ALGAL STUDY IN SPRINGS AND STREAMS IN SHAQLAWA DISTRICT, ERBIL PROVINCE-IRAQ III- CHLOROPHYCEAE WITHOUT ZYGNEMATALES

Janan. J. Toma **Farhad. H. Aziz**
Assist. Prof. **Prof.**
Dept. Environ Sci and Health, Sci Coll. University of Salahaddin-Erbil, Kurdistan Region- Iraq
Email: janan.toma@su.edu.krd

ABSTRACT

Freshwater algae (Chlorophyceae-except Zygnematales) were collected from 18 sites (12 springs and 6 streams) in Shaqlawa district within Erbil Province, Kurdistan Region of Iraq from September-2019 to August-2020. Aim of this study isolation and identification new algal species. 27 new algal genera with 40 species records at first time in Kurdistan Region and others provinces of Iraq, which include the following, *Scenedesmus* considered the most abundance than others algae which seven species identified followed by genus of *Chlamydomonas*, genus of *Chlorophyceae*, genus of *Characium* with three species for each one recorded, but genera *Geminella* have two species, finally the remaining genera have one species identified for each one

Keywords: freshwater, genera, species, first, time, records

مجلة العلوم الزراعية العراقية -2023 :54(1):70-84 **توما و عزيز**

دراسة الطحالب في الينابيع والجداول في قضاء شقلاوة ، محافظة أربيل – العراق

جنان جبار توما **فرهاد حسن عزيز**
استاذ مساعد **أستاذ**
قسم علوم البيئة والصحة، كلية العلوم، جامعة صلاح الدين–اربيل، اقليم كردستان–العراق

المستخلص

تم جمع طحالب المياه العذبة (صنف كلوروفايسي عدا زيكنيمتاليس) من 18 موقعا (اثني عشر ينبوع وستة جداول)في قضاء شقلاوة ضمن محافظة اربيل– اقليم كردستان العراق من ايلول–2019 الى أب– 2020 .الهدف من البحث هو عزل وتشخيص انواع جديد من الطحالب .أظهرت النتائج عزل وتشخيص 27 جنسا مع 40 نوعا تم تشخيصهم لاول مرة في اقليم كردستان وباقي محافظات العراق، حيث شملت جنس سينيدسمس الذي يعد الاكثر وفرة من بقية الطحالب حيث تم تشخيص سبعة انواع منه ، يليه كل من جنس كلاميديمونس ، وجنس كلوروفيسما وجنس كاراسيم وكل واحد منهم شخص له ثلاث انواع بينما جنس جيمينيلا شخص له نوعان فقط واخيرا الاجناس المتبقية تم تشخيص نوع واحد لكل منها.

الكلمات المفتاحية : المياه العذبة، أجناس، أنواع، أول، مرة، تسجل

Received:11/5/2021, Accepted:15/8/2021

INTRODUCTION

All aquatic system in the world found above and under surface of the earth, which their quality changes during anthropogenic activities, among fresh water algae considered as a primary producer and main source of energy for the remaining organisms within their ecosystem (20, 5, 30). Algae are considered importance groups from others organisms for their positive effect on human life(36). Microalgae represented very diverse and specialized groups of microorganisms their varied depended to environmental factors(35) .Microalgae take more attention for many researcher around the world for their many application in different field that very vital for human life(3). Chlorophyceae and other types of microalgae contain many types of bioactive compounds, like protein, lipids, pigments and amino acid which are responsible for formation antimicrobial, antioxidant , biofuel also they are able to produce nanoparticles (1) . It's very necessary to explore and identified new and very rare species of Chlorophyceae from various areas and maintain in culture for future studies or research that may be contain many bioactive compounds that serves humanity in many field (34). Studies about different kinds of fresh water algae within Chlorophyceae has been done domestically in Kurdistan region and others parts of Iraq by many authors such as (2 , 4 , 7, 9, 11, 13).The main purpose of the current works is to isolation and classification of Chlorophyceae algae in order to add new species that recording first time in the environmental of Shaqlawa district to list of algal flora of Kurdistan Region and Iraq.

MATERIALS AND METHODS

Description of studied sites: Aquban and Sarkand villages belong to Shaqlawa District is about 32Km northeast of Erbil city which is located north-east of Iraq, at 36° 42′ to 36^0 23′ N latitude and 44° 29′ to 44° 08′ E longitude. Knowledge about climate, hydrology, soil and geology are given by (9, 14). Sites under study in Aquban consist of five shallow to medium depth (1, 2, 3, 4 and 5) found within mountain area contain different types of trees. In Sarkand village, six sites (6, 7, 8, 9, 11 and 14) along stream and seven springs (10, 12, 13, 15, 16, 17 and 18) follow from mountain area then to stream flow. All the studied sites is about 40 Km long (figure 1).

Collection, preservation and Identification of algae: Algal samples were collected by plankton net for planktonic forms and squeezing from leaves and stems of macrophytes plants. Then samples were preserved by using 1ml of lugal´s solution or formalin in air tight poly lab vial sealed and labeling then brought to laboratory(8). Chlorophyceae and other algae concentrated by sedimentation and examined under microscope (32, 33, 19, 18, 37). More details in this study carried under light microscope with camera and micrometer(µm)were used to explain long and wide for each species and photograph were taken and recorded species were checked by the last two check list (10, 26).

