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New Records of Algae in Shaqlawa District, Erbil, Kurdistan Region of Iraq

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Abstract

Monthly samples of algae collected in eighteen sites of springs and streams through September-2019 till August-2020during morning till afternoon in Shaqlawa district within Erbil Province, Kurdistan Region of Iraq. Eleven various kinds of algae were identified for first time in Iraqi inland water, distributed to three genera of blue-green algae, which include *Marssoniella elegans*, *Pseudoanabaena catenata*, *Cyanotheca aeroginosa*, also in Pyrrophyta identified four new species genera include *Gymnodium inversum*, *Woloszynskia tenuissima*, *Peridinium goslaviense*, *Hemidinium naustum* and Xanthopyta recorded three species were *Ophiocytium arbuscula*, *Ophiocytium parvulum*, *Tetraedriella polychloris* while Cryptophyta only have one species was *Cryptomonas reflex*. According to physicals and chemicals characteristics, water temperature varied from 14.942 °C to 18.475 °C, pH lies on alkaline side of neutrality, electrical conductivity ranged between (627.472-2092.306 µs/cm) and high concentration of salinity recorded in Azarian spring, higher value of calcium and magnesium recorded in Azarian and Benwan springs were 294.84 mg/L and 106.578 mg/L respectively. Lower value of nitrate and phosphate reported in Sard and Piawan springs, while lower value of sulfate observed in Prenga spring.

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1. Introduction

Algae are base of food chain and primary producer in aquatic environment, also they have a great role for water purification and water quality assessment because these organisms are sensitive to any changes in inland water and reflect healthy status of any water ecosystem, therefore they used to indicate quality of water and pollution status in any water ecosystem [1]. Algae abundant in different areas and habitat some of these are cosmopolitan in distribution and found in various parts of the world's [2]. Microalgae are photoautotrophic, and they have bioactive, antibacterial and antioxidant compounds or considered sources of food, clean energy and plant fertilizer [3]. Variation of algae in water ecosystem depended on the changes of the environmental factors [4]. More recently algal studies in Kurdistan region of Iraq get attentions, there are many studies occurred on algal flora, a total 1341 algal flora was records in the check list Kurdistan Region of Iraq by[5], also list of Algae in Iraq contains 2647 taxa by [6]. Furthermore, many of studies recently published in Kurdistan Region and Iraq may do by [1, 4, 7-11]. The purposes of the current study are to know composition of non-diatoms algae in Shaqlawa district within Erbil Province and contribution to algae in Iraq and Kurdistan Region of Iraq.

2. Materials and Methods

2.1 Description of studied sites

Aquban and Sarkand villages belong to Shaqlawa District is about 32 Km northeast of Erbil city which is located north-east of Iraq, at 36° 42′ to 36° 23′ N latitude and 44° 29′ to 44° 08′ E longitude. Knowledge about climate, hydrology, soil and geology are given by [9,12]. Sites under study in Aquban consist of five shallows 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 are about 40 Km long (Figure 1) and (Table 1).

2.2 Collection, preservation and identification of algae

Algal samples were collected by plankton net for planktonic forms which pore size 25micrometer and squeezing from leaves and stems of macrophytes plants. Then samples were preserved by using 1ml of lugal solution in air tight polylab vial sealed and labeling then brought to laboratory, Chlorophyceae and other algae concentrated by sedimentation and examined under microscope [13-18]. 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[5, 6]. Identified various types of Algae as soon as possible to avoid loss of the taxonomic characters by light Microscope (Hund Wetzel S200) at 10X, 40X magnification. Water temperature was measured immediately in the field by placing a clean mercury thermometer (0-60 °C) graduated up to 0.1 °C inside the water. EC & pH were measured by using (pH-EC-TDS meter, HI 9812, Hanna instrument). Calcium, magnesium, nitrate, phosphate and sulfate were determined by [19]

