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Journal of Advanced Laboratory Research in Biology

We- together to save yourself society

e-ISSN 0976-7614

Volume 3, Issue 4, October 2012

Research Article

Algal Flora on some springs within Sherwan Mazn Subdistrict, Erbil–Kurdistan Region of Iraq, Iraq

Samiaa Jamil Abdulwahid*

Department of General Science, Faculty of Education, School of Basic Education, Soran University, Erbil, Iraqi Kurdistan Region, Iraq.

Abstract: This paper describes the first study of algal assemblages at 6 spring sites within Sherwan Mazn subdistrict between October 2011 to March 2012, with particular reference to abundance, distribution and periodicity were investigated in the samples collected. A total of 42 species was identified in 3 divisions, among them, 24 taxa was belonged of Bacillariophyta, 13 taxa was Chlorophyta and 5 taxa was Cyanophyta. The seasonality of algal flora was decreased at all springs in December and January. The dominant species among non-diatoms were, *Oscillatoria*, *Lyngbya*, *Tribonema*, *Vaucheria* and *Spirogyra* whereas among the diatoms were *Navicula*, *Syndra*, *Gomphonema*, and *Nitzschia*.

Keywords: Erbil, Sherwan Mazn, Algae, springs.

1. Introduction

Algal floras are a highly diverse group of organisms with important functions in aquatic habitats (1). It is the basic food for aquatic fauna and fish because they are the primary energy producers in aquatic ecosystems. Algal flora is an important indicator of water pollution and bloom in water bodies receiving agriculture waste, domestic water and household waste (2). Algae particularly diatoms are generally accepted as one of the most suitable bioindicators of aquatic ecosystem for water quality monitoring and organic pollution (3, 4). Specific algae grow in specific environments and therefore, their distribution pattern, periodicity and productivity are different, vary from water to water body. However, algal species, community structure, fine spatial distribution and biomass vary day to day, season to season as affected by environmental factor (5). Although, the composition of phytoplankton community has been changed little in the past 10 years especially, Cyanophyta because they are extremely very stress to environmental conditions (6).

In the Kurdistan region of Iraq, many studies have been conducted on algae in a different freshwater ecosystem. Hirano (7) was the first Phycologist to start a systematic study of the algae from this area and reported 120 species. Maulood and Hinton (8) mainly worked on algae; 86 species have been recorded but added 63 new species to the list of this region. Since last 6 decades, more than 2131 taxa of algae were recorded in Iraq as a whole (9). While the last checklist was made by Aziz (10). All most, all recorded taxa either in the Iraqi Kurdistan region as a whole or in Iraq; they represented 1341 and 350 algal flora in their checklists respectively. Moreover, he was added Glaucospira as a new species recorded to Iraqi flora.

All natural resources of water contain a range of inorganic and organic component. The first derived from rocks and soil through which water percolates or over which it flows, whereas the organic component derived from the breakdown of plant and animal materials or from algal or other microorganism growing in the water or on the sediments (11). However, the quality of groundwater depends on the geochemical composition of the strata through which it moves and the length of contact time (11).

In the Kurdistan region of Iraq, springs are occurring throughout the landscape and vary greatly in morphology and size. They play an important role in

*Corresponding author:
E-mail: samiaa.abdulwahid@gmail.com.

terms of public health, economic, commercial agriculture, tourism and human activities. Most rural areas of Kurdistan are using springs water for drinking, recovery from certain skin, allergies and other diseases, and hydropower electric generation, such as the fountains of Sheki Balakian, Bekhal etc.

The aim of this study was to investigate species of algal composition, abundance, distribution and periodicity. Finally, influence the biotic composition of landscape and water bodies.

