

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

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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 Khurmali drinking water project in Khurmali 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 ($18377.28 \text{ ind} \times 10^3/\text{l}$), followed by ($12513.34 \text{ ind} \times 10^3/\text{l}$) at Station 2 and ($4779.45 \text{ ind} \times 10^3/\text{l}$) at Station 3. The results of total Count of phytoplankton at all stations ranged between $5913 \times 10^3 \text{ cell/l}$ and $29 \times 10^3 \text{ cell/l}$.

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 Khurmali drinking water project (Figure 1).

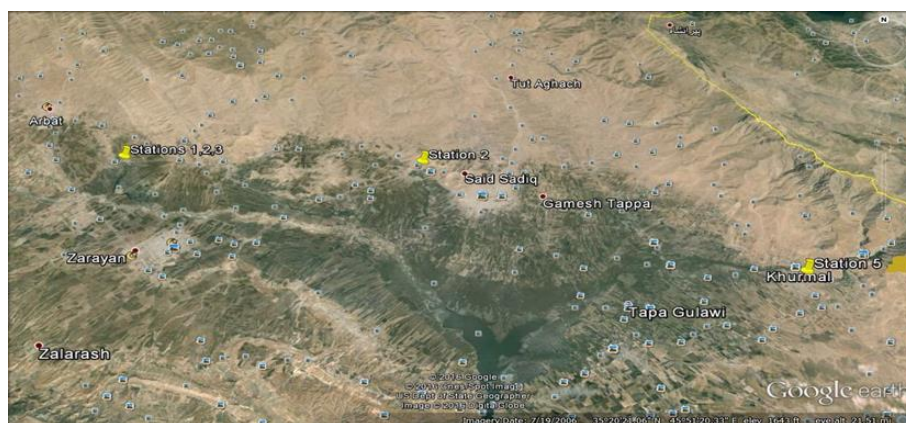


Figure 1: Location of the Studied Sites (Google earth, 2015)

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 khormal drinking water project.

2.3 Qualitative analysis (Algal identification)

Non-diatom 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-diatom 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.

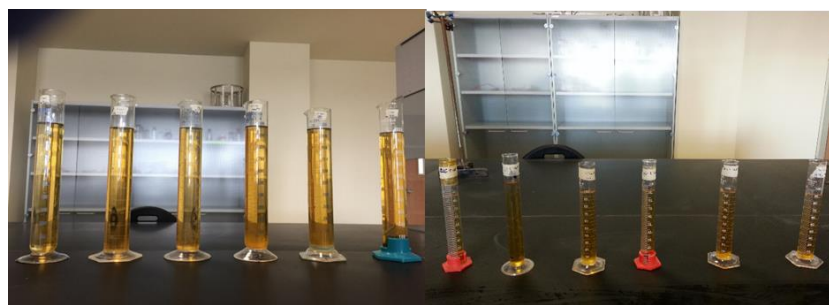


Figure 2: Sedimentation Method

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 appendices 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 ($\text{NO}_3\text{-N}$ and $\text{PO}_4\text{-P}$) 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

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.

