Qualitative and quantitative study of algae in three drinking water plants supply springs in Sulaymaniyah province - Kurdistan region of Iraq

Bashar T. I. AL-Shandah[1] , Riadh Abas Abd Al-Jabar[1] , Trifa K. J. Farkha[2]
[1] *Department of Biology, College of Science, University of Tikrit , Tikrit , Iraq*
[2] *Department of Biology, College of Science, University of Sulaymaniyah , Sulaymaniyah , Iraq*

Abstract
In this study, three drinking water treatment plant supply springs were selected within different sites in Sulaymaniyah province- Kurdistan region of Iraq. Samples were collected over period of eight months from May to the end of December 2015.
Five stations were selected, Stations 1, 2 and 3 were located at Bestan Sowr drinking water project in Sharazur district, station 4 was located at Saray Subhan Agha drinking water project in Said sadiq district and station 5 was located at Khurmal drinking water project in Khurmal district within Halabja district.
The study involved a qualitative (identification) and quantitative (Density and Total count) study of phytoplankton in water for selected stations.
A total of 155 algal species were identified belong to 9 classes in all studied stations, 80 species belonged to Bacillariophyceae (diatoms), 35 species to chlorophyceae, 30 species to Cyanophyceae, 3 species to Euglenophyceae, 2 species for each of Crptophyceae and Pyrophyceae and 1 species for each of Chrysophyceae, Dinophyceae and Xanthophyceae. Diatoms were dominated (according to the total count of taxa) over all other phytoplankton in all sites, Chlorophyceae formed the second most algal group at the selected sites and Cyanophyceae formed the third most algal group of phytoplankton at the selected sites.
The results of phytoplankton quantitative study in the studying stations recorded the highest total density of phytoplankton during the study period was at Station1 (18377.28 ind×10^3/l), followed by (12513.34 ind×10^3/l) at Station 2 and (4779.45 ind×10^3/l) at Station 3. The results of total Count of phytoplankton at all stations ranged between 5913×10^3 cell/l and 29×10^3 cell/l.

1. Introduction
Algae most commonly occur in water, be it fresh water, marine, or brackish. However, they can also be found in almost every other environment on earth, from the algae growing in the snow of some American mountains to algae living in lichen associations on bare rocks, to unicellular algae in desert soils, to algae living in hot springs. In most habitats they function as the primary producers in the food chain, producing organic material from sun light, carbon dioxide, and water [1].
Algae are made up of two broad groups. Macrophytes are large and are often attached to rocks and other surfaces and can be seen with the unaided eye. Phytoplankton, which are suspended in the water column, usually require a microscope for individual organisms to be seen, unless present in large quantities [2].
Microalgae are unicellular micro-organisms. Microalgae are categorized as prokaryotes and eukaryotes. Organelles are the major difference between prokaryotes and eukaryotes. Prokaryotes do not possess chloroplast, mitochondria and nuclei but they contain chlorophyll a and high protein contents. Microalgae are further divided into different groups based on their taxonomy, including blue-green, green, yellow-green, red, brown, and golden algae. There are more than 50,000 species of microalgae [3].

2. Materials and Methods
2.1 Studying Area
Five stations were selected for the study, all outside the city of Sulaymaniyah center. Three of these in a Bestan Sowr drinking water project within Sharazur district, the fourth station lie in Saray Subhan Agha drinking water project in Said Sadiq district, and the fifth station in Khurmal drinking water project (Figure 1).

Figure 1: Location of the Studied Sites (Google earth, 2015)

2.2 Studying stations

First station:

The sample of water in this station was taken from the beginning of the assembly basin at Bestan Sowr drinking water project.

Second station:

The sample of water in this station was taken from the mid of the assembly basin at Bestan Sowr drinking water project.

Third station:

The sample of water in this station was taken from the end of the assembly basin at Bestan Sowr drinking water project.

Forth station:

The sample of water in this station was taken from the assembly basin at Saray Subhan Agha drinking water project.

Fifth station:

The sample of water in this station was taken from the assembly basin at khurmal drinking water project.

2.3 Qualitative analysis (Algal identification)

Non-diatomic algae were identified by preparing slides and examined under 40 xs by using a compound microscope depending on the following references which were used for identification of non-diatomic algae [4-7.

While diatoms were identified after dissolving the organic matter by using nitric acid and examined under 100 xs depending on [8] and [9].

2.4 Quantitative analysis

Total number count of phytoplankton was performed by using the sedimentation method [10] (Figure 2).

One liter of each sample taken was put in graduated cylinder (1000ml), samples were preserved by adding drops of Lugol's solution and left in stand place, after seven days, 900 ml were sucked by siphon method. The rest was transported to another cylinder (100 ml) and left at the same method to seven days, after that 90 ml was withdrawn and the rest (10ml) put in covered glass container and adding two drops of Lugol's solution.

Figure 2: Sedimentation Method

Non diatomic phytoplankton was measured by using haemocytometer, 1ml of concentrate was put on the slide chamber and covered with cover slide then non diatoms identified and enumerated under microscope, the results expressed as individual per Liter (ind/l).

For diatomic algae, a clean slide was left on a hot plate at 75-80°C and a 1ml of the preserved concentrated sample was put in the middle of the slide and dried, then a drop of concentrated Nitric acid was put on the dried drop and after evaporation of the acid drop, Canada Balsam was placed on a cover slide and put on the dried sample and pressed to remove any air bubbles [10].

The calculation was done by the equations have been mentioned by [11].

Lugol's solution prepared by dissolving 10g pure iodine in distilled water, then 20g potassium iodide was added then the volume completed to 200 ml distilled water containing 20 ml glacial acetic acid and kept in a dark glass bottle [12].

2.5 Statistical Analysis

The results of this study were analyzed statistically using analysis of variance test (F test), and has been compared the means by a polynomial Duncan test in level of 0.05.

3. Results and Discussion

3.1 Qualitative study of phytoplankton

A total of 155 algal taxa (Appendix 1) were identified belong to 9 classes in all studied stations, 80 taxa belonged to Bacillariophyceae (diatoms), 35 taxa to chlorophyceae, 30 taxa to Cyanophyceae, 3 taxa to Euglenophyceae, 2 taxa for each of Crptophyceae and Pyrophyceae and 1 taxa for each of Chrysophyceae, Dinophyceae and Xanthophyceae.

As noted in the appendces 2, 3, 4, 5, and 6, and Figures 3, 4, 5, 6 and 7, Diatoms were dominated (according to the total count of taxa) over all other phytoplankton in all sites. Bacillariophyceae or diatom group remained dominant in most stations during winter in the present investigation which could be attributed to the fact that they are able to grow under the condition of weak light and low temperature which are less suitable for other algae and low concentration of nutrients (NO_3-N and PO_4-P) in the winter [13]. In diatom, the pennales diatom was abundant over the centrals, figures below show the dominance of diatoms in all studied stations.

The most abundant species of Bacillariophyceae which identified in all studied stations and most periods of study were (Centrales): Cyclotella ocellata, (Pannales): *Achnanthes minutissima, Cocconeis pediculus, Cocconeis placentula var. euglypta, Cymbella microcephala, Fragilaria ulna, Navicula cryptocephala,* these species were recorded to be the most dominant species amongst the

ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

bacillariophyceae, in addition to the clear dominant for some species of Bacillariophyceae in certain stations such as *Navicula riediana* was dominant in station 5.

Chlorophyceae (35 species) formed the second most algal group at the selected sites, The most abundant species of Chlorophyceae which identified in most studied stations and in most periods of study were: *Ankistrodesmus falcatus, Chlorella vulgaris, Oedogonium sp., Pediastrum boryanum,* Scenedesmus biguga, *Scenedesmus quadricauda.* Amongst chlorophyceae, Oedogonium sp. was found to be the most dominant species at all stations, in addition to Desmodesmus itascaensis were dominant in stations 2 and 3, *Desmodesmus lunatus* in stations 1, 2 and 3, *Ulothrix zonata* in stations 1 and 4.

Cyanophyceae (30 species) formed the third most algal group of phytoplankton at the selected sites, the most abundant species of Cyanophyceae which identified in most studied stations and in most periods of study were: *Chroococcus disperses, Oscillatoria limnetica, Oscillatoria tenuis*. Amongst Cyanophyceae, *Oscillatoria tenuis* was found to be the most dominant species at all stations, in addition to *Calothrix fusca* were dominant in station 4 and *Chroococcus turgidus* in station 1.

Same results were Observed in many research in Iraqi and Kurdistan region such as[14,15,11] in Dukan lake, [16] in Duhok lake, [17,18] in Baghdad, [19,20] in Sarchnar spring and Chaq-Chaq stream in Sulaymaniyah Province.