1.1 Study Area

In this study, 6 sites to be sampled presented in Fig. 1, all sites are located in Sherwan Mazn has Mergasur district include villages and town, as Coordinates with latitude of 36° 37N and longitude of 44° 49E. It is situated 1008 meters above sea level, about 150 km northeast of Erbil city which located in the northeast of Iraq Kurdistan region. All geological formation in northern Iraq is a sedimentary origin with the rare exception of some rocks in the thrust zone; the zone consists of uppermost mountain areas along Irani and Turkish border. Sherwan Mazn is located in the mountain area like Shireen, Shana and Piran. The fold zone is characterized by symmetrical folds. The geology of the area varied from Bakhtiari, Paleocinous and Cretaceous, to recent sediment (12). The calcareous nature gives water an alkaline status (13). The oldest formation known outcrop in northern Iraq is Paleozoic Era age, deposited 500 to 250 million years ago in marine basins (14). Generally, the climate of Sherwan Mazn is similar to that of other parts of the Iraqi Kurdistan region characterized by hot, dry summer and cold winter more rainfall in northern than central and southern part While the average rainfall above 1237mm. Year and 1.5 meters of snow fall recorded during the winter in Sherwan Mazn (15). In the northern mountain region, maximum temperature recorded 41°C (13). People depended on agriculture activities income came from farming and foraging.

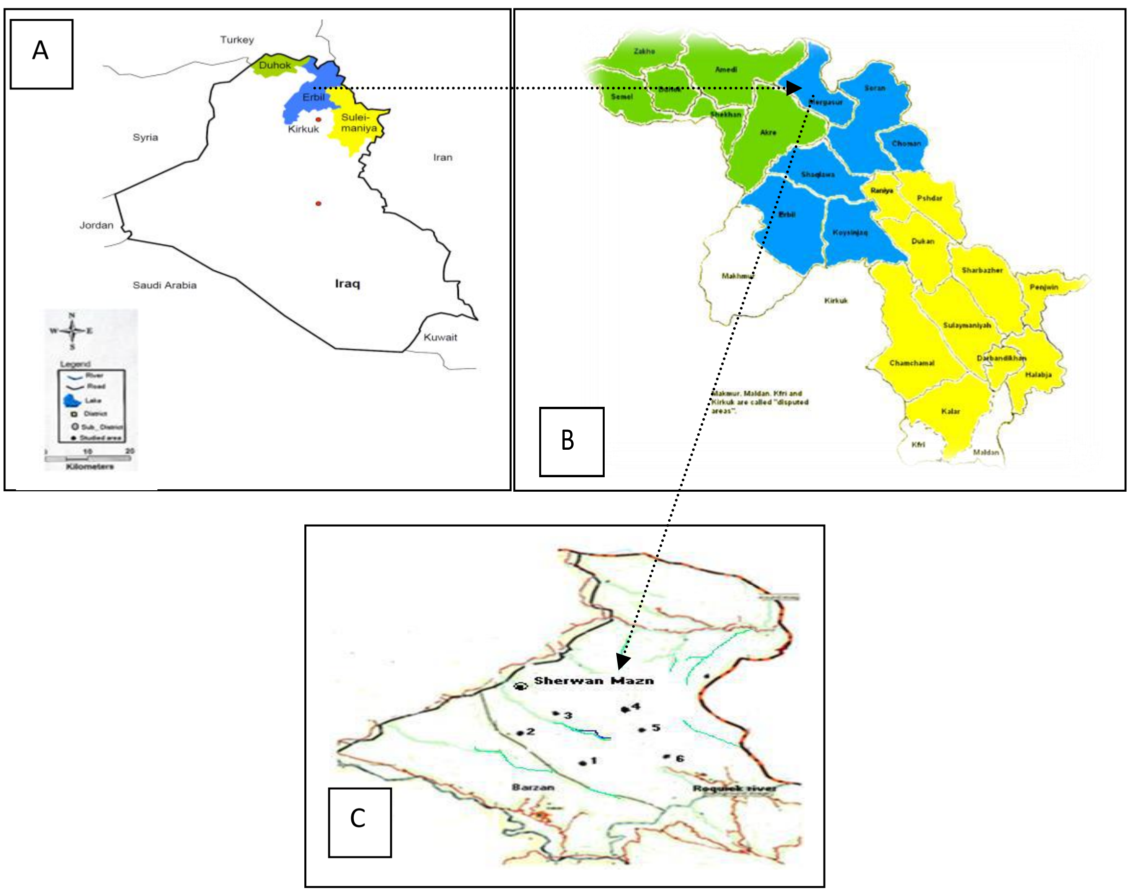

Fig. 1. Map of Iraq, Iraqi Kurdistan region and Erbil province showing the position of sample collection.