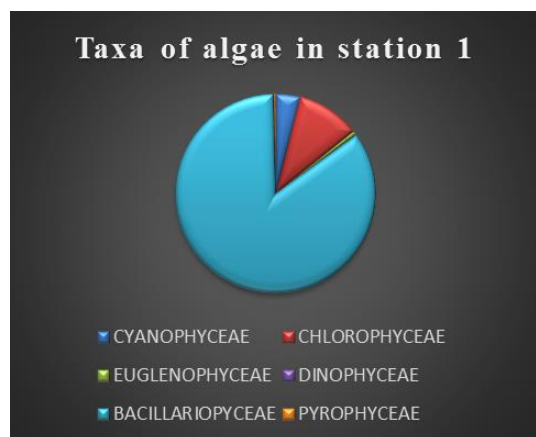


Figure 3: Taxa of algae in station 1

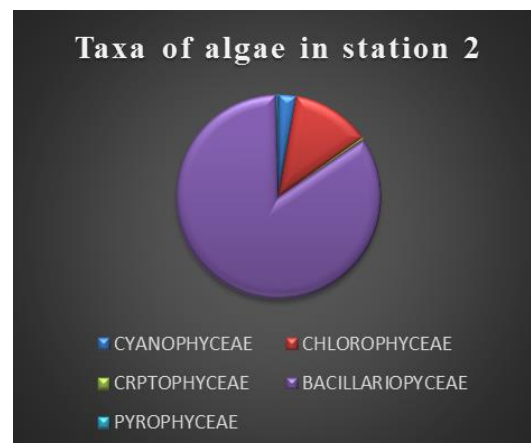


Figure 4: Taxa of algae in station 2

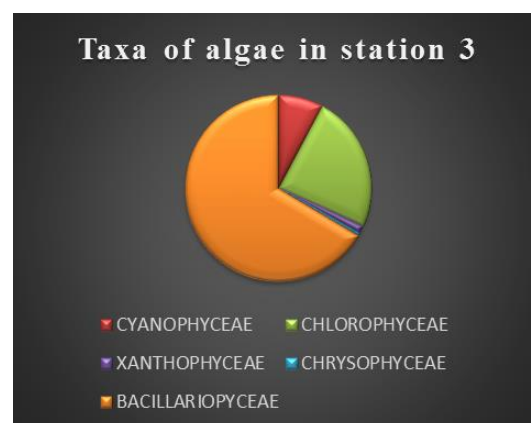


Figure 5: Taxa of algae in station 3

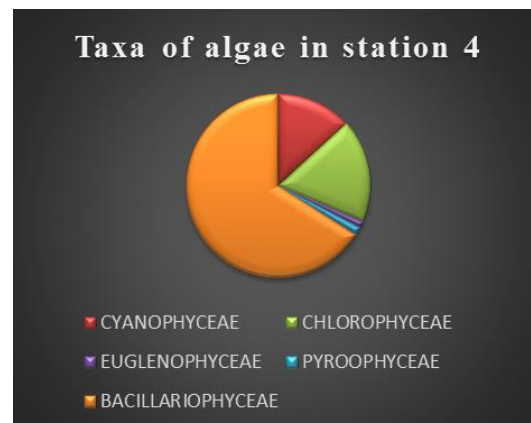


Figure 6: Taxa of algae in station 4

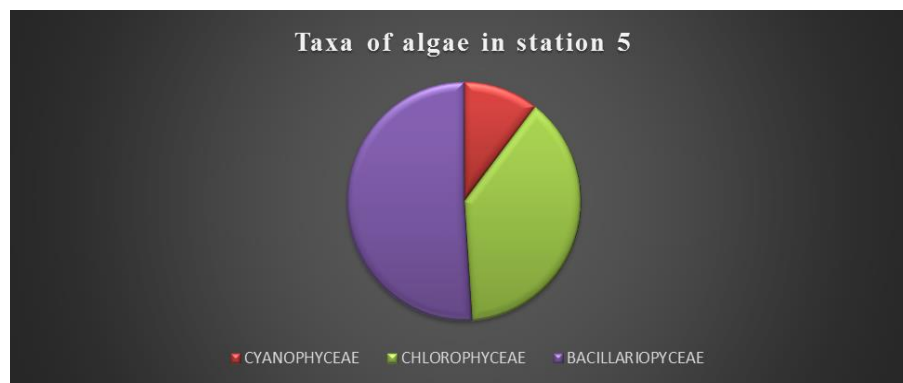


Figure 7: Taxa of algae in station 5

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 Station 1 ($18377.28 \text{ ind} \times 10^3/\text{l}$), followed by ($12513.34 \text{ ind} \times 10^3/\text{l}$) at Station 2 and ($4779.45 \text{ ind} \times 10^3/\text{l}$) at Station 3. The lowest total density was recorded at Station 5 which was ($2834.43 \text{ ind} \times 10^3/\text{l}$) 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.

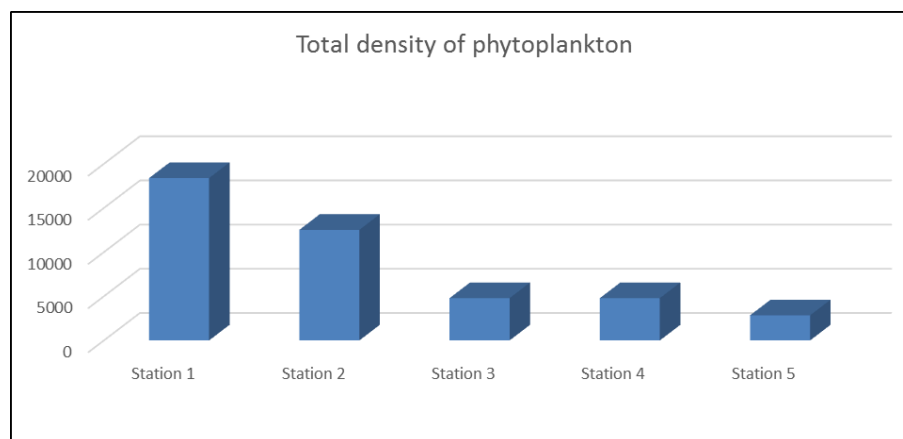


Figure 8: Total density of phytoplankton in studied stations

Generally and regardless of the type of algae the results of total Count of microalgae at all stations ranged between $5913 \times 10^3 \text{ cell/l}$ and $29 \times 10^3 \text{ cell/l}$. The highest number of total Count of phytoplankton

$5913 \times 10^3 \text{ cell/l}$ was recorded at station 1 during September and the lowest number $29 \times 10^3 \text{ cell/l}$ was recorded at stations 5 during December (Figure 9).