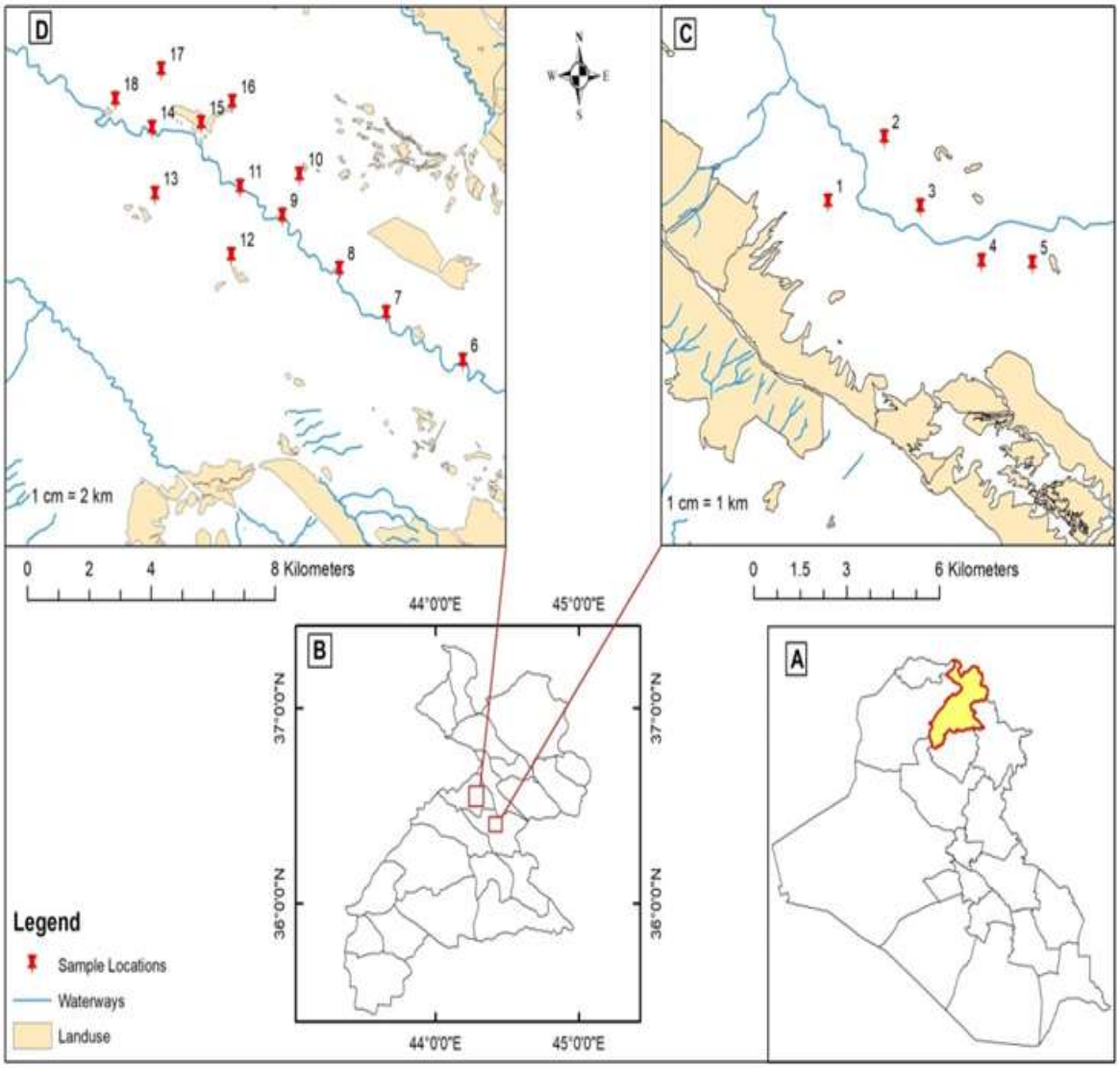


Figure 1. A- Map of Iraq and Erbil province shaded B- Map of Erbil governorate C-quban village D- Sarkand village

RESULTS AND DISCUSSIONS

In the current study a total of 40 new records of Chlorophyceae species were identified from Shaqlawa district, within Erbil Province during September-2019 till August-2020, these species are belong to 27 genera and 18 family, 8 order and one class (Table 1 and 2) (10, 26). In this study ***Scenedesmus*** considered dominance one than others genera with seven species identified, this may be due that ***Scenedesmus*** considered high productive among others green algae and its membrane layers containing passive zone for absorption heavy metals and nuclides(27).While genera ***Chlamydomonas*** , ***Chlorophysema*** recorded in this study with three species for each genus, they able to tolerance low temperature and appeared in late spring in this study, similar conclusion made by (16),***Characium*** **and Geminella** have two species for each genus, they able to adaptation and tolerate the stress of changes in environmental factors, and the results of this work were in agreement with a study done by others (28, 6) , and the remaining genera have one species for each one. The differences of various species found in sites under study this may be due to the geology of the area, depths of sites, seasonal variations and environmental conditions (2, 3).Also some genera found in small water system and in pool was temporary, and some genera found or live in winter seasons, while most of the species are only recorded or thrive in summer seasons (3). By accurate diagnostic and depending on new and scientific references we were able to determine new records species of algae not identified in Iraq so far and add them in the list of algal flora of Iraq and appear it as follows.

Table 1.List of new records species of Chlorophyceae in the study sites during the studied period

Division: Chlorophyta	
Class: Chlorophyceae	***Stylosphaeridium*** **Geitler & Gimesi, 1925**
Order: Chlamydomonadales	**11-*Stylosphaeridium stipitatum* (Bachmann) Geitler et Gimesi 1925**
	Family Palmellopsidaceae
Family:Chlamydomondaceae	
Chlamydomonas **Ehrenberg 1892**	***Nautocapsa*** **(Czosnowski) H.et O.Ettl 1959**
1- *Chlamydomonas bolyaiana* Kol 1947	**12-*Nautocapsa neustophila* (Czosnowski) H.et O.Ettl 1959**
2-*Chlamydomonas sanguinea* Lagerheim 1892	**Family Protosiphonaceae**
3-*Chlamydomonas yellowstonesis* Kol 1941	***Protosiphon*** **(Kutzing) Klebs 1896**
4-*Vitreochlamya aulata* Korschikoff 1925 Syn: *Chlamydomonas aulata* Pascher 1927	**13-*Protosiphon botryoides* (Kutzing) Klebs 1896**
Family Chlorochytriaceae	**Family Tetrasporaceae**
Chlorochytrium **Cohn, F. (1872).**	***Chaetochloris*** **Pascher & Korshikov, 1932**
5-*Chlorochytrium facciolae* (Borzi) Bristol 1920	**14-*Chaetochloris depauperata* Pascher1940**
Family Chlorococcaceae	**Order Sphaeropleales**
Nautococcus **Korshikov 1926**	**Family Characiaceae**
6-*Nautococcus mammilatus* Korshikov 1971	***Ankyra*** **Fott 1957**
Radiosphaera **J.W.Snow1918**	**15-*Ankyra judayi* (G.M.Smith) Fott 1957**
7-*Radiosphaera dissecta* (Korshikov) Starr 1955	***Characium*** **A.Braun in Kutzing 1849**
Family Chlorangiellaceae	**16-*Characium cylindricum* A. Braun in Kutzing 1849**
Chlorophysema **Pascher 1927**	**17-*Characium saccatum* Filarsky 1914**
8-*Chlorophysema ampliata* Skuja 1956	**18-*Characium sieboldii* A.Braun 1855**
9-*Chlorophysema melosirae* Fott 1945	**Family Hydrodictyaceae**
10-*Chlorophysema inertis* (Kors) Pascher 1953	***Pediastrum*** **Meyen 1829**

Table (1) Continued

19-*Pediastrum integrum* var. *priva* Printz 1914	**33-*Klebsormidium dissectum* P.C.Silva 1972**
Tetraedron **Lemmermann 1808**	**Order Chlorellales**
20-*Tetraedron caudatum* var. *longispinum* Lemmermann 1808	**Family Chlorellaceae**
Family Schizochlamydaceae	***Closteriopsis*** **Lemmermann, E. 1899**
21-*Planktosphaeria gelatinosa* G.M.Smith1918	**34-*Closteriopsis acicularis* (G.M.Smith) J.H.Belcher et Swale 1962**
Family Scenedesmaceae	***Golenkiniopsis*** **Korshikov 1953**
Scenedesmus **Meyen 1829**	**35-*Golenkiniopsis chlorelloides* (J.W.G.Lund) Fott 1981**
22-*Scenedesmus bernardii* G.M.Smith 1916 Syn: *S. acuminatus* var *bernardii* (G.M.Smith) Dedusenko	***Geminella*** **Turpin 1828**
23-*Scenedesmus circumfusus* Hortobagy 1960	**36-*Geminella pulchra* Turpin 1828**
24-*Scenedesmus costatus* Schmidle 1895	**37-*Geminella ellipsoidea* G.M.Smith 1950**
25-*Scenedesmus raciborskii* Woloszynska 1914	**Order Trebouxiales**
26-*Scenedesmus obtusus* Meyen 1829	**Family Trebouxiaceae**
27-*Scenedesmus* sp Meyen 1829	***Myrmecia*** **G.M.Smith 1933**
28-*Scenedesmus planctonica* (Korshikov) Fott 1973 Syn: *Didymocystis planctonica* Korshikov 1962	**38-*Myrmecia aquatic* G.M.Smith 1933**
Tetradesmus **G.M.Smith 1913**	**Order Trentepohliales**
29-*Tetradesmus wisconsinense* G.M.Smith 1913	**Family Trentepohliaceae**
Family Selenastraceae	***Trentepohlia*** **Martius, C.F.P. von 1817**
Chlorolobion **Korshikov, A.A.1953**	**39-*Trentepohlia arborum* C. Agardh 1889**
30-*Chlorolobion* obtusum Korschi 1958	**Order Chlorodendrales**
Monoraphidium **Legnerová, 1969**	**Family Chlorodendraceae**
31-*Monoraphidium komarkovae* Nygaard 1979	***Tetraselmis*** **F.Stein 1878**
Pseudokirchneriella **(Korshikov) F.Hindák 1990**	**40-*Tetraselmis cordiformis* (H.J.Carter) F.Stein 1878**
32-*Pseudokirchneriella subcapitata* (Korshikov) F.Hindák 1990	
Order: Klebsormidiales	
Family: Klebsormidiaceae	
Klebsormidium **P.C.Silva, Mattox 1972**	