[21] reported that the great similarity between species in the studied sites belonging to the same source of water which provides these sites.

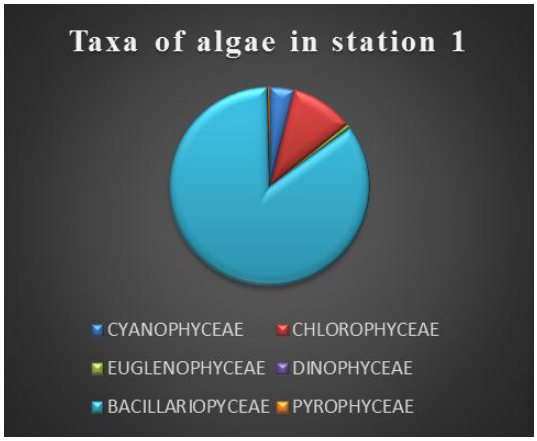

Figure 3: Taxa of algae in station 1

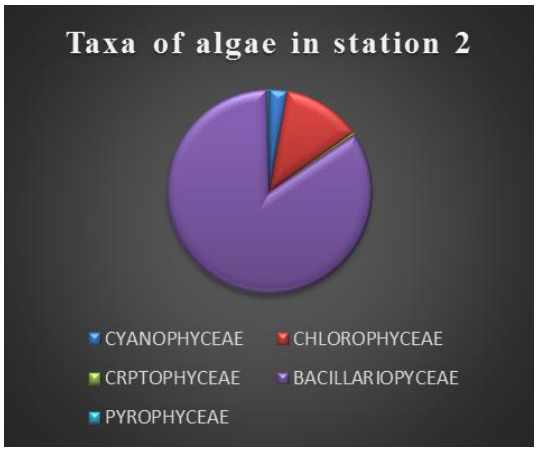

Figure 4: Taxa of algae in station 2

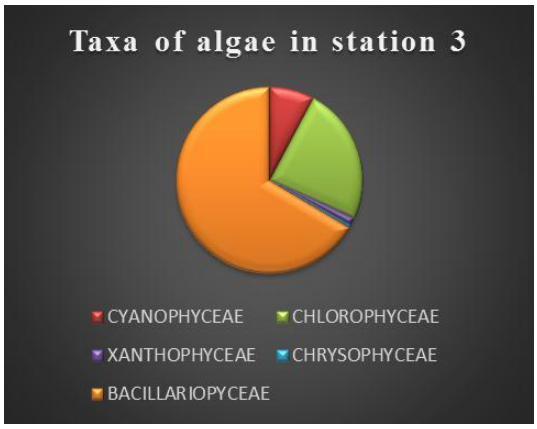

Figure 5: Taxa of algae in station 3

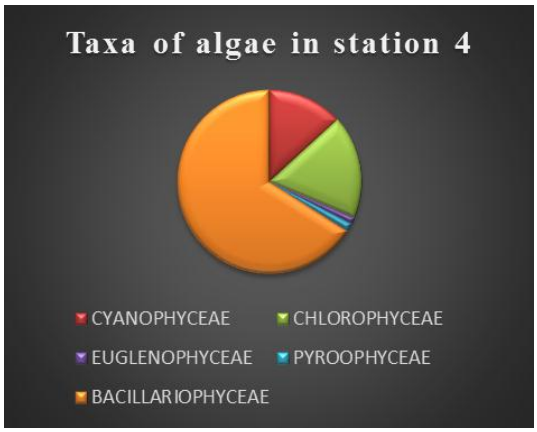

Figure 6: Taxa of algae in station 4

ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

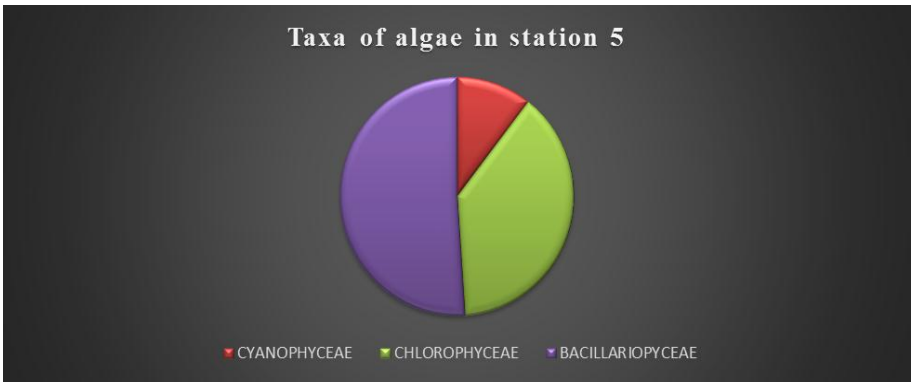

Figure 7: Taxa of algae in station 5

3.2 Quantitative study of phytoplankton (Density and Total count)

The results of phytoplankton quantitative study in the studying stations recorded the highest total density of phytoplankton during the study period was at Station1 (18377.28 ind×10^3/l), followed by (12513.34 ind×10^3/l) at Station 2 and (4779.45 ind×10^3/l) at Station 3. The lowest total density was recorded at Station 5 which was (2834.43 ind×10^3/l) as shown in Appendix (1) and Figure (8). This variation of phytoplankton density and total count between the sites may be due to the differences of the environmental factors at those sites such as light penetration, temperature, nutrient enrichment, toxic substances, mixing of water, parasites, herbivores and heterotrophic microorganism activities influenced the phytoplankton growth [22] and [23], as well as there are several other factors that may be helped in the formation of these differences in density of phytoplankton between stations 1, 2 and 3 (located in the assembly basin at Bestan Sowr drinking water project) Which ones the third station is located under the shade of trees, consequently, the place of sampling for third station exposure to direct sunlight slightly compared with a first and second station, in addition to the third station exposed to concentrations of chlorine which is pumped into the assembly basin for the purpose of reducing the concentration of algae as one of the methods used by those working in the project, as well as the lack of depth of the water in the first station which allowed to sunlight from reaching the bottom of the basin, all of these reasons could explain this difference in the density of phytoplankton in the studying stations.

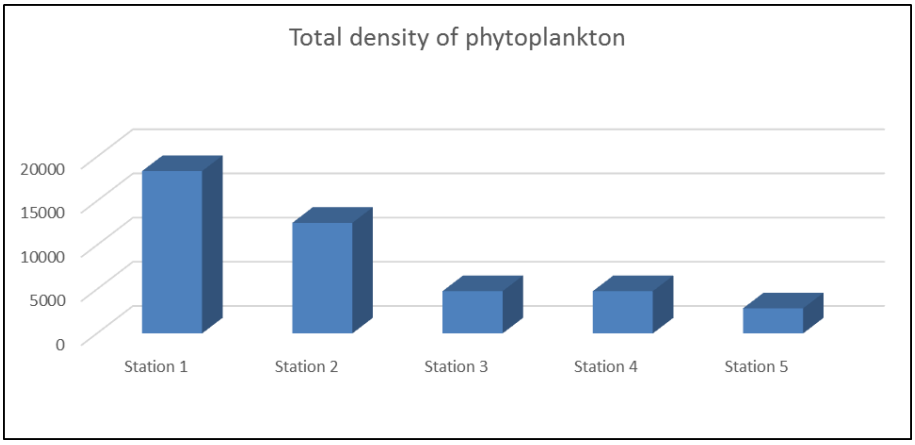

Figure 8: Total density of phytoplankton in studied stations

Generally and regardless of the type of algae the results of total Count of microalgae at all stations ranged between 5913×10^3cell/l and 29×10^3 cell/l. The highest number of total Count of phytoplankton 5913×10^3cell/l was recorded at station 1 during September and the lowest number 29×10^3 cell/l was recorded at stations 5 during December (Figure 9).

ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

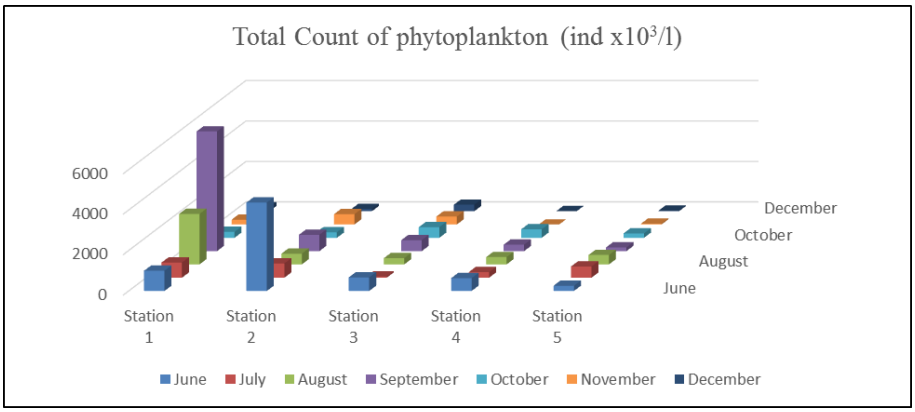

Figure 9: Total Count of phytoplankton in studied stations

As previously noted, and depending on the total count of phytoplankton, the Bacillariophyta (Diatoms) were dominated over all other phytoplankton in all stations, followed by Chlorophyceae (Green algae) and Cyanophyceae (Blue green algae) followed by other types of algae the number of their cells a few (as shown in the appendces 2, 3, 4, 5, and 6). The first station has recorded total count of phytoplankton (9205.1×10^3, 1120.1×10^3 and 432.1×10^3) for Bacillariophyceae, Chlorophyceae and Cyanophyceae Respectively, station 2 has recorded total count of phytoplankton (6138.3×10^3, 907.1×10^3 and 204.6×10^3) for Bacillariophyceae, Chlorophyceae and Cyanophyceae Respectively, station 3 has recorded total count of phytoplankton (1871.3×10^3, 672.3×10^3 and 219.3×10^3) for Bacillariophyceae, Chlorophyceae and Cyanophyceae Respectively, station 4 has recorded total count of phytoplankton (1318.6×10^3, 360.9×10^3 and 264.4×10^3) for Bacillariophyceae, Chlorophyceae and Cyanophyceae Respectively, station 5 has recorded total count of phytoplankton (884.5×10^3, 667.5×10^3 and 180.5×10^3) for Bacillariophyceae, Chlorophyceae and Cyanophyceae Respectively.

Figure (9) showed that the total count of phytoplankton recorded a rise in the number of phytoplankton during the summer, especially in the months of August and September in most of the stations, as well as the lower numbers of phytoplankton showed at the end of summer and the beginning of autumn and the decline of their numbers during the winter these results agree with many of the research and studies on the phytoplankton in freshwater, however, mainly seasonal changes regulated pattern of phytoplankton growth. Studies reported that the summer is the most suitable season for the growth of phytoplankton in freshwater bodies because of long duration of sunshine period, increased salinity and trophotropic activities and therefore increased phosphorus and nitrate concentration [24]. Conversely, in late summer, autumn and winter the production of phytoplankton reduced because of heavy rainfall, high turbidity, reduced salinity, temperature, overcast skies and low nutrient concentration along with consumption of phytoplankton by zooplankton [25].

This variation of phytoplankton total count between the sites may be due to the differences of the environmental factors at those sites, which related to the geological formation in this sites [14]. Phytoplankton distribution majorly forced by factors such as seasonal fluctuations in water body. Factors such as seasonality, period of sunshine, wind patterns, depth of water, temperature, pH, turbidity, dissolved oxygen, nutrient enrichment like dissolved chloride, phosphate Nitrogen and organic carbon ultimately influenced the occurance phytoplankton in the freshwater body [26]. Total quantity of phytoplankton was determined as a good indicator to know the water quality and types of nutrients which present in it [26]. This study revealed that the water quality parameters such as temperature, pH, nitrate and phosphate play a very important role in altering the Quantity phytoplankton.

Appendix (1): List of phytoplankton identified in the studying stations. (A) = Density (ind ×10^3/l), (B) = Density percentage (%), (C) = Number of frequency, - = absence.

Stations / Taxa	Station one			Station two			Station three			Station four			Station five		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
CYANOPHYCEAE (Total)	**483.76**	**3.31**		**350.67**	**2.77**		**331.45**	**6.82**		**453.17**	**13.17**		**309.88**	**10.28**	
Anabaena sp.	22.11	0.11	1	44.22	0.35	1	-	-	-	-	-	-	-	-	-
Aphanocapsa sp.	22.11	0.11	1	21.42	0.17	1	-	-	-	-	-	-	-	-	-
Calothrix fusca Bornet & Flahault	-	-	-	-	-	-	-	-	-	121.52	3.54	3	-	-	-
Chamaesiphon sp.	44.22	0.23	2	-	-	-	-	-	-	22.11	0.64	1	22.11	0.73	1
Chroococcus sp.	-	-	-	-	-	-	44.22	0.91	1	-	-	-	-	-	-
C. dispersus	22.11	0.11	1	22.11	0.17	1	22.11	0.45	1	22.11	0.64	1	-	-	-
C. limneticus Lemm.	-	-	-	-	-	-	22.11	0.45	1	-	-	-	-	-	-
C. perelegans	22.11	0.11	1	42.85	0.34	1	-	-	-	-	-	-	-	-	-
C. turgidus (Kützing) Nägeli	16.02	0.88	5	-	-	-	-	-	-	44.22	1.29	2	-	-	-
Gloeocapsa sp.	-	-	-	-	-	-	-	-	-	-	-	-	22.11	0.73	1
Gloeotrichia sp.	-	-	-	-	-	-	-	-	-	-	-	-	22.11	0.73	1
Lyngbya limnetica Lemm.	-	-	-	-	-	-	-	-	-	44.22	1.29	2	66.33	2.21	2
Merismopedia gluca (Ehr.) Naeg.	22.11	0.11	1	-	-	-	-	-	-	-	-	-	22.11	0.73	1
Merismopedia tenuissima	-	-	-	-	-	-	44.22	0.91	1	-	-	-	-	-	-
Microcystis sp.	-	-	-	-	-	-	-	-	-	-	-	-	22.11	0.73	1
M. aeruginosa Kutz.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nostoc sp.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
Oscillatoria amphibia Ag.	44.22	0.23	2	-	-	-	-	-	-	-	-	-	-	-	-
O. amona	-	-	-	-	-	-	110.35	2.29	1	22.11	0.64	1	-	-	-
O. chalybea Mertens.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
O. limnetica Lemm.	180.31	0.96	5	42.85	0.34	1	22.11	0.45	1	-	-	-	22.11	0.73	1
O. minima Gick.	-	-	-	-	-	-	-	-		22.11	0.64	1	66.67	2.22	1
O. minus	-	-	-	-	-	-	44.22	0.91	1	-	-	-	-	-	-
O. protus	44.22	0.23	2	-	-	-				44.22	1.29	1	-	-	-
O. sancta (Kutz.) Gomont.	-	-	-	-	-	-	22.11	0.45	1	-	-	-	-	-	-
O. splendida Grev.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
O. tenuis Ag.	44.22	0.23	2	22.11	0.17	1				22.11	0.64	1	44.22	1.47	2
Phormidium sp.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
Spirulina sp.	-	-	-	88.44	0.7	1	-	-	-	-	-	-	-	-	-
S. major Kutz.	-	-	-	66.67	0.53	1	-	-	-	-	-	-	-	-	-
CHLOROPHYCEAE (Total)	**1919.81**	**10.21**		**1554.73**	**12.36**		**1152.28**	**21.63**		**618.55**	**18.03**		**1033.5**	**34.38**	
Actinastrum sp.													44.22	1.47	1
Ankistrodesmus falcatus (Corda.) Ralfs	88.44	0.47	2				71.81	1.48	2	21.42	0.64	1	-	-	-
Botryococcus braunii Kutz.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chladophora sp.	22.11	0.11	1	-	-	-	-	-	-	22.11	0.64	1	-	-	-
C. fracta	66.33	0.35	3	-	-	-	-	-	-	-	-	-	-	-	-
Chlamydomonas sp.	-	-	-	-	-	-	44.22	0.19	2	-	-	-	132.66	4.42	1
Chlorella sp.	-	-	-	-	-	-	-	-	-	-	-	-	66.33	2.21	2
C. vulgaris Beyer.	320.51	1.71	3	-	-	-	309.54	6.41	3	226.07	6.6	3	88.44	2.95	3
Coelastrum astroideum	-	-	-	-	-	-	44.22	0.19	1	-	-	-	22.11	0.73	1
C. microporum	44.22	0.23	2	22.11	0.17	1	-	-	-	-	-	-	24.85	0.82	1
Cosmarium sp.							44.22	0.19	1	-	-	-	49.7	1.65	1
C. granutum				22.11	0.17	1				-	-	-	-	-	-
C. hammeri Rein.	93.92	0.5	2				66.33	1.37	1	-	-	-	110.55	3.69	1
C. leave	-	-	-	22.11	0.17	1	-	-	-	-	-	-	24.85	0.82	1
Crucigenia tetrapedia (Kirch.)West & West.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
Desmodesmus itascaensis M.Fawley	-	-	-	193.33	1.54	5	116.03	2.40	4	-	-	-	-	-	-