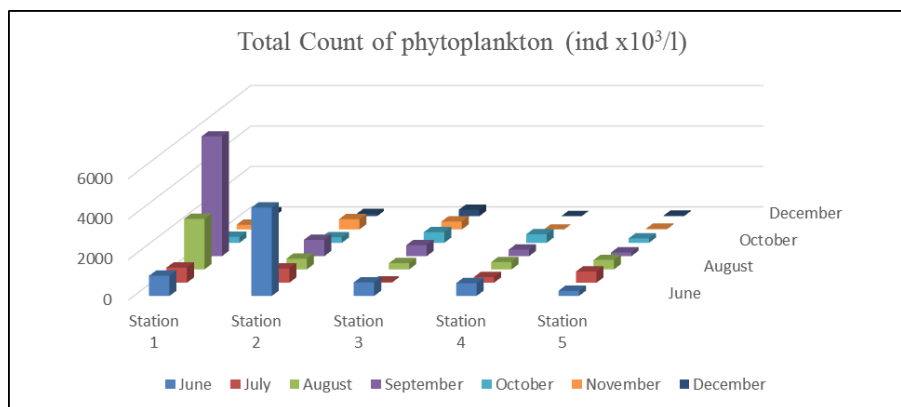


Figure 9: Total Count of phytoplankton in studied stations

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 occurrence 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 $\times 10^3/l$), (B) = Density percentage (%), (C) = Number of frequency, - = absence.

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

<i>D. lunatus</i> (West&West) E. Heg.	776.27	4.16	6	848.08	6.77	7	143.63	2.97	4	-	-	-	-	-	-
<i>Kirchneriella</i> sp.	-	-	-	66.67	0.53	1	-	-	-	-	-	-	44.22	1.47	1
<i>K. lunaris</i> (Kirch.) Moebius.	-	-	-	-	-	-	-	-	-	-	-	-	66.33	2.21	1
<i>Monoraphidium</i> sp.	-	-	-	-	-	-	44.22	0.91	1	-	-	-	88.44	2.95	1
<i>Mougeotia</i> sp.	-	-	-	88.44	0.7	3	-	-	-	-	-	-	22.11	0.73	1
<i>Oedogonium</i> 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
<i>Oocystis</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	22.11	0.73	1
<i>O. elliptica</i> w. West	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pediastrum boryanum</i> (Turp.)	-	-	-	46.96	0.37	2	22.11	0.45	1	22.11	0.64	1	71.81	2.39	2
<i>P. tetras</i>	22.11	0.11	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Scenedesmus acuminatus</i> (Lag.) Chod.	22.11	0.11	1	-	-	-	44.22	0.91	1	-	-	-	-	-	-
<i>S. arcuatus</i> Lemm.	44.22	0.23	1	-	-	-	-	-	-	22.11	0.64	1	-	-	-
<i>S. biguga</i> (Turp.) Lag.	-	-	-	66.67	0.53	1	69.07	1.43	2	50.56	1.47	1	88.44	2.95	1
<i>S. diarmorphus</i> (Turp.) Kutz.	-	-	-	-	-	-	-	-	-	22.11	0.64	1	-	-	-
<i>S. quadricauda</i> (Turp.) Breb.	110.55	0.59	4	42.85	0.34	1	88.44	1.83	2	22.11	0.64	1	-	-	-
<i>Spirgyra</i> sp.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	22.11	0.73	1
<i>Tetraedron minimum</i> (A.Br.) Hansg.	-	-	-	-	-	-	22.11	0.45	1	49.7	1.45	1	-	-	-
<i>Ulothrix zonata</i> (F. Weber & Mohr) Kützing	220.93	1.18	5	-	-	-	-	-	-	93.92	2.74	3	-	-	-
<i>Zygnema</i> sp.	65.98	0.35	1	66.33	0.53	2	-	-	-	-	-	-	22.11	0.73	1
CHRYSTOPHYCEAE (Total)	-	-	-	-	-	-	22.11	0.45	-	-	-	-	-	-	-
<i>Dinobryon divergens</i> Imhof.	-	-	-	-	-	-	22.11	0.45	1	-	-	-	-	-	-
CRPTOPHYCEAE (Total)	-	-	-	44.22	0.34	-	-	-	-	-	-	-	-	-	-
<i>Chroomonas</i> sp.	-	-	-	22.11	0.17	1	-	-	-	-	-	-	-	-	-
<i>C. nordstedtii</i> Hansg.	-	-	-	22.11	0.17	1	-	-	-	-	-	-	-	-	-
DINOPHYCEAE (Total)	22.11	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Glenodinium quadridens</i> (Stein.) Schiller	22.11	0.11	1	-	-	-	-	-	-	-	-	-	-	-	-
EUGLENOPHYCEAE (Total)	107.81	0.56	-	-	-	-	-	-	-	42.84	1.24	-	-	-	-
<i>Euglena</i> sp.	64.96	0.34	3	-	-	-	-	-	-	21.42	0.62	1	-	-	-
<i>Lepocinclis</i> sp.	-	-	-	-	-	-	-	-	-	21.42	0.62	1	-	-	-
<i>phacus</i> sp.	42.85	0.22	2	-	-	-	-	-	-	-	-	-	-	-	-
PYROPHYCEAE (Total)	66.33	0.34	-	42.85	0.34	-	-	-	-	49.7	1.45	-	-	-	-
<i>Dinobryon sertularia</i>	22.11	0.11	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Peridinium cinctum</i> (Mull.) Ehr	44.22	0.23	2	42.85	0.34	1	-	-	-	49.7	1.45	1	-	-	-
XANTHOPHYCEAE (Total)	-	-	-	-	-	-	66.33	1.37	-	-	-	-	-	-	-
<i>Tribonema affine</i> G.S. West.	-	-	-	-	-	-	66.33	1.37	1	-	-	-	-	-	-
BACILLARIOPHYCEAE (Total)	15777.46	84.69	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	-
<i>Aulacoseira granulate</i> (Ehr.) Simensen	-	-	-	-	-	-	149.97	3.1	1	74.55	2.17	3	-	-	-
<i>A. varian</i>	49.7	0.26	2	-	-	-	-	-	-	-	-	-	-	-	-
<i>Coscinodiscus lacustris</i> Grun.	-	-	-	49.7	0.39	2	-	-	-	-	-	-	-	-	-
<i>Cyclotella atomus</i> Hustedt.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	24.85	0.82	1
<i>C. compta</i> (Ehr.) Kutz.	-	-	-	24.85	0.19	1	-	-	-	97.69	2.85	2	-	-	-
<i>C. kuetzingiana</i> Thw.	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
<i>C. meneghiniana</i> Kutz.	-	-	-	-	-	-	24.85	0.51	1	49.7	1.45	2	-	-	-

