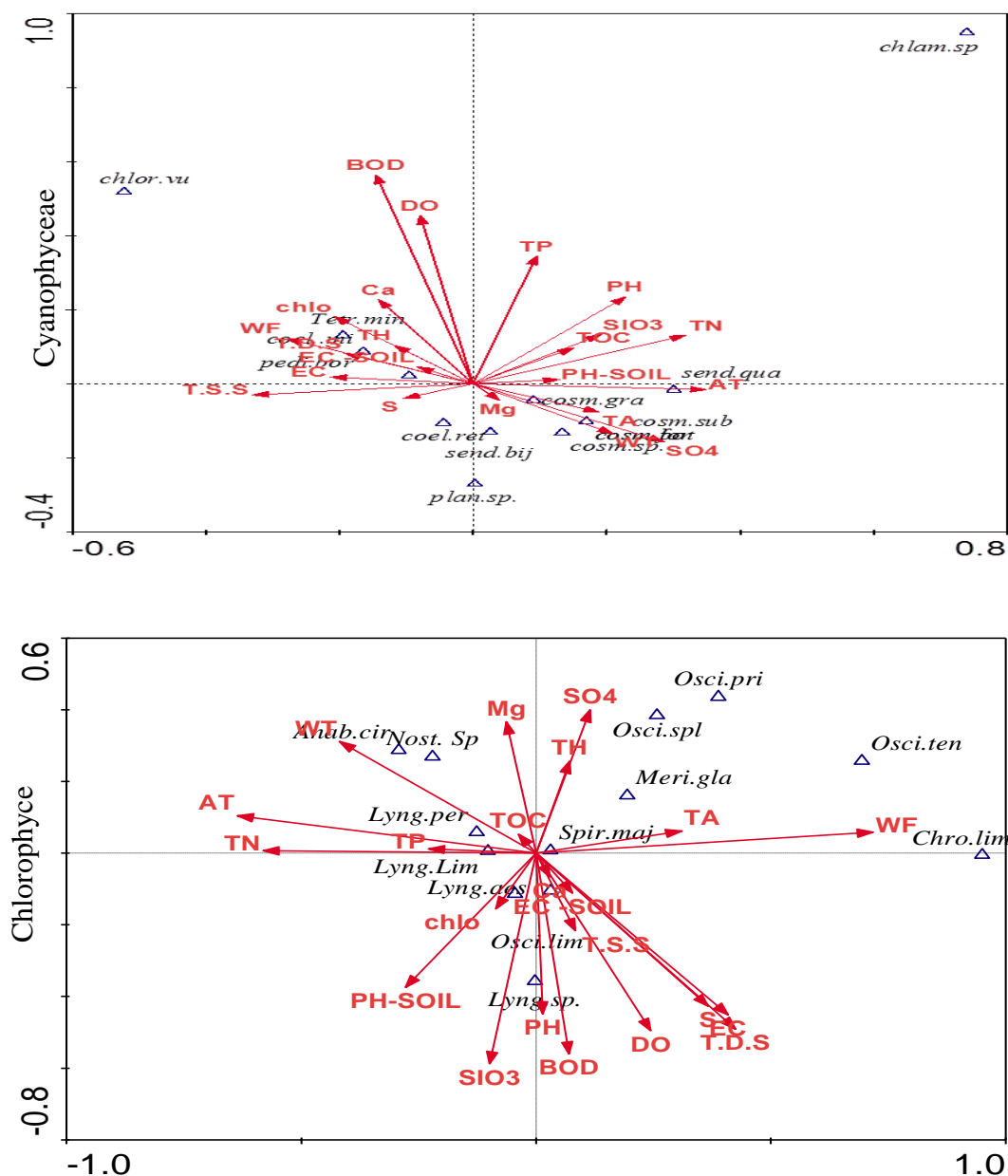
Figure 7. CCA of environmental parameters and both Cyanophyceae and Chlorophyceae. The abbreviation is noted in the text.

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التركيب المجتمعي الطحالب القاعية في نظام المياه الجارية ـ محافظة كربلاء – العراق

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الخلاصة :

تركز الدراسة على الطحالب القاعية (الطحالب الملتصقة على الطين وعلى الخرسانة الكونكريتية) في نهر بني حسن في محافظة كربلاء المقدسةـ العراق. حيث تم اجراء دراسات نوعية وكمية للطحالب القاعية عن طريق جمع 240 عينة من خمس مواقع في منطقة الدراسة للفترة من كانون الاول 2012 الى تشرين الثاني 2013. وتم فحص المتغيرات البيئية للنهر الزماني والمكاني. واظهرت النتائج ان النهر كان قاعديا وعسرا وقليلة الملوحة وذات تهوية جيدة. وبينت نتائج نسبة النتروجين الكلي الى الفسفور الكلي بان النتروجين محددا لنمو الطحالب. تم تشخيص 129 نوعا من الطحالب والتي تعود الى 57 جنسا. وكانت الدايتومات هو السائد (95 نوعا) وتلتها الطحالب الخضر (16 نوعا) ثم الطحالب الخضر المزرقة (14 نوعا) واليوغلينية (3 انواع) والبرواتية (نوعا واحدا). وقد سادت بعض الاجناس طيلة فترة الدراسة وهي: *Nitzschia* و *Navicula* و*Cymbella* و*Gomphonema* و*Surirella* و*Cocconeis* و *Aulacoseira* و *Oscillatoria*و*Lyngbya* و *Spirulina* و *Scenedesmus* . وسجل في موقع 3اكبر عدد للطحالب في ربيع 2013 وكان ادنى عدد في الموقع الخامس في خريف 2013. ان تركيز الكلوروفيل ـأ لايتطابق مع العدد الكلي للطحالب.

الكلمات المفتاحية: الطحالب القاعية، الطحالب الملتصقة على الطين، الانهر المبطنة بالكونكريت، البيئات المائية الجارية.