D. lunatus (West&West) E. Heg.	776.27	4.16	6	848.08	6.77	7	143.63	2.97	4	-	-	-	-	-	-
Kirchneriella sp.	-	-	-	66.67	0.53	1	-	-	-	-	-	-	44.22	1.47	1
K. lunaris (Kirch.) Moebius.	-	-	-	-	-	-	-	-	-	-	-	-	66.33	2.21	1
Monoraphidium sp.	-	-	-	-	-	-	44.22	0.91	1	-	-	-	88.44	2.95	1
Mougeotia sp.	-	-	-	88.44	0.7	3	-	-	-	-	-	-	22.11	0.73	1
Oedogonium sp.	22.11	0.11	1	44.22	0.35	1	22.11	0.45	1	44.22	1.29	1	22.11	0.73	1
Oocystis sp.	-	-	-	-	-	-	-	-	-	-	-	-	22.11	0.73	1
O. elliptica w. West	-	-	-	-	-	-	-	-	-	-	-	-			
Pediastrum boryanum (Turp.)	-	-	-	46.96	0.37	2	22.11	0.45	1	22.11	0.64	1	71.81	2.39	2
P. tetrus	22.11	0.11	1	-	-	-	-	-	-	-	-	-	-	-	-
Scenedesmus acuminatus (Lag.) Chod.	22.11	0.11	1	-	-	-	44.22	0.91	1	-	-	-	-	-	-
S. arcuatus Lemm.	44.22	0.23	1	-	-	-	-	-	-	22.11	0.64	1	-	-	-
S. biguga (Turp.) Lag.	-	-	-	66.67	0.53	1	69.07	1.43	2	50.56	1.47	1	88.44	2.95	1
S. diamorphus (Turp.) Kutz.	-	-	-							22.11	0.64	1			
S. quadricauda (Turp.) Breb.	110.55	0.59	4	42.85	0.34	1	88.44	1.83	2	22.11	0.64	1			
Spirygyra sp.	-	-	-	24.85	0.19	1							22.11	0.73	1
Tetraedron minimum (A.Br.) Hansg.	-	-	-	-	-	-	22.11	0.45	1	49.7	1.45	1			
Ulothrix zonata (F.Weber & Mohr Kützing	220.93	1.18	5	-	-	-	-	-	-	93.92	2.74	3			
Zygnema sp.	65.98	0.35	1	66.33	0.53	2	-	-	-	-	-	-	22.11	0.73	1
CHRYSOPHYCEAE (Total)	-	-	-	-	-	-	**22.11**	**0.45**		-	-	-	-	-	-
Dinobryon divergens Imhof.	-	-	-	-	-	-	22.11	0.45	1	-	-	-	-	-	-
CRPTOPHYCEAE (Total)	-	-	-	**44.22**	**0.34**	-	-	-	-	-	-	-	-	-	-
Chroomonas sp.	-	-	-	22.11	0.17	1	-	-	-	-	-	-	-	-	-
C. nordstedtii Hansg.	-	-	-	22.11	0.17	1	-	-	-	-	-	-	-	-	-
DINOPHYCEAE (Total)	**22.11**	**0.11**		-	-	-	-	-	-	-	-	-	-	-	-
Glenodinium quadridens (Stein.) Schiller	22.11	0.11	1	-	-	-	-	-	-	-	-	-	-	-	-
EUGLENOPHYCEAE (Total)	**107.81**	**0.56**		-	-	-	-	-	-	**42.84**	**1.24**		-	-	-
Euglena sp.	64.96	0.34	3	-	-	-	-	-	-	21.42	0.62	1	-	-	-
Lepocinclis sp.				-	-	-	-	-	-	21.42	0.62	1	-	-	-
phacus sp.	42.85	0.22	2	-	-	-	-	-	-	-	-	-	-	-	-
PYROPHYCEAE (Total)	**66.33**	**0.34**		**42.85**	**0.34**		-	-	-	**49.7**	**1.45**		-	-	-
Dinobryon sertularia	22.11	0.11	1				-	-	-	-	-	-	-	-	-
Peridinium cinctum (Mull.) Ehr	44.22	0.23	2	42.85	0.34	1	-	-	-	49.7	1.45	1	-	-	-
XANTHOPHYCEAE (Total)	-	-	-	-	-	-	**66.33**	**1.37**		-	-	-	-	-	-
Tribonema affine G.S. West.	-	-	-	-	-	-	66.33	1.37	1	-	-	-	-	-	-
BACILLARIOPYCEAE (Total)	**15777.46**	**84.6**	**59**	**10520.87**	**83.82**	**76**	**3207.28**	**66.36**	**50**	**2259.9**	**65.82**	**57**	**1491.05**	**49.52**	**42**
Centrales	**149.11**	**0.79**		**489.49**	**3.88**		**299.08**	**6.18**		**445.61**	**12.99**		**149.11**	**4.95**	
Aulacoseira granulate (Ehr.) Simensen	-	-	-	-	-	-	149.97	3.1	1	74.55	2.17	3	-	-	-
A. varian	49.7	0.26	2	-	-	-	-	-	-	-	-	-	-	-	-
Coscinodiscus lacustris Grun.	-	-	-	49.7	0.39	2	-	-	-	-	-	-	-	-	-
Cyclotella atomus Hustedt.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	24.85	0.82	1
C. comta (Ehr.) Kutz.	-	-	-	24.85	0.19	1	-	-	-	97.69	2.85	2	-	-	-
C. kuetzingiana Thw.	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
C. meneghiniana Kutz.	-	-	-	-	-	-	24.85	0.51	1	49.7	1.45	2			

C. ocellata Pant.	99.41	0.53	3	315.54	2.52	5	124.26	2.57	2	198.82	5.8	4	99.41	3.31	3
C. striata (Kutz.) Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
Stephanodiscus astrea (Ehr.) Grun.	-	-	-	49.7	0.39	2	-	-	-	-	-	-	-	-	-
Pennales	**15628.35**	**83.81**	**54**	**10031.38**	**79.94**	**65**	**2908.2**	**60.18**	**46**	**1814.29**	**52.83**	**45**	**1341.94**	**44.57**	**37**
Achnanthes hungvica	24.85	0.13	1	-	-	-	-	-	-	-	-	-	-	-	-
A. minutissima Kutz.	13716.63	73.6	7	6103.04	48.76	7	847.4	17.56	5	273.38	7.98	2	74.55	2.48	3
Amomoeoneis exilis Kutz.	-	-	-	124.43	0.79	2	-	-	-	-	-	-	24.85	0.82	1
Amphora sp.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	3
A. coffeae formis (Ag.) Kutz.	-	-	-	99.92	0.99	1	-	-	-	-	-	-	-	-	-
A. veneta Kutz.	-	-	-	-	-	-	49.7	1.03	1	124.26	3.62	1	-	-	-
Bacillaria paxillifer (Mull.) Hend.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
Caloneis amphisbaena (Bory.) Cl.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
Cocconeis pediculus Ehr.	74.55	0.4	2	565.96	4.52	5	149.11	3.09	4	49.7	1.45	2	24.85	0.82	1
C. placentula Ehr.	370.05	1.98	6	621.49	4.96	6	174.48	3.61	3	-	-	-	49.7	1.65	1
C. placentula var.euglypta (Ehr.) Cl.	223.67	1.2	6	673.77	5.38	6	273.38	5.66	3	24.85	0.72	1	24.85	0.82	1
C. placentula var. lineata (Ehr.) Cl.							24.85	0.51	1	-	-	-	-	-	-
Cymbella affinis Kutz.	149.11	0.8	3	572.81	4.57	7	224.01	4.64	5	24.85	0.72	1	-	-	-
C. cistula (Hemp.)	-	-	-	-	-	-	24.85	0.51	1	24.85	0.72	1	-	-	-
C. differta (A.Cl.) Krieger.	99.41	0.53	2	124.77	0.99	1	-	-	-	-	-	-	-	-	-
C. microcephala Grun.	74.55	0.4	3	74.55	0.59	2	99.41	2.06	3	49.7	1.45	2	49.7	1.65	1
C. pusilla Grun.	298.75	1.6	6	74.55	0.59	3	24.85	0.51	1	-	-	-	-	-	-
C. ventricosa Kutz.	-	-	-	74.55	0.59	2	-	-	-	-	-	-	-	-	-
Denticula sp.	-	-	-	24.85	0.19	1	49.7	1.03	1	24.85	0.72	1	-	-	-
Diatoma elongatum (Lyngb.) Ag.	124.26	0.66	4	24.85	0.19	1	-	-	-	-	-		-	-	-
D. vulgare Bory.	-	-	-	-	-	-	49.7	1.03	1	24.85	0.72	1	-	-	-
Diploneis sp.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
D. ovalis (Hilse.) Cl.	-	-	-	74.55	0.59	2	-	-	-	-	-	-	-	-	-
Epithemia Zebra (Ehr.) Kutz.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
Eunotia pectinalis	-	-	-	-	-	-	49.7	1.03	1	-	-	-	49.7	1.65	1
Fragilaria acus Kutz.	-	-	-	24.85	0.19	1	73.01	1.51	1	-	-	-	-	-	-
F. fasciculate	-	-	-	24.85	0.19	1	-	-	-	149.11	4.35	1	-	-	-
F. nana	-	-	-	-	-	-	-	-	-				24.85	0.82	1
F. ulna (Nitz.) Ehr.	99.41	0.53	3	74.55	0.59	3	99.41	2.06	1	49.7	1.45	2	74.55	2.48	2
F. vaucheriae (Kutz.) Peters.	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
Gomphoneis olivacea (Lyngb.)Daw.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
Gomphonema angustatum (Kutz.) Rabh.	-	-	-	24.85	0.19	1	-	-	-	124.43	3.63	3	124.26	4.14	3
G. constrictum	-	-	-	-	-	-	48.67	1	1	-	-	-	-	-	-
G. parvulum (Kutz.) Grun.	-	-	-	99.92	0.79	1	-	-	-	-	-	-	-	-	-
Hantzchia sp.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
H. amphioxys (Ehr.) Grun.	-	-	-	-	-	-	24.85	0.51	1	24.85	0.72	1	74.55	2.48	1
Navicula sp.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
N. anglica Ralfs.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	-	-	-
N. atomus	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
N. bacillum Ehr.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
N. crucicula (W.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	-	-	-