<i>C. ocellata</i> 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
<i>C. striata</i> (Kutz.) Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>Stephanodiscus astrea</i> (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
<i>Achnanthes hungvica</i>	24.85	0.13	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>A. minutissima</i> 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
<i>Amomoeoneis exilis</i> Kutz.	-	-	-	124.43	0.79	2	-	-	-	-	-	-	24.85	0.82	1
<i>Amphora</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	3
<i>A. coffeae formis</i> (Ag.) Kutz.	-	-	-	99.92	0.99	1	-	-	-	-	-	-	-	-	-
<i>A. veneta</i> Kutz.	-	-	-	-	-	-	49.7	1.03	1	124.26	3.62	1	-	-	-
<i>Bacillaria paxillifer</i> (Mull.) Hend.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>Caloneis amphisbaena</i> (Bory.) Cl.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>Cocconeis pediculus</i> 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
<i>C. placentula</i> Ehr.	370.05	1.98	6	621.49	4.96	6	174.48	3.61	3	-	-	-	49.7	1.65	1
<i>C. placentula</i> var. <i>euglypta</i> (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
<i>C. placentula</i> var. <i>lineata</i> (Ehr.) Cl.	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
<i>Cymbella affinis</i> Kutz.	149.11	0.8	3	572.81	4.57	7	224.01	4.64	5	24.85	0.72	1	-	-	-
<i>C. cistula</i> (Hemp.)	-	-	-	-	-	-	24.85	0.51	1	24.85	0.72	1	-	-	-
<i>C. differta</i> (A.Cl.) Krieger.	99.41	0.53	2	124.77	0.99	1	-	-	-	-	-	-	-	-	-
<i>C. microcephala</i> 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
<i>C. pusilla</i> Grun.	298.75	1.6	6	74.55	0.59	3	24.85	0.51	1	-	-	-	-	-	-
<i>C. ventricosa</i> Kutz.	-	-	-	74.55	0.59	2	-	-	-	-	-	-	-	-	-
<i>Denticula</i> sp.	-	-	-	24.85	0.19	1	49.7	1.03	1	24.85	0.72	1	-	-	-
<i>Diatoma elongatum</i> (Lyngb.) Ag.	124.26	0.66	4	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>D. vulgare</i> Bory.	-	-	-	-	-	-	49.7	1.03	1	24.85	0.72	1	-	-	-
<i>Diploneis</i> sp.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>D. ovalis</i> (Hilse.) Cl.	-	-	-	74.55	0.59	2	-	-	-	-	-	-	-	-	-
<i>Epithemia Zebra</i> (Ehr.) Kutz.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>Eunotia pectinalis</i>	-	-	-	-	-	-	49.7	1.03	1	-	-	-	49.7	1.65	1
<i>Fragilaria acus</i> Kutz.	-	-	-	24.85	0.19	1	73.01	1.51	1	-	-	-	-	-	-
<i>F. fasciculate</i>	-	-	-	24.85	0.19	1	-	-	-	149.11	4.35	1	-	-	-
<i>F. nana</i>	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
<i>F. ulna</i> (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
<i>F. vaucheriae</i> (Kutz.) Peters.	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
<i>Gomphoneis olivacea</i> (Lyngb.) Daw.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>Gomphonema angustatum</i> (Kutz.) Rabh.	-	-	-	24.85	0.19	1	-	-	-	124.43	3.63	3	124.26	4.14	3
<i>G. constrictum</i>	-	-	-	-	-	-	48.67	1	1	-	-	-	-	-	-
<i>G. parvulum</i> (Kutz.) Grun.	-	-	-	99.92	0.79	1	-	-	-	-	-	-	-	-	-
<i>Hantzchia</i> sp.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>H. amphioxys</i> (Ehr.) Grun.	-	-	-	-	-	-	24.85	0.51	1	24.85	0.72	1	74.55	2.48	1
<i>Navicula</i> sp.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
<i>N. anglica</i> Ralfs.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	-	-	-
<i>N. atomus</i>	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
<i>N. bacillum</i> Ehr.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>N. crucicula</i> (W.	-	-	-	49.7	0.39	1	-	-	-	-	-	-	-	-	-