Table 1. Total number of algal species with their percentage % recorded during the studied period.

Division	Classes	Order	Families	Genera	Species	Percentage %
Cyanophyta	1	1	1	3	5	11.90
Heterokontophyta	2	7	9	13	24	57.14
Chlorophyta	4	5	5	7	13	30.96
Total	7	13	15	23	42	100

2. Materials and Methods

The algae samples were collected from springs once a month from October 2011 to March 2012. Algal flora stored initially in a glass 250ml size by a large mouth with water from the collecting sites, and then it was preserved by adding 3-4 drops of formalin solution 4-10% to 100ml as described by (16). The sample collection and preparation for laboratory analysis depended on (17). Sample of non-diatoms was collected and transferred into a dark glass bottle that preserved by Formaldehyde glacial acetic acid alcohol (FAA: 1:1:8). It is the most commonly used as standard preservation; samples are stored in dark condition (18). Identification of algae; flagellated forms of algae and some Cyanophyta were identified before algae fixation as soon as possible because of their loss of taxonomic characters. To the diatoms, most common method was applied in this study by (19). Preserved of algae were identified by using the references of (20, 21, 22, 23, 24, 25, 26, 27). Classification and arrangement of algal taxa were done according to (17). On the other hand, Water sample taken to determine the pH, EC and TDS was measured in the field, according to the method described in (28).

3. Results and Discussion

3.1 Environmental conditions

Some chemical characters of water sample: pH water of the Sherwan Mazn springs ranged from 6.85 to 8.30 with (mean 7.72). According, the spring water was slightly alkaline; this may be related to the soil and watershed characters of the mountain area. Realized that in the Iraqi Kurdistan region the water is alkaline, pH level were concerned with minimum discharge and maximum phytoplankton abundance, while the number of algal species increased with pH (29). In the present work, Electrical conductivity and Total dissolved solids were measured between 192 to 668µS $cm^{-1}$with (mean 427µS cm^{-1}) and 96 to 334mg l^{-1}, with (mean 212.6mg 1^{-1}) respectively. They are mainly depending upon the degree of mineralization, temperature, soil and geological formation (30).

3.2 Species composition

In the present study, a total 42 species belong to 23 genera and 3 divisions of algae were identified. The highest bulk of identifying algae was 24 species with 57.14% belonged Heterokontophyta (formerly known as Chrysophyta) dominated by Bacillariophyceae and Xanthophyceae. Chlorophyta was in the second-ranked by 13 species with 30.96% and then by Cyanophyta 5 species with 11.90%. The non-diatom algal species in (Table 2 and list 1) represented by 3 divisions, 6 classes, 8 order, 8 families, 12 genera and 20 species. The distribution of non-diatom algal species within studied sites was varied from 2 to 7 species, for the site 1 to 6 respectively. While the maximum number of 9 species was recorded on site 3 and the minimum number of 1 species were observed on site 5 (Table 3).

Table 2. Total number of non-diatom species with their percentage recorded during the studied period.

Genera	No. of species	Percentage%
Lyngbya	2	10
Oscillatoria	2	10
Spirulina	1	5
Tribonema	1	5
Vaucheria	1	10
Stigeoclonium	2	15
Cladophora	3	10
Rhizoclonium	1	5
Spirogyra	3	15
Closterium	2	10
Cosmarium	1	5
Chara	1	5
Total	20	100

List 1. The non-diatom algal species recorded during the studied period.