Table 2. New records with their percentages in the study sites during the studied period

	Name of Algal genus	Number of Species	New Records Species	%
	Division: Chlorophyta			
	Class: Chlorophyceae			
1	***Chlamydomonas* Ehrenberg 1892**	3	3	7.5
2	***Vitreochlamya* Korschikoff 1925**	1	1	2.5
3	***Chlorochytrium* Cohn, F. (1872)**	1	1	2.5
4	***Nautococcus* Korshikov 1926**	1	1	2.5
5	***Radiosphaera* J.W.Snow, 1918**	1	1	2.5
6	***Chlorophysema* Pascher 1927**	3	3	7.5
7	***Stylosphaeridium* Geitler 1925**	1	1	2.5
8	***Nautocapsa* H.et 1959**	1	1	2.5
9	***Protosiphon* (Kutzing) Klebs 1896**	1	1	2.5
10	**Chaetochloris Pascher & Korshikov, 1932**	1	1	2.5
11	***Ankyra* Fott 1957**	1	1	2.5
12	***Characium* A.Braun in Kutzing 1849**	3	3	7.5
13	***Pediastrum* Meyen 1829**	14	1	2.5
14	***Tetraedron* Lemmermann 1808**	1	1	2.5
15	***Planktosphaeria* G.M.Smith 1918**	1	1	2.5
16	***Scenedesmus* Meyen 1829**	18	7	10
17	***Tetradesmus* G.M.Smith 1913**	1	1	2.5
18	***Chlorolobion* Korshikov, A.A.1953**	1	1	2.5
19	***Monoraphidium* Legnerová, 1969**	1	1	2.5
20	***Pseudokirchneriella* Korshikov 1990**	1	1	2.5
21	***Klebsormidium* P.C.Silva, Mattox 1972**	1	1	2.5
22	***Closteriopsis* Lemmermann, E. 1899**	1	1	2.5
23	**Golenkiniopsis Korshikov 1953**	1	1	2.5
24	***Geminella* Turpin 1828**	3	2	5
25	***Myrmecia* G.M.Smith 1933**	1	1	2.5
26	***Trentepohlia* Martius, C.F.P. von 1817**	1	1	2.5
27	***Tetraselmis* F.Stein 1878**	1	1	2.5
	Total	62	40	

Descriptions of new records

***Chlamydomonas bolyaiana* Kol 1947(Pl.1, Fig.1):** Cell4-15µm width,5-18µm length , oval to circular shape, thin cell membrane found around cell, chloroplast distributed in most of body cell, appeared in late spring when air temperature increase. (Pl.3, Fig 15-27) (21).Identified along streams at site 9 during August-2020.

***Chlamydomonas sanguinea* Lagerheim 1892 (Pl.1, Fig.2):** Cells 4-12µm in width and 6-16µ in length , their membranous no cellulosic, circular to oval in shape, circular and transparent portion found in upper part of body cell, rounded in basal site of cell., found in terrestrial and in freshwater, appeared in late summer when air temperature rise but can able to tolerance low temperature. (Pl.3, Fig 30-40)(21). Records in Sard and Zhnan springs during February-2020

***Chlamydomonas yellowstonesis* Kol 1941 (Pl.1, Fig.3):** Cells 4- 10µm in width and 6-14µm in length ,Cell shape like pear or oval to ellipsoidal, Chloroplast cup shaped, with eye spot , a large pyrenoid appeared , palmella stage presence, found in freshwater and terrestrial. (Pl.3, Fig.1-12,14)(21). Found in Piawan spring during July-2020

***Vitreochlamya aulata* (Pascher) Gerloff 1940 (Pl.1, Fig.4):** Cell 10-30µm width and15-38µm length, its spherical or may be inverted ovoid or ellipsoidal form, wide and thin cell wall, papilla absent, chloroplast have cup form, nucleus in the center of cell, pyrenoids present(Pl.15, Fig.5-10)(25).

***Chlorochytrium facciolae* (Borzi) Bristol 1920 (Pl.1, Fig.5):** Cells 4-16µm width and 6-22µm length, ellipsoidal to spherical shape, solitary cell, with thick wall, single pyrenoids found within chloroplast. (P.477, Pl.136B) (18). Found in Nawkand Spring in November-2019

***Nautococcus mammilatus* Korshikov 1971 (Pl.1, Fig.6) :** cell 5-10µm width and 7-15µm length, oval to ellipsoidal shaped and elongated, upper end rounded , while other end attenuated to small tail, chloroplast covered most of body cell. (P.38, Pl.38) (31) . Identified in Piawan spring during June-2020

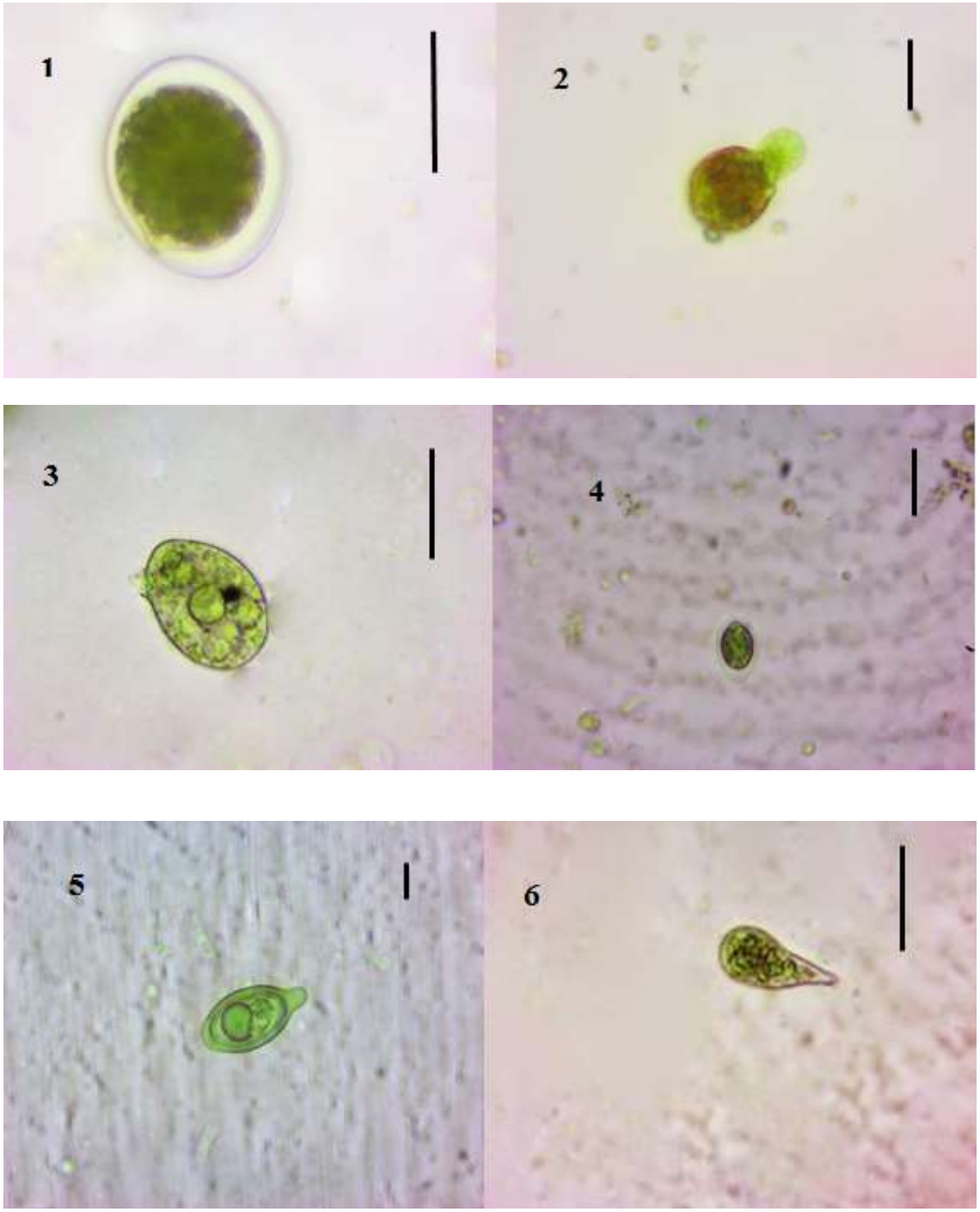


Plate 1. Photomicrographs of Algae species recorded in the study area: 1. *Chlamydomonas bolyaiana,* 2. *Chlamydomonas sanguinea*, 3. *Chlamydomonas yellowstonesis*, 4. *Vitreochlamya aulata,* 5. *Chlorochytrium facciolae, 6. Nautococcus mammilatus* Scale bar=10µm