Smith.) Donkin.															
<i>N. cryptocephala</i> 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
<i>N. cuspidata</i> Kutz.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	1
<i>N. gracilis</i> Ehr.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>N. halphila</i>	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>N. radiosa</i> Kutz.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	24.85	0.82	1
<i>N. rhynchocephala</i> Kutz.	-	-	-	25.02	0.19	1	-	-	-	24.85	0.72	1	24.85	0.82	1
<i>N. riediana</i> Lange-Bertalot & Rumrich	-	-	-	-	-	-	-	-	-	-	-	-	99.41	3.31	3
<i>N. parva</i> (Menegh.) Cl.	-	-	-	-	-	-	-	-	-	74.55	2.17	2	-	-	-
<i>N. pygmaea</i>	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
<i>N. spicula</i> (Dickie.) Cl.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
<i>N. tuscula</i> (Ehr.) Grun.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	1
<i>N. viridula</i>	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
<i>Nitzchia acicularis</i> W. Smith.	-	-	-	-	-	-	48.67	1	1	74.55	2.17	2	-	-	-
<i>N. amphibia</i> Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>N. angustata</i> (W. Smith.) Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	1	-	-	-
<i>N. apiculata</i> (Greg.) Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	1	-	-	-
<i>N. capronii</i> Breb.	-	-	-	-	-	-	-	-	-	-	-	-	24.85	0.82	1
<i>N. commutata</i> Grun.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>N. dissipatae</i> Grun.	-	-	-	-	-	-	-	-	-	-	-	-	49.7	1.65	1
<i>N. fasciculata</i> Grun.	-	-	-	-	-	-	-	-	-	49.7	1.45	2	-	-	-
<i>N. frustulum</i> (Kutz.) Rabh.	-	-	-	-	-	-	24.85	0.51	1	-	-	-	-	-	-
<i>N. hungarica</i> Grun.	-	-	-	-	-	-	-	-	-	99.41	2.9	1	24.85	0.82	1
<i>N. microcephala</i> Grun.	49.7	0.26	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>N. palea</i> (Kutz.) W. Smith.	224.01	1.2	6	249.9	1.99	2	273.89	5.67	4	-	-	-	124.26	4.14	3
<i>N. sigma</i> (Kutz.) W. Smith.	-	-	-	24.85	0.19	1	-	-	-	-	-	-	-	-	-
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.	49.7	0.26	2	-	-	-	-	-	-	-	-	-	24.85	0.82	1
<i>Pinnularia lundii</i> Hust.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>Surirella</i> sp.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	-	-	-
<i>S. ovata</i> Kutz.	-	-	-	-	-	-	-	-	-	24.85	0.72	1	24.85	0.82	1
Total Density (ind ×10³/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 ×10³/l) of each taxa