Division: Cyanophyta
Class: Cyanophyceae
Order: Oscillatoriales
Family: Oscillatoriacea
Lyngbya Agardh, (1892)
L. bipunctata Lemm.
L. nordgordhii Will
Oscillatoria Vaucher, (1892)
O. acuta Bruhl & Biswas, Orth. mut. Geitler
O. amphibia Ag. ex. Gomont
Spirulina Turpin and Gardner, (1827)
S. laxissima West, G.S.

Division: Heterokontophyta
Class: Xanthophyceae
Order: Tribonematales
Family: Tribonemataceae
Tribonema Derbes & Solier (1856).
T. minus (Will.) Hazen.

Order: Vaucheriales
Family: Vaucheriaceae
Vaucheria De Candolle, (1803).
V. compacta Collins.

Division: Chlorophyta
Class: Chlorophyceae
Order: Chaetophorales
Family: Chaetophoraceae
Stigeoclonium Kuetzing, (1843)
S. lubricum (Dill.) Kutz.
S. variabile (Naeg.) Islam

Class: Cladophoraphyceae
Order: Cladophorales
Family: Cladophoraceae

Cladophora Kuetzing, (1843)
C. glomerata (Kuetzing)
C. oligoctona
C. fracta Kuetzing
Rhizoclonium Kuetzing, (1843)
R. heiroglyphicum (Ag) Kuetz.

Class: Zygnematophyceae
Order: Zygnematales
Family: Zygnemataceae
Spirogyra Link, (1820)
S. daedaleoides Czurda
S. inflate (Vauch.) Dumortier
S. pratensis Transeau

Order: Desmidiales
Family: Desmidiaceae
Closterium Nitzsch, (1817)
C. lunula (O.F. Mull.) Nitzsch ex Ralfs
C. moniliferum (n. Migula, var., Andert, Abb)
Cosmarium Corda, (1834)
C. contractum Kirchn.

Class: Charophyceae
Order: Charales
Family: Characeae
Chara Vaillant, (1719)
C. excelisa Allen.

Table 3. The distribution of non-diatom algal species among studies sites during the studied period.

Non-diatom species	Sites					
	1	2	3	4	5	6
***Lyngbya* Agardh, (1892)**						
***L. bipunctata* Lemm.**	+	+				
***L. nordgordhii* Will**			+			
***Oscillatoria* Vaucher, (1892)**						
***O. acuta* Bruhl & Biswas, Orth. mut. Geitler**		+				
***O. amphibia* Ag. ex. Gomont**			+			
***Spirulina* Turpin and Gardner, (1827)**						
***S. laxissima* West, G.S.**	+					+
***Tribonema* Derbes & solier, (1856)**						
***T. minus* (will.) Hazen.**						+
***Vaucheria* De Candolle, (1803)**						
***V. compacta* Collins**					+	
***Stigeoclonium* Kuetzing, (1843)**						
***S. lubricum* (Dill.) Kutz.**						+
***S. variabile* (Naeg) Islam**						+
***Cladophora* Kuetzing, (1843)**						
***C. glomerata* (Kuetzing)**		+	+			
C. oligoctona				+		
***C. fracta* Kuetzing**				+		
***Rhizoclonium* Kuetzing, (1843)**						
***R. heiroglyphicum* (Ag) Kuetz.**		+				
***Spirogyra* Link, (1820)**						
***S. daedaleoides* Czurda**			+			
***S. inflate* (Vauch.) Dumortier**			+			+
***S. pratensis* Transeau**			+			+
***Closterium* Nitzsch, (1817)**						
***C. lunula* (O.F. Mull.) Nitzsch ex Ralfs**			+			
***C. moniliferum* (n. Migula, var., Andert, Abb)**		+				
***Cosmarium* Corda, (1834)**						
***C. contractum* Kirchn.**			+			+
***Chara* Vaillant, (1719)**						
***C. excelisa* Allen.**		+	+			
Total	**2**	**6**	**9**	**2**	**1**	**7**