***Radiosphaera dissecta* (Korshikov) Starr 1955 (Pl.2, Fig.1) :** cells 30-150 µm width, spherical to ellipsoidal shape, one chloroplast for a cell and broad lobes dividing directly toward end, pyrenoid and vacuoles present . (P.328, Pl.82P)(19). Found along streams at site 7 during from November-2019

***Chlorophysema ampliata* Skuja 1965 (Pl.2, Fig.2):** Cells 5-10µm width and 7-15µm length, circular to ovoid shaped, upper end rounded, lower end terminated with small stalk, Chloroplast cover most of the cell. (P.19, Pl.19)(31).Identified along stream at site 11 during July-2020

***Chlorophysema inertis* (Kors) Pascher 1927 (Pl.2, Fig.3):** Cells 4-8µm width and 6-12µm length, oval to circular shaped, small projection found in upper portion, basal part rounded, cell body surrounded with mucilaginous sheath, chloroplast parietal. (P.24, Pl.24)(31).Recorded along stream in site 9 during August-2020

***Chlorophysema melosirae* Fott 1927 (Pl.2, Fig.4):** Cells 5-10µm in width and 6-12µm length, chloroplast distributed in all of cell body, cell surrounded by broad mucilaginous sheath. (P.24, Pl.24)(31). Found in Benwan spring during March-2020.

***Stylosphaeridium stipitatum* (Bachmann) Geitler et Gimesi 1925 (Pl.2, Fig.5):** Cells 4-8µm width and 5-10µm length, long stalk found, cup shaped chloroplast, and pyrenoid at basal, eye spot may be present or absent. (19) (P.301, Pl.76K). Identified along streams at site 8 during June-2020

***Nautocapsa neustophila* (Czosn) H.et O.Ettl 1922 (Pl.2, Fig.6) :** Cells 6-8µm width and 10-15µm length, solitary, colored, thin mucilaginous sheath surrounded it, open cell at the base and closed from upper part of cell, chloroplast single covered most of cell body, pyrenoids found within cell. (P. 41, Pl. 41)(31). Recorded in Azarian spring through July-2020

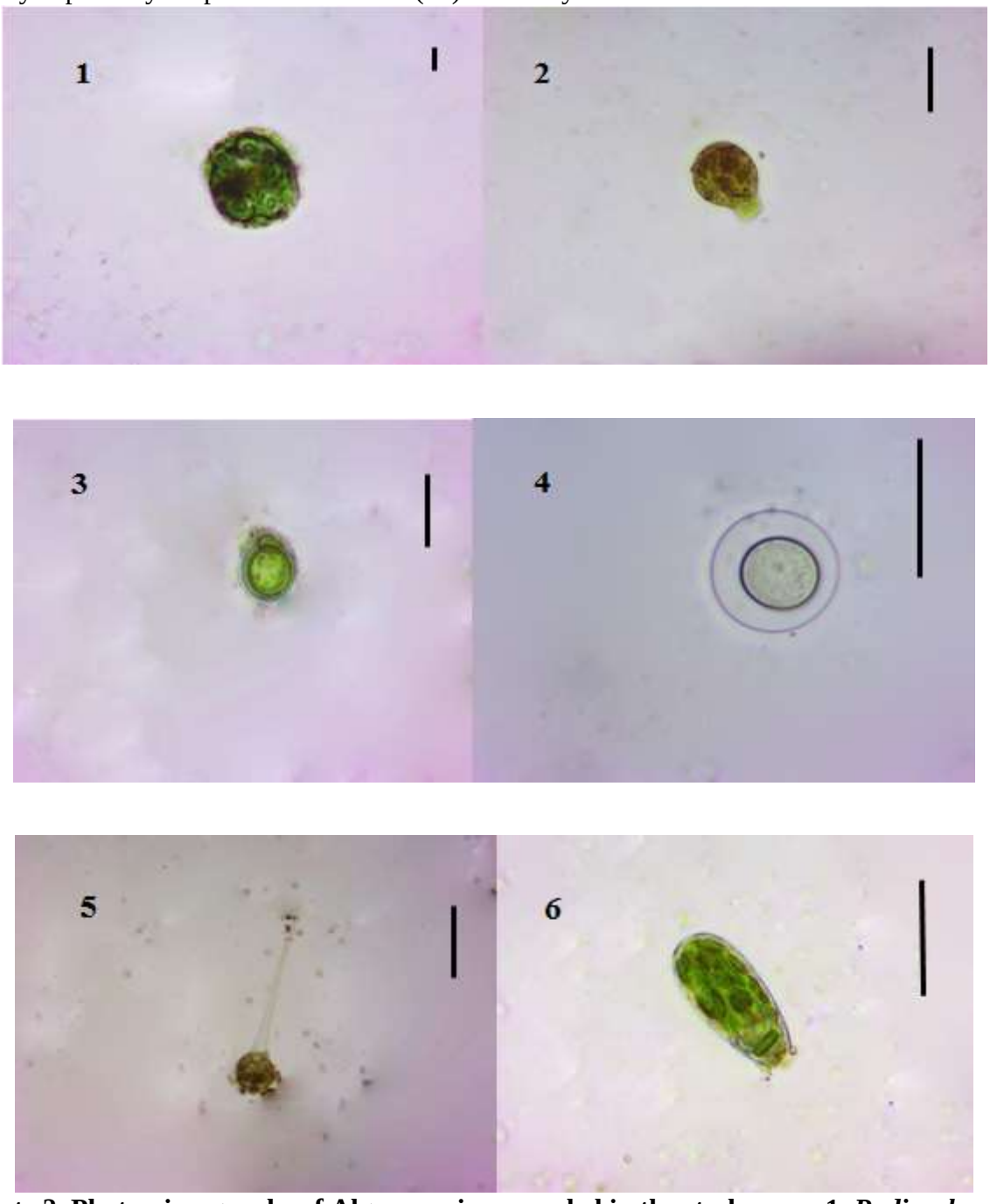


Plate 2. Photomicrographs of Algae species recorded in the study area: 1. *Radiosphaera dissecta*, 2. *Chlorophysema ampliata*, 3. *Chlorophysema inertis*, 4. *Chlorophysema melosirae*, 5. *Stylosphaeridium stipitatum*, *6. Nautocapsa neustophila* Scale bar=10µm

***Protosiphon botryoides* Kutzing 1896 (Pl.3, Fig.1):** Cells 5-15µm width and 25-95µm length, Unicellular, found in the fresh water comprise only one species, upper portion is broad and tubular bulbous form or like vesicular sac, rhizoid like portion long and extend to penetrate to soil, chloroplast have reticulate form and cover most of cell . (P.790, Pl.1-3) (29). Found in Sard spring during April-2020.