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

<i>Chlorella vulgaris</i> Beyer.	38.7	58	90.3	-	-	-	-	187
<i>Coelastrum microporum</i>	-	-	-	12.9	12.9	-	-	25.8
<i>Cosmarium hamneri</i> Rein.	25.8	29	-	-	-	-	-	54.8
<i>Desmodesmus lunatus</i> (West & G.S.West) E. Heg.	101	116.6	90.3	87	29	29	-	452.9
<i>Oedogonium</i> sp.	-	-	-	12.9	-	-	-	12.9
<i>Pediastrum tetras</i>	-	-	-	-	12.9	-	-	12.9
<i>Scenedesmus acuminatus</i> (Lag.) Chod.	-	-	-	-	12.9	-	-	12.9
<i>Scenedesmus arcuatus</i> Lemm.	-	-	25.8	-	-	-	-	25.8
<i>Scenedesmus quadricauda</i> (Turp.) Breb.	12.9	12.9	25.8	-	-	12.9	-	64.5
<i>Ulothrix zonata</i> (F. Weber & Mohr) Kützing	29	29	29	29	-	12.9	-	128.9
<i>Zygnema</i> sp.	-	-	-	38.5	-	-	-	38.5
Total count of Chlorophyceae phytoplankton =								1120.1
EUGLENOPHYCEAE								
<i>Euglena</i> sp.	12.5	12.5	12.9	-	-	-	-	37.9
<i>Phacus</i> sp.	12.5	12.5	-	-	-	-	-	25
Total count of Euglenophyceae phytoplankton =								62.9
DINOPHYCEAE								
<i>Glenodinium quadridens</i> (Stein.) Schiller.	-	-	12.9	-	-	-	-	12.9
Total count of Dinophyceae phytoplankton =								12.9
BACILLARIOPHYCEAE								
Centrales								
<i>Aulacoseira varian</i>	14.5	14.5	-	-	-	-	-	29
<i>Cyclotella ocellata</i> Pant.	14.5	14.5	-	-	29	-	-	58
Pennales								
<i>Achnanthes hungvica</i>	-	-	-	14.5	-	-	-	14.5
<i>Achnanthes minutissima</i> Kutz.	408.2	101	1924.3	5336	58.3	58.3	116.6	8002.7
<i>Cocconeis pediculus</i> Ehr.	-	-	29	-	-	-	14.5	43.5
- <i>placentula</i> Ehr.	14.5	29	29	116	-	12.9	14.5	215.9
- - <i>var. euglypta</i> (Ehr.) Cl.	29	29	14.5	14.5	-	29	14.5	130.5
<i>Cymbella affinis</i> Kutz.	-	-	29	43.5	-	-	14.5	87
<i>Cymbella differta</i> (A.Cl.) Krieger.	29	29	-	-	-	-	-	58
<i>Cymbella microcephala</i> Grun.	-	-	14.5	-	14.5	14.5	-	43.5
<i>Cymbella pusilla</i> Grun.	29	29	14.5	72.8	14.5	14.5	-	174.3
<i>Denticula elegans</i> Kutz.	14.5	14.5	29	14.5	-	-	-	72.5
<i>Fragilaria ulna</i> (Nitz.) Ehr.	14.5	14.5	29	-	-	-	-	58
<i>Navicula cryptocephala</i> Kutz.	-	-	14.5	-	-	-	14.5	29
<i>Nitzschia microcephala</i> Grun.	-	-	-	29	-	-	-	29
<i>Nitzschia palea</i> (Kutz.) W. Smith.	14.5	14.5	14.5	14.5	29	43.7	-	130.7
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.	14.5	14.5	-	-	-	-	-	29
Total count of Bacillariophyceae phytoplankton =								9205.1
PYROPHYCEAE								
<i>Dinobryon sertularia</i>	-	-	-	-	12.9	-	-	12.9
<i>Peridinium cinctum</i>	-	-	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								
<i>Anabaena</i> sp.	25.8							25.8
<i>Aphanocapsa</i> sp.				12.5				12.5
<i>Chroococcus disperses</i>	12.9							12.9
<i>Chroococcus perelegans</i>				25				25
<i>Oscillatoria limnetica</i> Lemm.				25				25
<i>Oscillatoria tenuis</i> Ag.				12.9				12.9
<i>Spirulina</i> sp.	51.6							51.6
<i>S. major</i> Kutz.	38.9							38.9
Total count of Cyanophyceae phytoplankton =								204.6
CHLOROPHYCEAE								
<i>Coelastrum microporum</i>				12.9				12.9
<i>Cosmarium granutum</i>				12.9				12.9
<i>Cosmarium leave</i>				12.9				12.9