Smith.) Donkin.															
N. cryptocephala Kutz.	49.7	0.26	2	24.85	0.19	1	199.16	4.12	3	74.55	2.17	2	149.11	4.97	2
N. cuspidata Kutz.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	1
N. gracilis Ehr.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
N. halphila	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
N. radiosa Kutz.	-	-	-				-	-	-	24.85	0.72	1	24.85	0.82	1
N. rhynchocephala Kutz.	-	-	-	25.02	0.19	1	-	-	-	24.85	0.72	1	24.85	0.82	1
N. riediana Lange-Bertalot & Rumrich	-	-	-	-	-	-	-	-	-	-	-	-	99.41	3.31	3
N. parva (Menegh.) Cl.	-	-	-	-	-	-	-	-	-	74.55	2.17	2	-	-	-
N. pygmaea	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
N. spicula (Dickie.) Cl.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
N. tuscula (Ehr.) Grun.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	1
N. viridula	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
Nitzchia acicularis W. Smith.	-	-	-	-	-	-	48.67	1	1	74.55	2.17	2	-	-	-
N. amphibia Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
N. angustata (W. Smith.) Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	1	-	-	-
N. apiculata (Greg.) Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	1	-	-	-
N. capronii Breb.	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
N. commutata Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
N. dissipatae Grun.	-	-	-	-	-	-	-	-	-				49.7	1.65	1
N. fasciculata Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
N. frustulum (Kutz.) Rabh.	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
N. hungarica Grun.	-	-	-	-	-	-	-	-	-	99.41	2.9	1	24.85	0.82	1
N. microcephala Grun.	49.7	0.26	1	-	-	-	-	-	-	-	-	-	-	-	-
N. palea (Kutz.) W. Smith.	224.01	1.2	6	249.9	1.99	2	273.89	5.67	4	-	-	-	124.26	4.14	3
N. sigma (Kutz.) W. Smith.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
Rhoicosphenia curvata (Kutz.) Grun.	49.7	0.26	2	-	-	-	-	-	-	-	-	-	24.85	0.82	1
Pinnularia lundii Hust.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
Surirella sp.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
S. ovata Kutz.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	24.85	0.82	1
Total Density (ind ×10^3/l)	18377.28			12513.34			4779.45			3424.16			2834.43		

Appendix (2): phytoplankton identified in station 1, and their taxa and total count (Cell ×10^3/l) of each taxa

TAXA	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Sum
CYANOPHYCEAE								
Anabaena sp.	-	-	-	-	12.9	-	-	12.9
Aphanocapsa sp.	-	-	-	12.9	-	-	-	12.9
Chamaesiphor	12.9	12.9	-	-	-	-	-	25.8
Chroococcus disperses	-	-	12.9	-	-	-	-	12.9
Chroococcus perelegans	-	-	-	12.9		-	-	12.9
Chroococcus turgidus (Kützing) Nägeli	29	29	12.9	12.9	12.9	-	-	96.7
Merismopedia gluca (Ehr.) Naeg.	-	-	-	-	12.9	-	-	12.9
Oscillatoria amphibia Ag.	12.9	12.9	-	-	-	-	-	25.8
Oscillatoria limnetica Lemm.	37.5	29	-	12.9	12.9	12.9	-	105.2
Oscillatoria protus	12.9	12.9	-	-	-	-	-	25.8
Oscillatoria tenuis Ag.	-	-	12.9	12.9	-	-	-	25.8
Phormidium sp.	25	37.5			-	-	-	62.5
	Total count of Cyanophyceae phytoplankton						=	**432.1**
CHLOROPHYCEAE								
Ankistrodesmus falcatus (Corda.) Ralfs	25.8	25.8	-	-	-	-	-	51.6
Chladophora sp.	-	-	12.9	-	-	-	-	12.9
- fracta	12.9	12.9		12.9	-	-	-	38.7

Chlorella vulgaris Beyer.	38.7	58	90.3	-	-	-	-	187
Coelastrum microporum	-	-	-	12.9	12.9	-	-	25.8
Cosmarium hammeri Rein.	25.8	29	-	-	-	-	-	54.8
Desmodesmus lunatus (West & G.S.West) E. Heg.	101	116.6	90.3	87	29	29	-	452.9
Oedogonium sp.	-	-	-	12.9	-	-	-	12.9
Pediastrum tetrus	-	-	-	-	12.9	-	-	12.9
Scenedesmus acuminatus (Lag.) Chod.	-	-	-	-	12.9	-	-	12.9
Scenedesmus arcuatus Lemm.	-	-	25.8	-	-	-	-	25.8
Scenedesmus quadricauda (Turp.) Breb.	12.9	12.9	25.8	-	-	12.9	-	64.5
Ulothrix zonata (F.Weber & Mohr) Kützing	29	29	29	29	-	12.9	-	128.9
Zygnema sp.	-	-	-	38.5	-	-	-	38.5
	Total count of Chlorophyceae phytoplankton =							**1120.1**
EUGLENOPHYCEAE								
Euglena sp.	12.5	12.5	12.9	-	-	-	-	37.9
Phacus sp.	12.5	12.5	-	-	-	-	-	25
	Total count of Euglenophyceae phytoplankton =							**62.9**
DINOPHYCEAE								
Glenodinium quadridens (Stein.) Schiller.	-	-	12.9					12.9
	Total count of Dinophyceae phytoplankton =							**12.9**
BACILLARIOPYCEAE								
Centrales								
Aulacoseira varian	14.5	14.5	-	-	-	-	-	29
Cyclotella ocellata Pant.	14.5	14.5	-	-	29	-	-	58
Pennales								
Achnanthes hungvica	-	-	-	14.5	-	-	-	14.5
Achnanthes minutissima Kutz.	408.2	101	1924.3	5336	58.3	58.3	116.6	8002.7
Cocconeis pediculus Ehr.	-	-	29	-	-	-	14.5	43.5
- placentula Ehr.	14.5	29	29	116	-	12.9	14.5	215.9
- - var. euglypta (Ehr.) Cl.	29	29	14.5	14.5	-	29	14.5	130.5
Cymbella affinis Kutz.	-	-	29	43.5	-	-	14.5	87
Cymbella differta (A.Cl.) Krieger.	29	29		-	-	-	-	58
Cymbella microcephala Grun.	-	-	14.5	-	14.5	14.5	-	43.5
Cymbella pusilla Grun.	29	29	14.5	72.8	14.5	14.5	-	174.3
Denticula elegans Kutz.	14.5	14.5	29	14.5	-	-	-	72.5
Fragilaria ulna (Nitz.) Ehr.	14.5	14.5	29	-	-	-	-	58
Navicula cryptocephala Kutz.	-	-	14.5	-	-	-	14.5	29
Nitzchia microcephala Grun.	-	-	-	29	-	-	-	29
Nitzchia palea (Kutz.) W. Smith.	14.5	14.5	14.5	14.5	29	43.7	-	130.7
Rhoicosphenia curvata (Kutz.) Grun.	14.5	14.5	-	-	-	-	-	29
	Total count of Bacillariophyceae phytoplankton =							**9205.1**
PYROPHYCEAE								
Dinobryon sertularia	-	-	-	-	12.9	-	-	12.9
Peridinium cinctum	-	-	12.9	-	12.9	-	-	25.8
	Total count of Pyrophyceae phytoplankton =							**38.7**
Total count of all groups for each month	**998**	**747.4**	**2493.3**	**5913**	**290.4**	**240.6**	**189.1**	**10871.8**