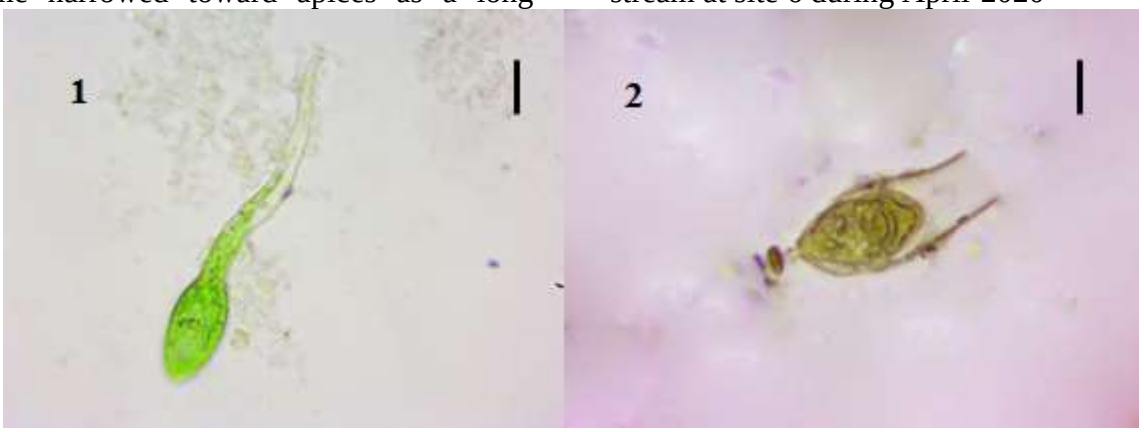
***Chaetochloris depauperata* Pascher1940 New Record (Pl.3, Fig.2):** Cells 15-25µm width, 20-50µm length, oval to ellipsoidal shaped, lower portion of cell have small stalk ended by small base to establishment, upper portion rounded, open cellular membranous surrounded the cells closed from lower but opened in the upper part.(P.28, Pl.28)(31).Recorded along streams at site 11 during October-2019

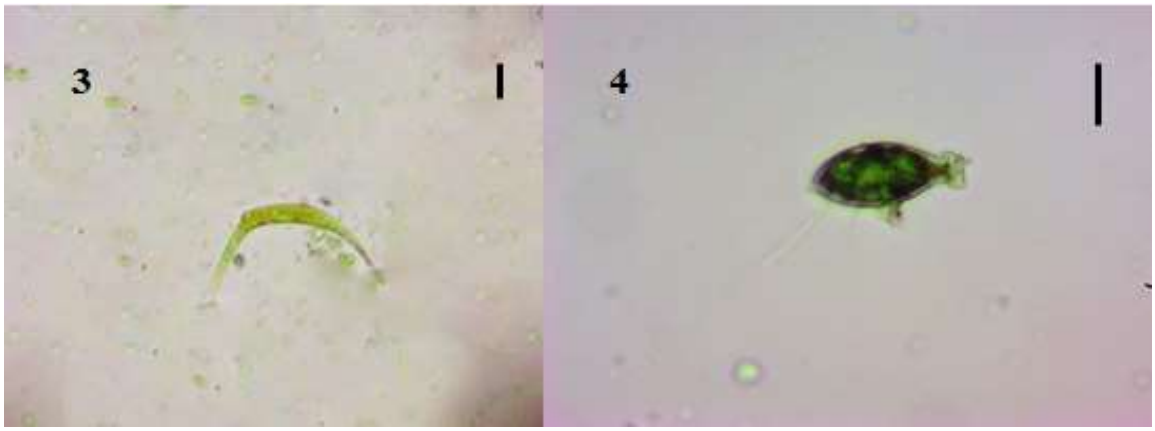
***Ankyra judayi* (G.M.Smith) Fott 1957 (Pl.3, Fig.3):** Cells 2-9µm width and 30-100µm length, slightly straight or curved depend on their age, shape varied from linear to spindly, become narrowed toward apices as a long spine. (P232-234) (25). Observed in Piawan spring during February-2020

***Characium saccatum* New Record (Pl.3, Fig.4):** Cell 12-25µm width, 35-37µm length, pear to ovoid and fusiformis shaped ,small stalk with base in lower end, both end narrowed than middle part of the species is brooded, Chloroplast distributed in almost of cell body.(17) Found is Piawan spring during December-2019

***Characium cylindricum* A. Braun in Kutzing 1849 (Pl.3, Fig.5):** Cells 10-20µm width, 24-430µm length, apex is rounded, tapering other end as a short stipe, cylindrical form, clear nucleus in center of organism and chromatophore is parietal.(P.73, Pl.79) (24). Identified in along stream at site 9 during December-2019

***Characium sieboldii* A.Braun 1855 (Pl.3, Fig.6):** Cells 17-33 µm width, 40-70µm length, appeared initially elongate to oval to linear then became pear form or ovoid, with limited short and thick stalk, very thin wall seen. (P.426, Pl.106J) (18). Recorded in along stream at site 6 during April-2020





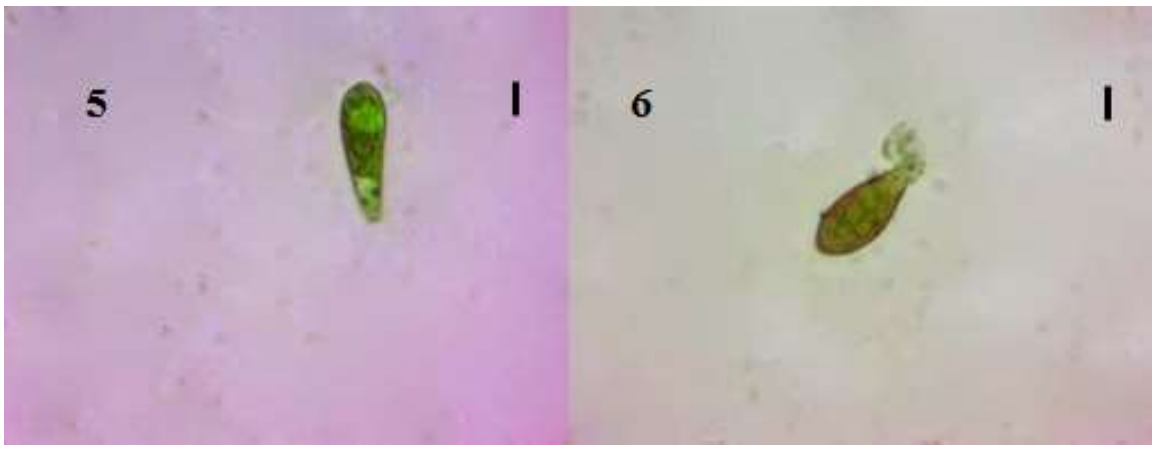


Plate 3.: Photomicrographs of Algae species recorded in the study area: 1. *Protosiphon botryoides*, 2. *Chaetochloris depauperata*, 3. *Ankyra judayi*, 4. *Characium saccatum*, 5. *Characium cylindricum, 6. Characium sieboldii* Scale bar=10µm

***Pediastrum privum* (Printz) E. Hegawald in Hegawald and Schnepf 1979 (Pl.4, Fig.1):** Coenobium 4-8, around 25µm across, sometimes cells have colorless thick mucilage surrounded it, cells 3.5-12µm , triangular-square or rounded shape in outside, very shallow outer wall and usually not clear. (P.465, Pl. 115K) (18). Found in Darmanawa spring through June-2020

***Tetraedron caudatum* var. *longispinum* Lemmermann 1808 (Pl.4, Fig.2):** Cells flat with five sided, rounded angles within sharp and short spines, sides is concave between angles, longest cell dimension is 4-22µm.Cells 5-8µm width, (P.263,Pl.59, Fig.17, 24-25)(33). Identified along streams at site 8 through March-2020