<i>Desmodesmus itascaensis</i> M.Fawley	29	29	12.9	12.9	29			112.8
<i>Desmodesmus lunatus</i> (West & G.S.West) E. Heg.	101	90.3	116.6	87	58	29	12.9	494.8
<i>Kirchneriella</i> sp.	38.9							38.9
<i>Mougeotia</i> sp.	12.9		25.8	12.9				51.6
<i>Oedogonium</i> sp.	25.8							25.8
<i>Pediastrum boryanum</i> (Turp.)			14.5	12.9				27.4
<i>Scenedesmus biguga</i> (Turp.) Lag.	38.9							38.9
<i>Scenedesmus quadricauda</i> (Turp.) Breb.				25				25
<i>Spirgyra</i> sp.			14.5					14.5
<i>Zygnema</i> sp.	12.9		25.8					38.7
Total count of Chlorophyceae phytoplankton = 907.1								
CRPTOPHYCEAE								
<i>Chroomonas</i> sp.		12.9						12.9
- <i>nordstedtii</i> Hansg.		12.9						12.9
Total count of Crptophyceae phytoplankton = 25.8								
BACILLARIOPHYCEAE								
Centrales								
<i>Coscinodiscus lacustris</i> Grun.		14.5	14.5					29
<i>Cyclotella atomus</i> Hustedt.	29							29
<i>Cyclotella comta</i> (Her.) Kutz.			14.5					14.5
<i>Cyclotella ocellata</i> Pant.	43.7	29	29	38.7	43.7			184.1
<i>Stephanodiscus astrea</i> (Ehr.) Grun.	14.5	14.5						29
Pennales								
<i>Achnanthes minutissima</i> Kutz.	2915.7	47.3	131.2	160.4	29	218.6	58.3	3560.7
<i>Amphora coffeae formis</i> (Ag.) Kutz.	58.3							58.3
<i>Anomoeoneis exilis</i> Kutz.			14.5		58.1			72.6
<i>Bacillaria paxillifer</i> (Mull.) Hend.		14.5						14.5
<i>Caloneis amphisbaena</i> (Bory.) Cl.		14.5						14.5
<i>Cocconeis pediculus</i> Ehr.	145.7	14.5	29	112		29		330.2
- <i>placentula</i> Ehr.	29.1	130.5	14.5	145		29	14.5	362.6
- - var. <i>euglypta</i> (Ehr.) Cl.	306.1	29	14.5	14.5		14.5	14.5	393.1
<i>Cymbella affinis</i> Kutz.	87.5	43.7	14.5	14.5	14.5	145	14.5	334.2
<i>Cymbella differta</i> (A.Cl.) Krieger.	72.8							72.8
<i>Cymbella microcephala</i> Grun.		14.5			29			43.5
<i>Cymbella pusilla</i> Grun.	14.5		14.5			14.5		43.5
<i>Cymbella ventricosa</i> Kutz.	29				14.5			43.5
<i>Denticula</i> sp.	14.5							14.5
<i>Diatoma elongatum</i> (Lyngb.) Ag.	14.5							14.5
<i>Diploneis</i> sp.	14.5							14.5
- <i>ovalis</i> (Hilse.) Cl.	29	14.5						43.5
<i>Epithemia Zebra</i> (Ehr.) Kutz.		14.5						14.5
<i>Fragilaria acus</i> Kutz.		14.5						14.5
<i>Fragilaria fasciculate</i>				14.5				14.5
<i>Fragilaria ulna</i> (Nitz.) Ehr.	14.5		14.5	14.5				43.5
<i>Gomphonema angustatum</i> (Kutz.) Rabh.						14.5		14.5
<i>Gomphonema parvulum</i> (Kutz.) Grun.	58.3							58.3
<i>Navicula halphila</i>						14.5		14.5
<i>Navicula anglica</i> Ralfs.		29						29
<i>Navicula crucicula</i> (W. Smith.) Donkin.		29						29
<i>Navicula cryptocephala</i> Kutz.	14.5							14.5
<i>Navicula rhynchocephala</i> Kutz.			14.6					14.6
<i>Nitzschia palea</i> (Kutz.) W. Smith.	58.3	87.5						145.8
<i>Nitzschia sigma</i> (Kutz.) W. Smith.	14.5							14.5
Total count of Bacillariophyceae phytoplankton = 6138.3								
PYROPHYCEAE								
<i>Peridinium cinctum</i>				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 $\times 10^3/l$)
of each taxa**

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

<i>Navicula viridula</i>				14.5				14.5
<i>Nitzchia acicularis</i> W. Smith.				28.4				28.4
<i>Nitzchia frustulum</i> (Kutz.) Rabh.							14.5	14.5
<i>Nitzchia palea</i> (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 $\times 10^3/l$) 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.) Hansq.	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