Cyanophyta community assemblage was recorded by 5 species and 3 genera of 1 family, some species of Cyanophyta were recorded as *Lyngbya* restricted in distribution each in site 1, 2 and 3 because responded quickly to favorable environmental conditions (31). Cyanophyta more than any other algae tolerant to organic pollution because they are highly resistant to all sorts of ecological stresses and environmental hardships. When Cyanophyta occur in drinking water supplies and ability a serious health hazard to animals and human (32). The distribution of the *Oscillatoria* species during the studied period was in site 2 & 3. On the other hand, a single algal species like *Spirulina* during the studied period was found in site 6 *Spirulina* occurred in water containing high levels of carbon dioxide (5). However, *Spirulina* is not only used as a nutritive of fish or as a medicine but it is also used to remove heavy metals and bacteria in wastewater (33). Furthermore, *Tribonema* and *Vaucheria* both of them during the studied period were in site 6 and 5. They are common algae in spring habitat and they may indicate tolerant of cold water (34). *Chlorophyta* were represented by 7 genera and 13 species increase number of green algae was related to ecological condition. *Stigeoclonium* were observed on site 6, it is abundant in water with high levels of organic matter with responsible for cleaning water by removing nutrient. Moreover, the ability to grow in water polluted by heavy metals can be used as an indicator of Eutrophication (35, 36). *Closterium* & *Chara* exhibited higher sampling frequency in site 2, 3. It is emphasized; *Cosmarium*, *Closterium*, *Stigeoclonium* and *Chara* were found in hard and very hard water (37).

Table 4. The total number of diatom species with their percentage % recorded during the studied period.

Genera	No. of species	Percentage %
Melosira	1	4.5
Diatoma	1	4.5
Fragilaria	1	4.5
Syndra	2	9.09
Achnanthes	2	9.09
Cocconeis	2	9.09
Navicula	6	27.5
Amphora	1	4.5
Gomphonema	2	9.09
Hantzschia	1	4.5
Nitzschia	3	13.6
Total	22	100

3.3 Diatoms

It's clear from (list 2) that diatoms represented by 5 order 7 families and 11 genera. Also, it is clear from (Table 4) a total of 22 diatom algal taxa was identified. *Bacillariophyceae* was the dominant group because the members of *Bacillariophyceae* are sensitive to a wide range of limnological and environmental variables, and that their community structure may quickly respond to changes in the environmental condition. Algal community in most aquatic systems and diatoms have much to offer as freshwater bioindicators of aquatic ecosystem health, species like *Gomphonema* and *Navicula* are considered as pollution tolerant (38).

List 2. The diatom species recorded during the studied period.

Division: Heterokontophyta (Bacillariophyta)
Class: Bacillariophyceae
Order: Eupodiscales
Family: Coscinodiscaeae
Melosira Agardh, (1824)
M. granulata (Ehr) Ralf.

Order: Fragilariales
Family: Fragilariaceae
Subfamily: Diatomoideae
Diatoma de Cand, (1805)
D. elongatum (lyngb.) Heib.

Subfamily: Fragilliodeae
Fragilaria Lyngb., (1819)
F. crotenesis Kitton.
Synedra Ehrenberg, (1832)
S. acus Kuetz.
S. ulna (Nitzsch.) Ehr

Order: Achnanthales
Family: Achnanthaceae
Subfamily: Achnathiodeae
Achnanthes Bory, (1832).
A. microcephala (Kutzing) Grun.
A. minutissima Kutz var. affinis.

Subfamily: Cocconeioideae
Cocconeis Ehrenberg, (1838)
C. placentula Ehr
C. pediculus Ehr

Order: Naviculales
Family: Naviculaceae
Navicula Bory, (1824)
N. cohnii (Hills) Lange-Bertalot
N. cryptocephala Kutzing
N. gregaria Donkin
N. placentula (Ehr) Kutzing.
N. radiosa (Kutzing)
N. saxophila Bock

Family: Cymbellaceae
Amphora Ehrenberg, (1840)
A. ovalis Kuetz.