***Planktosphaeria gelatinosa* G.M.Smith 1918 (Pl.4, Fig.3):** Cells 12-234µm width, spherical shape and found solitary, loose aggregation through division of cell and without mucilaginous sheath, chloroplast has cup shape with pyrenoid. (P.439,Fig.3.221) (25). Found along stream at site 7 during October-2019

***Scenedesmus bernardii* G.M.Smith 1916 Syn: S. acuminatus var bernardii G.M.Smith (Pl.4, Fig.4):** Coenobia of 2-4-8-16cells, arrangement in zigzag, every cell united to adjacent cell by its apical or sub apex or may be median portion, cells 1.5-7.3µm width, 7-48µm length. (P.390, Pl.96P)(19) . Recorded along streams at site 8 in August-2020

***Scenedesmus circumfusus* Hortobagy 1960 (Pl.4, Fig.5):** Coenobia in a row 2-4 or 8 linear cells arranged, cells2.0-5.5µm width, 8-16.8µm length, and cells ovoid and elongate, apices rounded, 1-2 short and small teeth may be straight or slightly curved, a single longitudinal row of warty teeth. (P.390, Pl.96F) (19). Found in Prenga spring in June-2020

***Scenedesmus costatus* Schmidle 1895 (Pl.4, Fig.6):** Coenobia is flat, comprising of 2, 4 or 8-16 cells distributed in two rows, cells 4-14µm width, 7.5-22µm length, not content mucilaginous sheath, space present between apices, straight or curved slightly. (P.392, Pl.96K) (18). Found in along streams in site 11 during November-2019

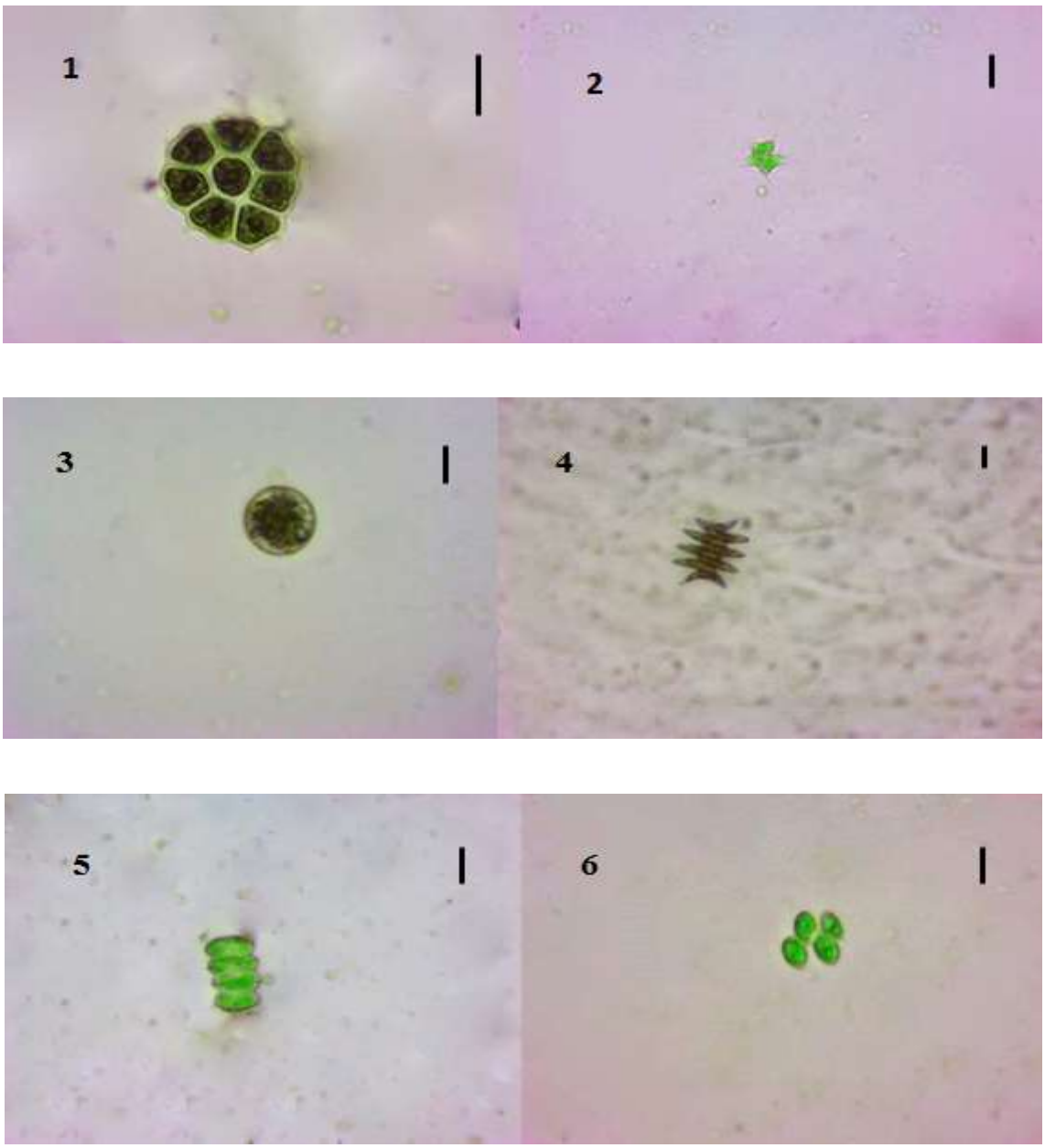


Plate 4: Photomicrographs of Algae species recorded in the study area: 1. *Pediastrum privum*, 2. *Tetraedron caudatum* var. *longispinum*, 3. *Planktosphaeria gelatinosa*, 4. *Scenedesmus bernardii*, 5. *Scenedesmus circumfusus, 6. Scenedesmus costatus* Scale bar=10µm

***Scenedesmus obtuse* Meyen 1829 (Pl.5, Fig.1):** Coenobia of 2 rows of 4 or 8 clearly cell arrangement alternating, cells contact though Subapical part, Cells 3-13µm width, 4-21µm length, apices are round, and convex to outside. (P.397, Pl.97D)(19). Recorded in along stream at site 11 during November-2019

***Scenedesmus* sp Meyen 1829 (Pl.5, Fig.2):** Cells 3-5-5.5µm width, 15-15µm length, colonies 2,4 or 8 cells connected by side, linearly arrangement, body of cell spindle to elliptical in shape, cells ended with medium to long spines (19). Found along streams at site 8 during September-2019

***Scenedesmus planctonicus* (Korshikov) Fott 1975 Syn: Didymocystis planctonica Korshikov (Pl.5, Fig.3)** : Coenobia of 2 cells attached by straight wall, cells 2.4-6.5µm width, 6-12µm length, ovoid broadly with concave outer wall and straight inner wall (P.397, Pl.97E) (19) . Identified along streams at site 14 and in Darmanawa spring during August-2020

***Scenedesmus raciborskii* Woloszynska 1914 Syn: *S. incrassatulus* var *mononae* G.M.Smith (Pl.5, Fig.4):** Coenobia of 2 or 4 cells arrangement alternately or linearly, curved but slightly or straight, cells 2.5-11.3µm width, 9-28µm length, spindle form (

P. 397, Pl. 97F) (19). Identified in along stream at site 9 and 11 during August-2020

***Tetradesmus wisconsinense* G.M.Smith 1913 Prescott Book (Pl.5, Fig.5):** Cells4-6µm width, 6-12µm length, have fusiform shape with long axes, cells connected to each other's by lateral walls, outer walls is concave form, cell narrowed at the poles, quadrate arrangement of cell appeared (P.283, Pl.64,Fig.12-14) (33) . Recorded along streams at site 8 during August-2020

***Chlorolobion obtusum* Korschi (Pl.5, Fig.6): Cells** 2-12 width, 12-45 length, Solitary cell may attached or free living, spindle to cylindrical shape, chloroplast covered almost of cell, pyrenoid seen in the cell, sometimes oil droplet present (P.284, Fig.245)(23). Recorded in Piawan spring during December-2020