<i>Fragilaria fasciculata</i>	87							87
<i>Fragilaria ulna</i> (Nitz.) Ehr.	14.5	14.5						29
<i>Gomphonopsis olivacea</i> (Lyngb.) Daw.		14.5						14.5
<i>Gomphonema angustatum</i> (Kutz.) Rabh.	29.1	14.5	29					72.6
<i>Hantzchia</i> sp.				14.5				14.5
<i>Hantzchia amphioxys</i> (Ehr.) Grun.		14.5						14.5
<i>Navicula</i> sp.		14.5		14.5				29
- <i>bacillum</i> Ehr.				14.5				14.5
- <i>cryptocephala</i> Kutz.			29	14.5				43.5
- <i>gracilis</i> Ehr.				14.5				14.5
- <i>parva</i> (Menegh.) Cl.		29		14.5				43.5
- <i>radiosa</i> Kutz.				14.5				14.5
- <i>rhynchocephala</i> Kutz.			14.5					14.5
- <i>spicula</i> (Dickie.) Cl.		14.5		14.5				29
<i>Nitzschia acicularis</i> W. Smith.		29		14.5				43.5
- <i>amphibia</i> Grun.				14.5				14.5
- <i>angustata</i> (W. Smith.) Grun.		29						29
- <i>apiculata</i> (Greg.) Grun.				29				29
- <i>commutata</i> Grun.				14.5				14.5
- <i>fasciculata</i> Grun.		14.5		14.5				29
- <i>hungarica</i> Grun.					58			58
<i>Pinnularia lundii</i> Hust.			14.5					14.5
<i>Surirella</i> sp.			14.5					14.5
- <i>ovata</i> 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 $\times 10^3/l$) of each taxa

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

	Total count of Chlorophyceae phytoplankton = 667.5						
BACILLARIOPHYCEAE							
Centrales							
<i>Cyclotella atomus</i> Hustedt.	14.5						14.5
<i>Cyclotella kuetzingiana</i> Thw.	14.5						14.5
<i>Cyclotella ocellata</i> Pant.	29			14.5	14.5		58
Pennales							
<i>Amomoeoneis exilis</i>					14.5		14.5
<i>Achnanthes minutissima</i> Kutz.				14.5		14.5	43.5
<i>Amphora</i> sp.					29		29
<i>Cocconeis pediculus</i> Ehr.			14.5				14.5
- <i>placentula</i> Ehr.	29						29
- - <i>var. euglypta</i> (Ehr.) Cl.	14.5						14.5
<i>Cymbella microcephala</i> Grun.				29			29
<i>Denticula</i> sp.					29		29
<i>Eunotia pectinalis</i>					29		29
<i>Fragilaria nana</i>					14.5		14.5
- <i>construens</i> (Ehr.) Grun.							
- <i>ulna</i> (Nitz.) Ehr.			14.5		29		43.5
<i>Gomphonema angustatum</i> (Kutz.) Rabh.				29		29	72.5
<i>Hantzchia amphioxys</i> (Ehr.) Grun.			43.5				43.5
<i>Navicula cryptocephala</i> Kutz.		14.5	72.5				87
<i>Navicula cuspidata</i> Kutz.		29					29
<i>Navicula pygmaea</i>					14.5		14.5
<i>Navicula radiosa</i> Kutz.		14.5					14.5
<i>Navicula rhynchocephala</i> Kutz.		14.5					14.5
<i>Navicula riediana</i> Lange-Bertalot & Rumrich	14.5		29		14.5		58
<i>Navicula tuscua</i> (Ehr.) Grun.		29					29
<i>Nitzschia dissipata</i> Grun.			29				29
<i>Nitzschia hungarica</i> Grun.		14.5					14.5
<i>Nitzschia palea</i> (Kutz.) W. Smith.			29	14.5	29		72.5
<i>Rhoicosphenia curvata</i> (Kutz.) Grun.			14.5				14.5
<i>Nitzschia capronii</i> Breb.			14.5				14.5
<i>Surirella ovata</i> 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

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دراسة نوعية وكمية للطحالب في ثلاث محطات لمياه الشرب ينبوعية المصدر في محافظة السليمانية – اقليم كردستان العراق

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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 سبجان اغا لمياه الشرب في قضاء سيد صادق، وتقع المحطة الخامسة في مشروع خورمال لمياه الشرب في ناحية خورمال ضمن قضاء حلبجة.

شملت الدراسة دراسة نوعية للهائمات النباتية ودراسة كمية 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 لـ *Bacillariophyceae* (دايتومات)، و 35 نوع تابعة لـ *chlorophyceae* (طحالب خضراء)، و 30 نوع تابعة لـ *Cyanophyceae* (خضراء مزرقية) وغيرها، ومن خلال العدد الكلي للطحالب كانت الدايتومات هي السائدة على جميع الانواع الاخرى في جميع المحطات تليها الطحالب الخضراء ثم الطحالب المزرقية.

نتائج الدراسة الكمية او العددية للهائمات النباتية اظهرت تسجيل اعلى كثافة للهائمات النباتية خلال الدراسة في المحطة الاولى (18377.28 ind×10³/l) تليها (12513.34 ind×10³/l) في المحطة الثانية ثم (4779.45 ind×10³/l) في المحطة الثالثة.

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