Appendix (3): phytoplankton identified in station 2, and their taxa and total count (Cell $\times 10^3$/l) of each taxa

TAXA	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Sum
CYANOPHYCEAE								
Anabaena sp.	25.8							25.8
Aphanocapsa sp.				12.5				12.5
Chroococcus disperses	12.9							12.9
Chroococcus perelegans				25				25
Oscillatoria limnetica Lemm.				25				25
Oscillatoria tenuis Ag.				12.9				12.9
Spirulina sp.	51.6							51.6
S. major Kutz.	38.9							38.9
	Total count of Cyanophyceae phytoplankton =							**204.6**
CHLOROPHYCEAE								
Coelastrum microporum				12.9				12.9
Cosmarium granutum				12.9				12.9
Cosmarium leave				12.9				12.9

Desmodesmus itascaensis M.Fawley	29	29	12.9	12.9	29			112.8
Desmodesmus lunatus (West & G.S.West) E. Heg.	101	90.3	116.6	87	58	29	12.9	494.8
Kirchneriella sp.	38.9							38.9
Mougeotia sp.	12.9		25.8	12.9				51.6
Oedogonium sp.	25.8							25.8
Pediastrum boryanum (Turp.)			14.5	12.9				27.4
Scenedesmus biguga (Turp.) Lag.	38.9							38.9
Scenedesmus quadricauda (Turp.) Breb.				25				25
Spirygyra sp.			14.5					14.5
Zygnema sp.	12.9		25.8					38.7
	Total count of Chlorophyceae phytoplankton = **907.1**							
CRPTOPHYCEAE								
Chroomonas sp.		12.9						12.9
- nordstedtii Hansg.		12.9						12.9
	Total count of Crptophyceae phytoplankton = **25.8**							
BACILLARIOPYCEAE								
Centrales								
Coscinodiscus lacustris Grun.		14.5	14.5					29
Cyclotella atomus Hustedt.	29							29
Cyclotella comta (Her.) Kutz.			14.5					14.5
Cyclotella ocellata Pant.	43.7	29	29	38.7	43.7			184.1
Stephanodiscus astrea (Ehr.) Grun.	14.5	14.5						29
Pennales								
Achnanthes minutissima Kutz.	2915.7	47.3	131.2	160.4	29	218.6	58.3	3560.7
Amphora coffeae formis (Ag.) Kutz.	58.3							58.3
Anomoeoneis exilis Kutz.			14.5		58.1			72.6
Bacillaria paxillifer (Mull.) Hend.		14.5						14.5
Caloneis amphisbaena (Bory.) Cl.		14.5						14.5
Cocconeis pediculus Ehr.	145.7	14.5	29	112		29		330.2
- placentula Ehr.	29.1	130.5	14.5	145		29	14.5	362.6
- - var. euglypta (Ehr.) Cl.	306.1	29	14.5	14.5		14.5	14.5	393.1
Cymbella affinis Kutz.	87.5	43.7	14.5	14.5	14.5	145	14.5	334.2
Cymbella differta (A.Cl.) Krieger.	72.8							72.8
Cymbella microcephala Grun.		14.5			29			43.5
Cymbella pusilla Grun.	14.5		14.5			14.5		43.5
Cymbella ventricosa Kutz.	29				14.5			43.5
Denticula sp.	14.5							14.5
Diatoma elongatum (Lyngb.) Ag.	14.5							14.5
Diploneis sp.	14.5							14.5
- ovalis (Hilse.) Cl.	29	14.5						43.5
Epithemia Zebra (Ehr.) Kutz.		14.5						14.5
Fragilaria acus Kutz.		14.5						14.5
Fragilaria fasciculate				14.5				14.5
Fragilaria ulna (Nitz.) Ehr.	14.5		14.5	14.5				43.5
Gomphonema angustatum (Kutz.) Rabh.						14.5		14.5
Gomphonema parvulum (Kutz.) Grun.	58.3							58.3
Navicula halphila						14.5		14.5
Navicula anglica Ralfs.		29						29
Navicula crucicula (W. Smith.) Donkin.		29						29
Navicula cryptocephala Kutz.	14.5							14.5
Navicula rhynchocephala Kutz.			14.6					14.6
Nitzchia palea (Kutz.) W. Smith.	58.3	87.5						145.8
Nitzchia sigma (Kutz.) W. Smith.	14.5							14.5
	Total count of Bacillariopyceae phytoplankton = **6138.3**							
PYROPHYCEAE								
Peridinium cinctum				25				25
	Total count of Pyrophyceae phytoplankton = **25**							
Total count of all taxa for each month	**4367.1**	**700.6**	**529.9**	**803.9**	**275.8**	**508.6**	**114.7**	7300.6

Appendix (4): phytoplankton identified in station 3, and their taxa and total count (Cell ×10^3/l) of each taxa

TAXA	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Sum
CYANOPHYCEAE								
Chroococcus sp.	25.8							25.8
- disperses				12.9				12.9
- limneticus Lemm.			12.9					12.9
Merismopedia tenuissima				25.8				25.8
Oscillatoria amona			64.5					64.5
Oscillatoria limnetica Lemm.	12.9							12.9
Oscillatoria minus	25.8							25.8
Oscillatoria sancta (Kutz.) Gomont.				12.9				12.9
Oscillatoria tenuis Ag.				25.8				25.8
	Total count of Cyanophyceae phytoplankton = **219.3**							
CHLOROPHYCEAE								
Actinastrum Lag.								
Ankistrodesmus falcatus (Corda.) Ralfs	12.9		29					41.9
Chlamydomonas sp.	12.9			12.9				25.8
Chlorella vulgaris Beyer.	103.2			51.6	25.8			180.6
Coelastrum astroideum	25.8							25.8
Cosmarium sp.				25.8				25.8
Cosmarium hammeri Rein	38.7							38.7
Desmodesmus itascaensis M.Fawley	12.9	29	12.9	12.9				67.7
Desmodesmus lunatus (West & G.S.West) E.Heg.	29	29	12.9		12.9			83.8
Monoraphidium sp.	25.8							25.8
Oedogonium sp.					12.9			12.9
Pediastrum boryanum (Turp.)				12.9				12.9
Scenedesmus acuminatus (Lag.) Chod.					25.8			25.8
Scenedesmus biguga (Turp.) Lag.	25.8		14.5					40.3
Scenedesmus quadricauda (Turp.) Breb.	12.9			38.7				51.6
Tetraedron minimum (A.Br.) Hansg.				12.9				12.9
	Total count of Chlorophyceae phytoplankton = **672.3**							
XANTHOPHYCEAE								
Tribonema affine G.S. West.				38.7				38.7
	Total count of Xanthophyceae phytoplankton = **38.7**							
CHRYSOPHYCEAE								
Dinobryon divergens Imhof.				12.9				12.9
	Total count of Chrysophyceae phytoplankton = **12.9**							
BACILLARIOPYCEAE								
Centrales								
Aulacoseira granulate (Ehr.) Simensen						87.5		87.5
Cyclotella meneghiniana Kutz.	14.5							14.5
Cyclotella ocellata Pant.	14.5		58					72.5
Pennales								
Achnanthes minutissima Kutz.			43.5	87	87	145.7	131.2	494.4
Amphora veneta Kutz.					29			29
Cocconeis pediculus Ehr.	43.5			14.5	14.5		14.5	87
- placentula Ehr.	72.8					14.5	14.5	101.8
- - var. euglypta (Ehr.) Cl.	14.5					87	58	159.5
- - var. lineata (Ehr.) Cl.						14.5		14.5
Cymbella affinis Kutz.	14.5		29	29	14.5		43.7	130.7
Cymbella cistula (Hemp.)					14.5			14.5
Cymbella microcephala Grun.	29		14.5			14.5		58
Cymbella pusilla Grun.						14.5		14.5
Denticula sp.	29							29
Diatoma vulgare Bory.					29			29
Eunotia pectinalis					29			29
Fragilaria acus Kutz.					42.6			42.6
Fragilaria ulna (Nitz.) Ehr.					58			58
Fragilaria vaucheriae (Kutz.) Peters				14.5				14.5
Gomphonema constrictum				28.4				28.4
Hantzchia amphioxys (Her.) Grun.						14.5		14.5
Navicula atomus	14.5							14.5
Navicula cryptocephala Kutz.				14.5	58		43.7	116.2