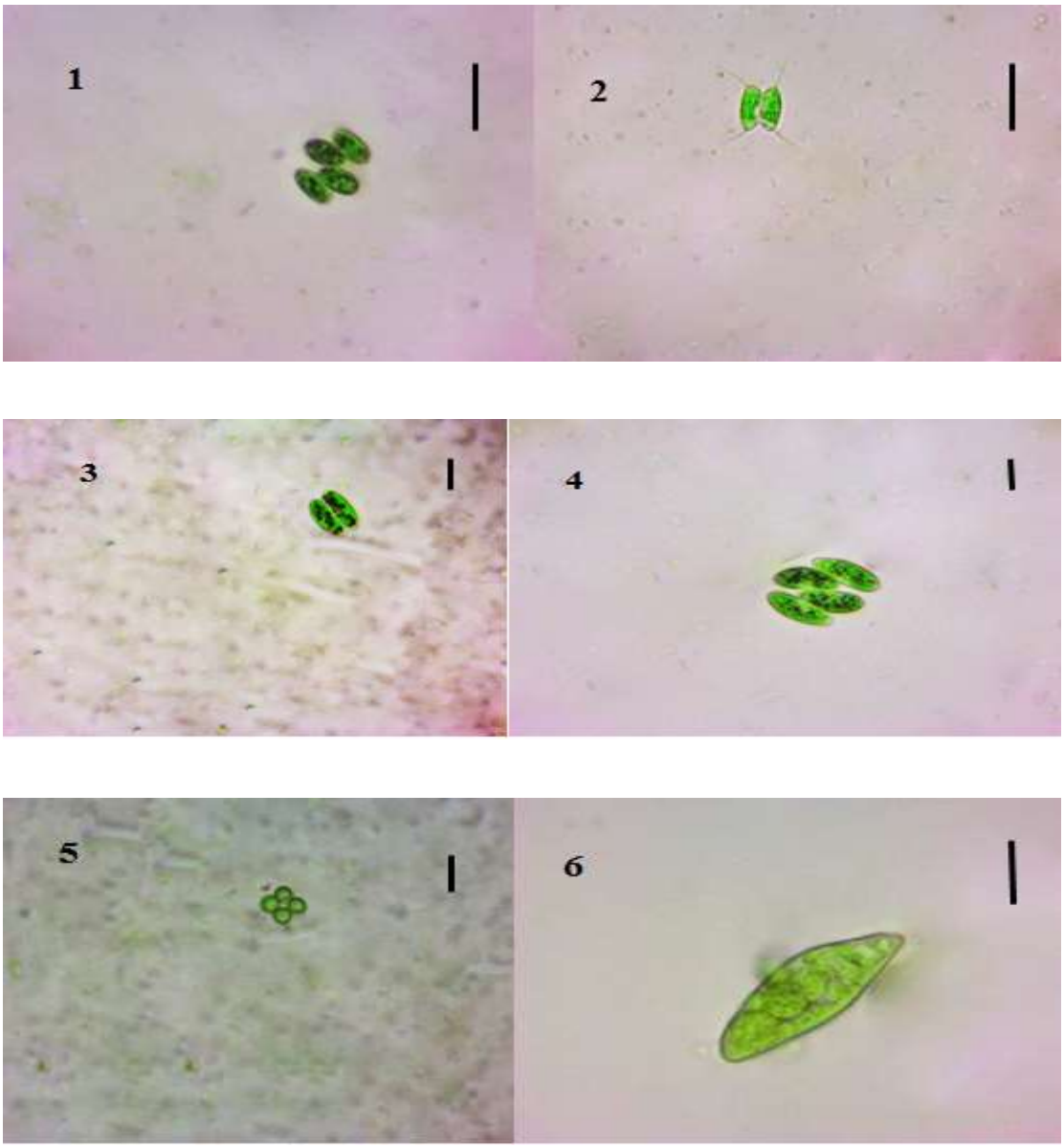


Plate 5. Photomicrographs of Algae species recorded in the study area: 1. *Scenedesmus obtusus*, 2. *Scenedesmus* sp, 3. *Scenedesmus planctonicus*, 4. *Scenedesmus raciborskii*, 5. *Tetradesmus wisconsinense, 6. Chlorolobion obtusum* Scale bar=10µm

***Monoraphidium komarkovae* Nygaard 1979 (Pl.6, Fig.1):** Cells 1.4-3.5µmwidth, 25-182 length, long of cell more than width by 20 times, Straight or curved but slightly, spindly form but cylindrically at the center of cell became narrow at end or at apex or spine(P.460, Pl.118A) (18). Recorded in along stream at site 14 during June-2020

***Pseudokirchneriella subcapitata* (Korshikov) F. Hindak 1990 (Pl.6, Fig.2):** Cells 2-4µm width and 6-14µm length, body curved and twisted sickle like, normally cell found in solitary, found in freshwater.(P.14, Fig,2) (22)

Identified in Zhnan spring during February-2020

***Klebsormidium dissectum* (Kutzing) P.C.Silva 1972 (Pl.6, Fig.3):** Filamentous straight or slightly bent, cells 5-14µm width, 1 to 3 times length than width, barrel to cylindrically shaped, smooth and thin walls, chloroplast covered mostly of the cell. (P.449, Pl.115J)(19). Identified in Azarian spring through March-2020

***Closteriopsis acicularis* (G.M.Smith) J.H.Belcher et Swale 1962 (Pl.6, Fig.4):** Cells 2-6.5µm width, 10-210µm length, Shape spindly and narrow, straight appeared or curved but slightly, banded chloroplast found within cell.(P.338,Pl.90D)(19). Recorded in along stream at site 14 during August -2020

***Geminella ellipsoidea* (Prescott) G.M.Smith 1950 (Pl.6, Fig.5):** Cells 7-10µm width and 3-6µm length, cell rectangular or cubic in shape, the cells pairs form and connected to each other's by end of wall, chloroplast almost of cell. Filamentous surrounded by clear, wide and mucilaginous sheath. (P.567,Fig.4.50-4.52) (25). Recorded in Sard spring during November-2019

***Geminella pulchra* Turpin 1828 (Pl.6, Fig.6):** Cells 2-3.5µm width, 7-10µm length, filamentous short and linear, body cell cylindrical slightly curved or straight ,rounded ends, surrounded mucilaginous sheath is non-clear, chloroplast single and parietal ,extending at two ends and pyrenoids absent (P.567, Fig. 4.50-4.52)(25). Identified in Sard spring through August-2020