Family: Gomphonemaceae
Gomphonema Ehrenberg, (1831)
G. pumilum (Grunow) Reichard & Lange
G. tergestium Fricke

Order: Bacillariales
Family: Nitzchiaceae
Hantzschia Grunow, (1877)
H. amphioxys var. major Grun.
Nitzschia Hass., (1845)
N. linearis W. Smith
N. palea (Kuetz.) W. Smith
N. subtubicola Grun.

Table 5. The distribution of diatom species among studies sites during the studied period.

Diatom species	**Sites**					
	1	2	3	4	5	6
***Melosira* Agardh, (1824)**						
***M. granulata* (Ehr) Ralf.**	+	+	+	+	+	
***Diatoma* de Cand, (1805)**						
***D. elongatum* (lyngb.) Heib.**		+				
***Fragilaria* Lyngb., (1819)**						
***F. crotenesis* Kitton.**	+			+		
***Synedra* Ehrenberg, (1832)**						
***S. acus* Kuetz.**			+	+	+	
***S. ulna* (Nitzsch.) Ehr**				+		
***Achnanthes* Bory, (1832).**						
***A. microcephala* (Kutzing) Grun.**				+		+
***A. minutissima* Kutz var. affinis.**			+			
***Cocconeis* Ehrenberg, (1838)**						
***C. placentula* Ehr**	+					+
***C. pediculus* Ehr.**				+		
***Navicula* Bory, (1824)**						
***N. cohnii* (Hills) Lange-Bertalot**					+	
***N. cryptocephala* Kutzing**	+					
***N. gregaria* Donkin**			+			
***N. placentula* (Ehr) Kutzing.**			+			
***N. radiosa* (Kutzing)**				+		+
***N. saxophila* Bock**			+			
***Amphora* Ehrenberg, (1840)**						
***A. ovalis* Kuetz.**				+		
***Gomphonema* Ehrenberg, (1831)**						
***G. pumilum* (Grunow) Reichard & Lange**			+	+	+	
***G. tergestium* Fricke**			+			
***Hantzschia* Grunow, (1877)**						
***H. amphioxys* var. major Grun.**				+	+	
***Nitzschia* Hass., (1845)**						
***N. linearis* W. Smith**			+			
***N. palea* (Kuetz.) W. Smith**			+	+		
***N. subtubicola* Grun.**					+	
	4	2	10	11	6	3

Table 6. The monthly distribution of non-diatom algal species recorded during the studied period.

Non diatom species	Months					
	Oct	Nov	Dec	Jan	Feb	Mar
***Lyngbya* Agardh, (1892)**						
***L. bipunctata* Lemm.**			+			+
***L. nordgordhii* Will**	+	+		+		+
***Oscillatoria* Vaucher, (1892)**						
***O. acuta* Bruhl & Biswas, Orth, mut. Geitler**	+					+
***O. amphibia* Ag. ex. Gomont**	+	+		+		
***Spirulina* Turpin and Gardner, (1827)**						
***S. laxissima* West, G.S.**					+	+
***Tribonema* Derbes & solier, (1856)**						
***T. minus* (will.) Hazen.**			+		+	
***Vaucheria* De Candolle, (1803)**						
***V. compacta* Collins**	+			+	+	+
***Stigeoclonium* Kuetzing, (1843)**						
***S. lubricum* (Dill.) Kuetz.**		+				+
***S. variable* (Naeg) Islam**		+				
***Cladophora* Kuetzing, (1843)**						
***C. glomerata* (Kuetzing)**	+	+	+	+	+	+
C. oligoctona	+	+	+	+		+
***C. fracta* Kuetzing**						
***Rhizoclonium* Kuetzing, (1843)**						

***R. heiroglyphicum* (Ag) Kuetz.**		+			+	+
***Spirogyra* Link, (1820)**						
***S. daedaleoides* Czurda**	+	+	+	+		+
***S. inflate* (Vauch.) Dumortier**	+				+	+
***S. pratensis* Transeau**	+				+	
***Closterium* Nitzsch, (1817)**						
***C. lunula* (O.F. Mull.) Nitzsch ex Ralfs**	+	+				+
***C. moniliferum* (n. Migula, var., Andert, Abb)**	+	+				
***Cosmarium* Corda, (1834)**						
***C. contractum* Kirchn.**	+				+	+
***Chara* Vaillant, (1719)**						
***C. excelisa* Allen.**	+	+	+	+	+	+
Total	13	11	6	7	9	14

Table 7. The monthly distribution of diatom algal species recorded during the studied period.