Navicula viridula				14.5				14.5
Nitzchia acicularis W. Smith.				28.4				28.4
Nitzchia frustulum (Kutz.) Rabh.							14.5	14.5
Nitzchia palea (Kutz.) W. Smith.	58.3		14.5	14.5	72.5			159.8
	Total count of Bacillariopyceae phytoplankton = **1871.3**							
Total count of all groups for each month	**669.5**	**58**	**306.2**	**542**	**526**	**392.7**	**320.1**	

Appendix (5): phytoplankton identified in station 4, and their taxa and total count (Cell ×10^3/l) of each taxa

TAXA	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	Sum
CYANOPHYCEAE								
Calothrix fusca Bornet & Flahault	29		12.9		29			70.9
Chamaesiphon sp.			12.9					12.9
Chroococcus disperses	12.9							12.9
Chroococcus turgidus (Kützing) Nägeli	12.9			12.9				25.8
Lyngbya limnetica Lemm.	12.9				12.9			25.8
Nostoc sp.					12.9			12.9
Oscillatoria amona		12.9						12.9
Oscillatoria chalybea Mertens.	12.9							12.9
Oscillatoria minima Gick.		12.9						12.9
Oscillatoria protus			25.8					25.8
Oscillatoria splendida Grev.	12.9							12.9
Oscillatoria tenuis Ag.	12.9							12.9
Phormidium sp.	12.9							12.9
	Total count of Cyanophyceae phytoplankton = **264.4**							
CHLOROPHYCEAE								
Ankistrodesmus falcatus (Corda.) Ralfs			12.5					12.5
Cladophora sp.	12.9							12.9
Chlorella vulgaris Beyer.	29.5		25		77.4			131.9
Crucigenia tetrapedia (Kirch.)West & West.	12.9							12.9
Oedogonium sp.					25.8			25.8
Pediastrum boryanum (Turp.)	12.9							12.9
- simplex (Meyen.) Lemm								
Scenedesmus arcuatus Lemm.	12.9							12.9
Scenedesmus biguga (Turp.) Lag.	29.5							29.5
- diamorphus (Turp.) Kutz.	12.9							12.9
- quadricauda (Turp.) Breb.	12.9							12.9
Tetraedron minimum (A.Br.) Hansg.	29							29
Ulothrix zonata (F.Weber & Mohr) Kützing	29	12.9		12.9				54.8
	Total count of Chlorophyceae phytoplankton = **360.9**							
EUGLENOPHYCEAE								
Euglena sp.			12.5					12.5
Lepocinclis sp.			12.5					12.5
	Total count of Euglenophyceae phytoplankton = **25**							
PYROPHYCEAE								
Peridinium cinctum (Mull.) Ehr.	29							29
	Total count of Pyrophyceae phytoplankton = **29**							
BACILLARIOPHYCEAE								
Centrales								
Aulacoseira granulate (Ehr.) Simensen.	14.5		14.5	14.5				43.5
Cyclotella comta (Ehr.) Kutz.			28.5	28.5				57
Cyclotella meneghiniana Kutz.	14.5			14.5				29
Cyclotella ocellata Pant.	14.5		29	14.5	58			116
Cyclotella striata (Kutz.) Grun.				14.5				14.5
Pennales								
Achnanthes minutissima Kutz.	87				72.5			159.5
Amphora veneta Kutz.					72.5			72.5
Cocconeis placentula Ehr.		14.5	14.5					29
- - var. euglypta (Ehr.) Cl.			14.5					14.5
Cymbella affinis Kutz.	14.5							14.5
Cymbella cistula (Hemp.)		14.5						14.5
Cymbella microcephala Grun.		14.5	14.5					29
Denticula sp.	14.5							14.5
Diatoma vulgare Bory.			14.5					14.5

Fragilaria fasciculate	87							87
Fragilaria ulna (Nitz.) Ehr.	14.5	14.5						29
Gomphoneis olivacea (Lyngb.) Daw.		14.5						14.5
Gomphonema angustatum (Kutz.) Rabh.	29.1	14.5	29					72.6
Hantzchia sp.				14.5				14.5
Hantzchia amphioxys (Ehr.) Grun.		14.5						14.5
Navicula sp.		14.5		14.5				29
- bacillum Ehr.				14.5				14.5
- cryptocephala Kutz.			29	14.5				43.5
- gracilis Ehr.				14.5				14.5
- parva (Menegh.) Cl.		29		14.5				43.5
- radiosa Kutz.				14.5				14.5
- rhynchocephala Kutz.			14.5					14.5
- spicula (Dickie.) Cl.		14.5		14.5				29
Nitzchia acicularis W. Smith.		29		14.5				43.5
- amphibia Grun.				14.5				14.5
- angustata (W. Smith.) Grun.		29						29
- apiculata (Greg.) Grun.				29				29
- commutata Grun.				14.5				14.5
- fasciculata Grun.		14.5		14.5				29
- hungarica Grun.					58			58
Pinnularia lundii Hust.			14.5					14.5
Surirella sp.			14.5					14.5
- ovata Kutz.			14.5					14.5
	Total count of Bacillariophyceae phytoplankton =							**1318.6**
Total count of all groups for each month	**632.8**	**270.7**	**360.1**	**315.3**	**419**	**0**	**0**	

Appendix (6): phytoplankton identified in station 5, and their taxa and total count (Cell ×10^3/l) of each taxa

TAXA	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Sum
CYANOPHYCEAE								
Chamaesiphon sp.	12.6							12.6
Gloeocapsa sp.	12.9							12.9
Gloeotrichia sp.	12.9							12.9
Lyngbya limnetica Lemm.		25.8	12.9					38.7
Merismopedia gluca (Ehr.) Naeg.			12.9					12.9
Microcystis sp.	12.9							12.9
Oscillatoria limnetica Lemm.	12.9							12.9
Oscillatoria minima Gick.	38.9							38.9
Oscillatoria tenuis Ag.		12.9	12.9					25.8
	Total count of Cyanophyceae phytoplankton =							**180.5**
CHLOROPHYCEAE								
Actinastrum sp.		25.8						25.8
Ankistrodesmus falcatus (Corda.) Ralfs	12.9			25.8				38.7
Botryococcus braunii Kutz.		25.8						25.8
Chlamydomonas sp.		77.4						77.4
Chlorella sp.		25.8		12.9				38.7
Chlorella vulgaris Beyer.	25.8	12.9		12.9				51.6
Coelastrum astroideum				12.9				12.9
Cosmarium sp.			29					29
Cosmarium hammeri Rein.		64.5						64.5
Cosmarium leave				14.5				14.5
Coelastratum microporum			14.5					14.5
Kirchneriella sp.		25.8						25.8
- lunaris (Kirch.) Moebius.		38.7						38.7
Monoraphidium sp.		51.6						51.6
Moungeotia sp.			12.9					12.9
Oedogonums sp.			12.9					12.9
Oocystis sp.		12.9						12.9
Pediastrum boryanum (Turp.)		12.9	29					41.9
Scenedesmus biguga (Turp.) Lag.			51.6					51.6
Spirogyra sp.		12.9						12.9
Zygnema sp.		12.9						12.9

	Total count of Chlorophyceae phytoplankton						=	**667.5**
BACILLARIOPYCEAE								
Centrales								
Cyclotella atomus Hustedt.	14.5							14.5
Cyclotella kuetzingiana Thw.	14.5							14.5
Cyclotella ocellata Pant.	29			14.5	14.5			58
Pennales								
Amomoeoneis exilis					14.5			14.5
Achnanthes minutissima Kutz.				14.5		14.5	14.5	43.5
Amphora sp.					29			29
Cocconeis pediculus Ehr.			14.5					14.5
- placentula Ehr.	29							29
- - var. euglypta (Ehr.) Cl.	14.5							14.5
Cymbella microcephala Grun.				29				29
Denticula sp.					29			29
Eunotia pectinalis					29			29
Fragilaria nana					14.5			14.5
- construens (Ehr.) Grun.								
- ulna (Nitz.) Ehr.			14.5		29			43.5
Gomphonema angustatum (Kutz.) Rabh.				29		29	14.5	72.5
Hantzchia amphioxys (Ehr.) Grun.			43.5					43.5
Navicula cryptocephala Kutz.		14.5	72.5					87
Navicula cuspidata Kutz.		29						29
Navicula pygmaea					14.5			14.5
Navicula radiosa Kutz.		14.5						14.5
Navicula rhynchocephala Kutz.		14.5						14.5
Navicula riediana Lange-Bertalot & Rumrich	14.5		29		14.5			58
Navicula tuscula (Ehr.) Grun.		29						29
Nitzchia dissipatae Grun.			29					29
Nitzchia hungarica Grun.		14.5						14.5
Nitzchia palea (Kutz.) W. Smith.			29	14.5	29			72.5
Rhoicosphenia curvata (Kutz.) Grun.			14.5					14.5
Nitzchia capronii Breb.			14.5					14.5
Surirella ovata Kutz.			14.5					
	Total count of Bacillariophyceae phytoplankton						=	**884.5**
Total count of all groups for each month	**257.8**	**554.6**	**464.1**	**180.5**	**217.5**	**43.5**	**29**	

References

[1] Lee, R.E. (2008). Phycology (Fourth edition). Colorado State University, USA, Published in the United States of America by Cambridge University Press, New York.