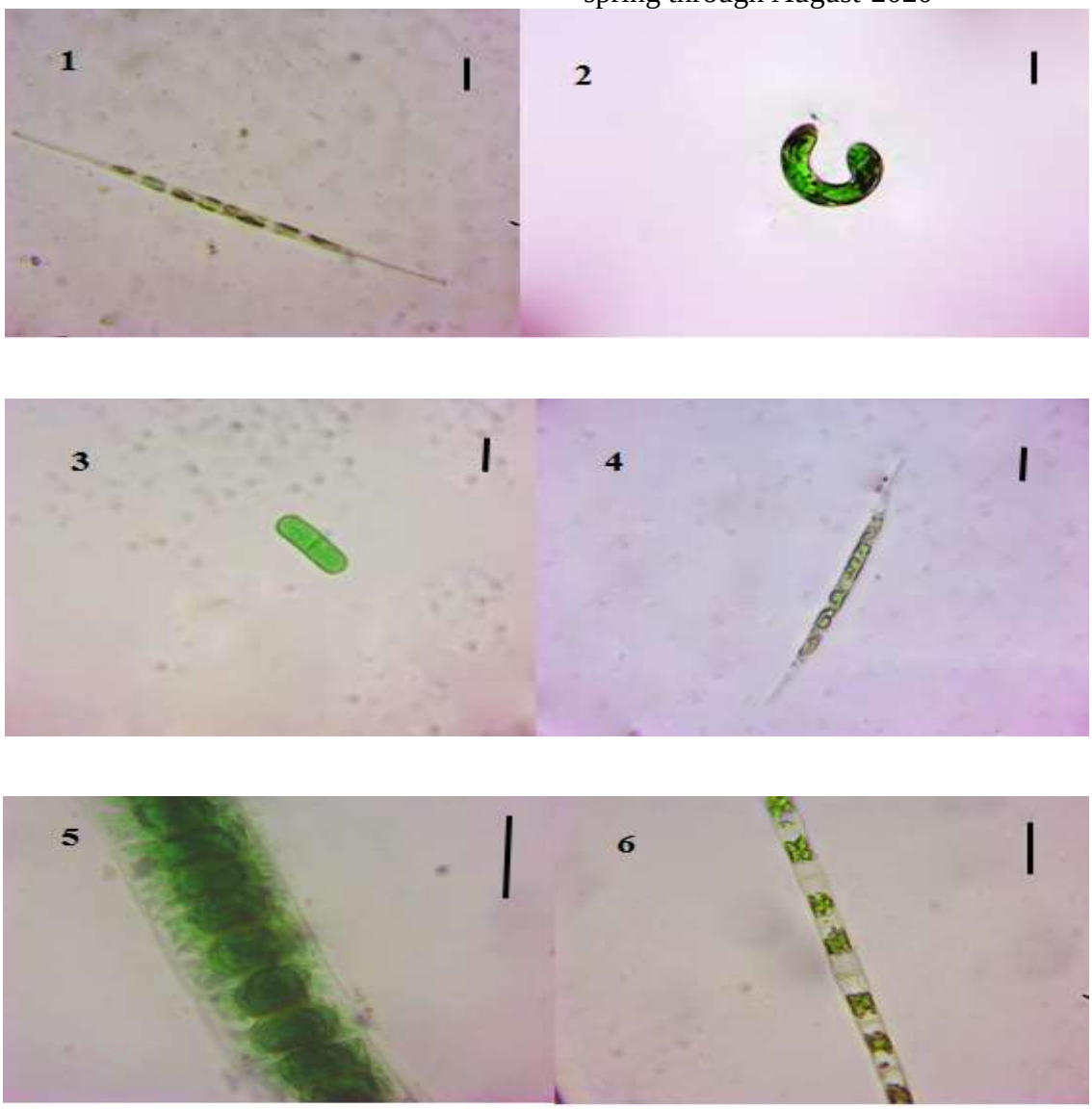


Plate 6: Photomicrographs of Algae species recorded in the study area: 1. *Monoraphidium komarkovae*, 2. *Pseudokirchneriella subcapitata* , 3. *Klebsormidium dissectum*, 4.*Closteriopsis acicularis*, 5. *Geminella ellipsoidea, 6. Geminella pulchra* Scale bar=10µm

***Golenkiniopsis chlorelloides* (J.W.G.Lund) Fott 1981 (Pl.7, Fig.1):** Cells 4-10µm width, ovoid form, sometimes may be irregular, wall thin, more than 20 spine bearing with swollen base for each one (P.484, Pl.120I) (18). Found in Darmanawa spring during October-2019

***Myrmecia aquatic* G.M.Smith 1829 (Pl.7, Fig.2):** Unicellular cell, pyriformis or spherical in shape, thickening shown of the wall in one side than other side is thin wall. Collected in freshwater (P.109, Fig.199) (32). Found in Piawan and Zhnan springs during March and April-2019 respectively

***Trentepohlia arborum* (C. Agardh) Hariot Journal de Botanique 1899 (Pl.7, Fig.3):** Branched filamentous with thin walls, cells 15-22µm width, 40-62µm length, long 2-4 times than wide, irregular branches, chloroplast covered two-third of cell (P.106, Fig.G) (15). Recorded in Piawan spring through February-2020

***Tetraselmis cordiformis* (H.J.Carter) F.Stein 1878(Pl.7, Fig.4):** Cells 12-22µm width and 14-20µm length, solitary cell, heart or oval form, chloroplast has cup shape, pyrenoid found and sometimes not appeared. (P.284, Pl.75D) (19). Or in (25)at (P.119-120). Found along streams at site 7 during December-2019

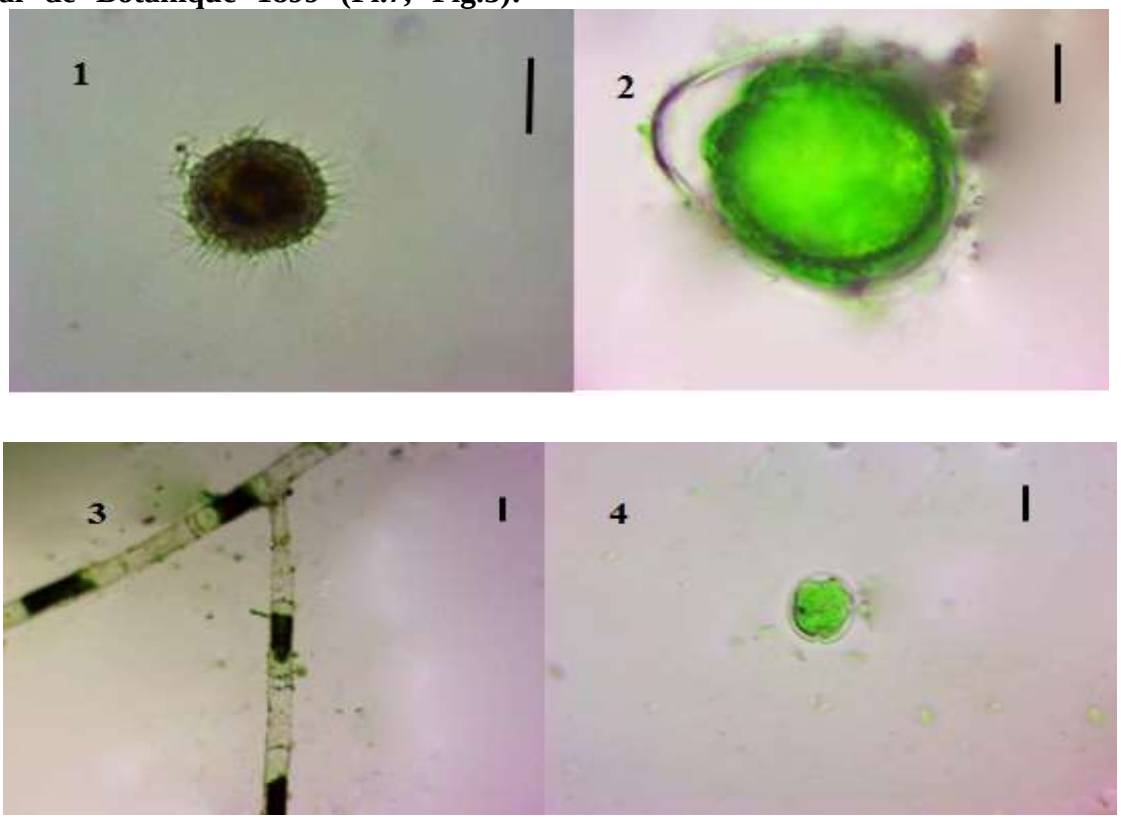


Plate 7. Photomicrographs of Algae species recorded in the study area: 1. *Golenkiniopsis chlorelloides*, 2. *Myrmecia aquatic*, 3. *Trentepohlia arborum*, 4. *Tetraselmis cordiformis*, Scale bar=10µm

CONCLUSIONS

It can be concluded through this study 27 genera with 40 species of Chlorophyceae without Zygnematales first times records in Iraq and added to List of algal flora in Iraq and the most abundant genera was ***Scenedesmus*** with seven species, followed by Chlorophysema and Characium with three genera for each one.

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