Diatom species	**Months**					
	Oct	Nov	Dec	Jan	Feb	Mar
***Melosira* Agardh, (1824)**						
***M. granulata* (Ehr) Ralf.**	+	+	+	+	+	+
***Diatoma* de Cand, (1805)**						
***D. elongatum* (lyngb.) Heib.**	+	+		+	+	+
***Fragilaria* Lyngb., (1819)**						
***F. crotenesis* Kitton.**	+	+		+		+
***Synedra* Ehrenberg, (1832)**						
***S. acus* Kuetz.**	+	+	+	+	+	+
***S. ulna* (Nitzsch.) Ehr**	+	+			+	
***Achnanthes* Bory, (1832).**						
***A. microcephala* (Kutzing) Grun.**	+					+
***A. minutissima* Kutz var. affinis.**		+		+	+	
***Cocconeis* Ehrenberg, (1838)**						
***C. placentula* Ehr**		+		+		
***C. pediculus* Ehr.**			+			+
***Navicula* Bory, (1824)**						
***N. cohnii* (Hills) Lange-Bertalot**	+	+		+		+
***N. cryptocephala* Kutzing**	+		+	+	+	+
***N. gregaria* Donkin**	+	+				
***N. placentula* (Ehr) Kutzing.**	+		+			
***N. radiosa* (Kutzing)**	+			+		
***N. saxophila* Bock**			+		+	+
***Amphora* Ehrenberg, (1840)**						
***A. ovalis* Kuetz.**	+					+
***Gomphonema* Ehrenberg, (1831)**						
***G. pumilum* (Grunow) Reichard & Lange**	+	+	+		+	+
***G. tergestium* Fricke**						+
***Hantzschia* Grunow, (1877)**						
***H. amphioxys* var. major Grun.**	+				+	+
***Nitzschia* Hass., (1845)**						
***N. linearis* W. Smith**	+	+	+			+
***N. palea* (Kuetz.) W. Smith**	+	+			+	+
***N. subtubicola* Grun.**	+				+	
Total	17	12	8	9	11	15

During the study period, the spatial variation of diatom species presentation in all spring sites were ranged between 2 to 11 the minimum and maximum number of species were observed on site 2 and 4 respectively. It is clear from (Table 5). In the present study, *Navicula* were recorded as dominant and most common with 6 species the *Nitzschia* was with 3 species, while *Navicula*, *Nitzschia* and *Gomphonema* are typically most common species from the region with calcareous hydrogeochemistry and higher nutrient concentration (35). *Syndra*, *Achnanthes*, *Cocconeis* and *Gomphonema* were each with 2 species. The species

Achnanthes was common in water characterized by low levels of pH (39). In addition, *Cocconeis* require large concentration of inorganic nutrient (40). *Gomphonema* it is well known indicates deteriorates of water quality (41). *Melosira*, *Diatoma*, *Fragilaria*, *Amphora* and *Hantzschia* was each with 1 species. However**,** the *Melosira* diatom that came from filamentous aggregation with filamentous green alga *Cladophora* attached of floating mats (42). While the species *Amphora* and *Cocconeis* were common in calcareous and slightly alkaline water (43).

Finally, the monthly variation of non-diatom and diatom algal flora presented in Table 6 and 7. Algal community decrease at all stations in December and January. Despite it is known that during winter, low algal growth is due to low irradiance and low water temperature (31). Generally, algal densities were increased in spring and summer while algal number decreased in autumn and winter (44).

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