[2] Burres, E. (2011). Standard Operating Procedure. The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment State Water Resources Control Board, DQM-SOP-3.5. 2011.

[3] Rashid, N., Muhammad Saif Ur Rehman, Madeha Sadiq, Tariq Mahmood, Jong In Han (2014). Current status, issues and developments in microalgae derived biodiesel production. Renewable and Sustainable Energy Reviews, Vol. 40, p.760–778.

[4] Desikachary T. (1959). Cyanophyta. Indian Council of Agricultural Research, monographs on Algae". New Delhi, India.

[5] Prescott, G.W. (1964). The alga: A review. Houghton Mifflin comp. Boston, pp 436.

[6] Prescott, G. W. (1978). How to Know the Freshwater Algae. Wm. C. Brown, Dubuque, IA. Prescott, G. W. (1982).Algae of the Western great lakes area.Otto Koeltz Sci.Pub.W-Germany.979 PP.

[7] Prescott, G.W. (1982). Algae of the Western Great Lakes Area. Koenigstein, West Germany, pp 977.

[8] Hustedt, F. (1930). Die Susswasser Flora Mitteleuropas. Heft 10. 2nd Edition. Bacillariophyta (Diatomeae). A. Pascher. Verlag von Gustav Fischer, Germany, pp 466.

[9] Hustedt, F. (1959). The Pennate Diatoms. A Translation of Hustedt´SDie Kieslalgen. with Supplement by Norman G. Jensen. Printed in Germany by Strauss and Cramer Gmbh, pp 918.

[10] Furet, J.E. and Benson- Evans, K. (1982). An Evaluation of the Time Required to Obtain Complete Sedimentation of Fixed Algal Particles Prior to Enumeration. Br. Phycol. J.; 17: 253-258.

[11] Sdiq, K. H. (2015). Ecological and Physiological Studies on Some Algae Species growth in Dukan Lake-Kurdistan Region of Iraq. M.Sc. thesis, University of Sulaymaniyah.

[12] Boney, A.D. (1975). Phytoplankton. Camlot Press. Ltd. Southampton.116PP.

[13] Ganai, A. H. and Parveen, S. (2013). Effect of physico-chemical conditions on the structureand composition of the phytoplankton community in

Wular Lake at Lankrishipora, Kashmir. International Journal of Biodiversity and Conservation, Vol. 6(1), pp. 71-84, January 2014.
[14] Toma J. J. (2000). Limnologicl study of Dokan Lake, Kurdistan region, Iraq. M.Sc. Thesis, Univ. of Salahaddin-Hawler. Iraq.
[15] Bilbas A.H.A., (2014). Ecosystem Health Assessment of Dukan Lake, Sulaimani, Kurdistan Region of Iraq″.Phd.Dissertation. Higher Education Coll., University of Salahaddin-Hawler, Iraq.
[16] AL-Nakshabandi I. Y. R. (2002). A Phycolimnological study on Dohuk impoundment & it's main Watershed″. Ph.D. Dissertation, Univ. of Dohuk.
[17] Farkha T. K. J. (2006). A Study of the Distribution of Phytoplankton & Aquatic Fungi in the Lotic Water in Baghdad District & the effect of Environmental Factors. Ph.D. Dissertation, Al-Mustansiryia Univ., Iraq.
[18] Abed, I.J. (2013) Environmental and Identification study of Algae Present in Three Drinking Water Plants in Baghdad and Molecular Detection of some Toxigenic Cyanobacteria .Ph.D. Dissertation, at College of Science-University of Baghdad.
[19] Muhammad, S. A. M. (2004). An ecological study on the Aquatic life of Sarchnar spring, Chaq-Chaq & Kliassan streams, Sulaimany, Kurdistan region of Iraq. M.Sc. Thesis, Univ. of Sulaimani, Iraq.
[20] Saadulla, S.O. (2003). Species composition and diversity of phytoplankton in Sarchnar Spring and Chaq-Chaq Stream within Sulaimani Province/ Kurdistan region of Iraq HD (High Dibloma) Thesis ,in University of Sulaimani.
[21] Al-Sarraf, M.A.A.A. (2006). Environmental study and taxonomic phytoplankton in the tributary Al-Adeim, Diyala and their impact on the Tigris River″. Ph.D thesis, College of Science for Women, University of Baghdad, Iraq, 231 p.
[22] Reynolds, C.S. (1987). The response of phytoplankton communities to changing lake Environment. Schweiz Z Hydrol., 49:220-236.
[23] Giripunje, M. D., Fulke, A. B., Khairnar, K., Meshram, P. U. and Paunikar, W. N. (2013). A Review of Phytoplankton Ecology in Freash water Lakes of India. Romanian Limnogeographical Association, Lakes, reservoirs and ponds, vol. 7(2): 127-141, 2013.
[24] Chaturvedi, R.K., Sharma, K.P., Sharma, K., Bharadwaj, S., Sharma, S. (1999). Plankton community of polluted water around Sanganer, Jaipur. Journal of Environment and Pollution, 6:77-84.
[25] Saravanakumar, A., Rajkumar, M., Thivakaran, G.A., Serebiah J.S. (2008). Abundance and seasonal variations of phytoplankton in the creek waters of western mangrove of Kachchh-Gujarat. J. Environ. Biol., 29:271-274.
[26] Reynolds, C., Huszar, V., Kruk, C., Naselli-Flores, L. & Melo S. (2002). Towards a functional classification of the freshwater phytoplankton. J. Plankton Res. 24:417-428.

Tikrit Journal of Pure Science 22 (6) 2017 *ISSN: 1813 – 1662 (Print)*
E-ISSN: 2415 – 1726 (On Line)

دراسة نوعيّة وكميّة للطحالب في ثلاث محطات لمياه الشرب ينبوعية المصدر في محافظة السليمانية – اقليم كردستان العراق

بشار طارق اسماعيل الشنداح[1] ، رياض عباس عبد الجبار[1] ، تريفه كمال جلال فرخة[2]

[1]قسم علوم الحياة ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

[2]قسم علوم الحياة ، كلية العلوم ، جامعة السليمانية ، السليمانية ، العراق

الملخص

في هذه الدراسة تم اختيار ثلاث مشاريع لمياه الشرب ينبوعية المصدر ضمن مواقع مختلفة من محافظة السليمانية – اقليم كردستان العراق. جمعت العينات لمدة ثمانية اشهر اعتبارا من شهر ايار 2015 وحتى نهاية شهر كانون الاول 2015.

اختيرت خمس محطات للدراسة، المحطات الثلاثة الاولى تقع في مشروع بيستان سور لمياه الشرب في قضاء شارزور، وتقع المحطة الرابعة في مشروع سراي سبحان اغا لمياه الشرب في قضاء سيد صادق، وتقع المحطة الخامسة في مشروع خورمال لمياه الشرب في ناحية خورمال ضمن قضاء حلبجة.

شملت الدراسة دراسة نوعيّة للهائمات النباتية ودراسة كميّة لتلك الهائمات (تضمنت الكثافة والعدد الكلي للهائمات النباتية) لمياه المحطات المختارة.

تم تشخيص 155 نوع من الطحالب في جميع المحطات المدروسة وهذه الانواع تابعة 9 اصناف من الطحالب، حيث تم تسجيل 80 نوع من الطحالب تابعة لصنف Bacillariophyceae (دايتومات)، و35 نوع تابعة لصنف chlorophyceae (طحالب خضراء)، و30 نوع تابعة لصنف Cyanophyceae (خضراء مزرقة) وغيرها، ومن خلال العدد الكلي للطحالب كانت الدايتومات هي السائدة على جميع الانواع الاخرى في جميع المحطات تليها الطحالب الخضراء ثم الطحالب الخضراء المزرقة.

نتائج الدراسة الكمية او العددية للهائمات النباتية اظهرت تسجيل اعلى كثافة للهائمات النباتية خلال الدراسة في المحطة الاولى (18377.28 ind×10^3/l) تليها (12513.34 ind×10^3/l) في المحطة الثانية ثم (4779.45 ind×10^3/l) في المحطة الثالثة.

اما نتائج العدد الكلي للهائمات النباتية في جميع المحطات فقد تراوحت مابين 103×5913 خلية/لتر و 103×29 خلية/لتر.