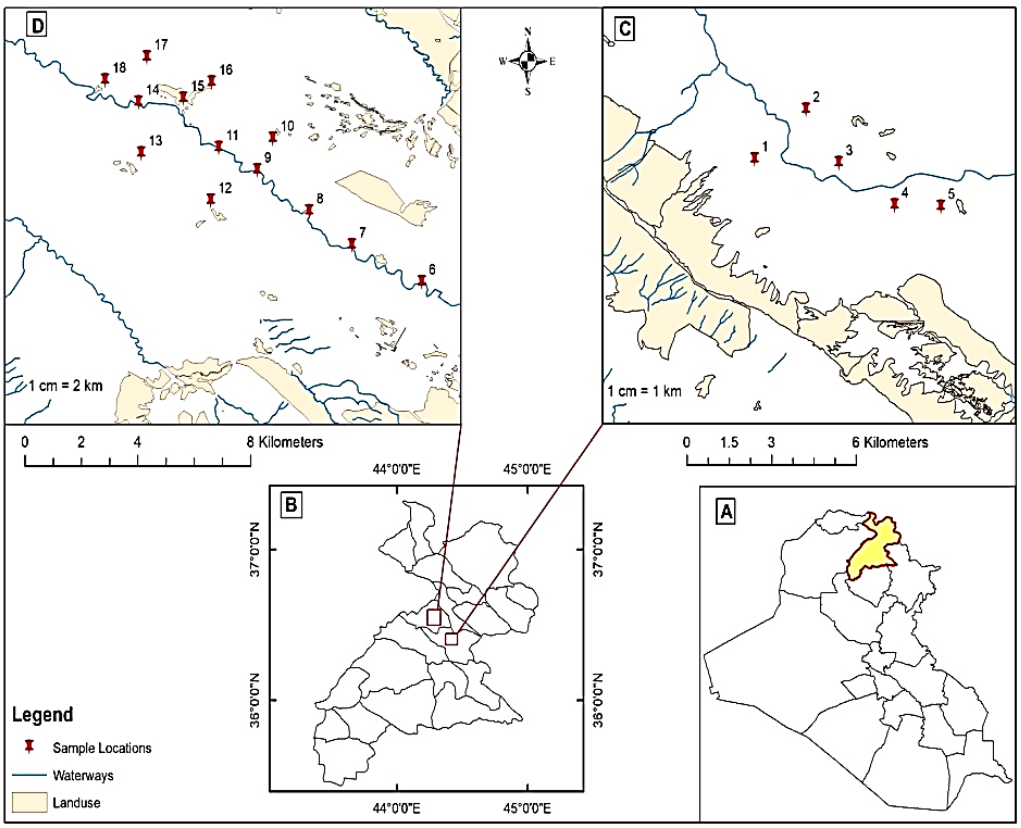

Figure 1. Show: (A) Map of Iraq and Erbil province shaded; (B) Map of Erbil governorate; (C) Aquban village; (D) Sarkand Khaylaneyan village.

Table 1. Shows type and location of the studied area within Shaqlawa District

Site	X-Field	Y-Field	Elevation	Location	Name of Village
1	447065.42	4024114.692	905 m	Sard Spring	
2	448620.345	4025272.842	902 m	Piawan Spring	
3	449343.633	4023623.880	887 m	Zhnan Spring	Aquban
4	450681.287	4022479.770	902 m	Darmanawa Spring	
5	452251.64	4022654.189	912 m	Mink Spring	
6	439655.001	4031776.001	736 m	Stream 1	
7	437278.463	4033076.147	709 m	Stream 2	
8	435814.981	4034419.117	707 m	Stream 3	
9	434042.001	4035935.001	648 m	Stream 4	
10	434707.036	4037048.419	713 m	Prenga Spring	
11	432436.724	4036853.074	669 m	Stream 5	
12	432416.266	4034657.028	712 m	Nawkand Spring	Sarkand
13	429994.136	4036337.350	651 m	Chemma Spring	
14	430060.282	4038321.729	668 m	Stream 6	
15	431498.957	4038387.875	743 m	Sarkand Spring	
16	432287.344	4039126.466	737 m	Benwan Spring	
17	430142.964	4039528.893	707 m	Azarian Spring	
18	428765.729	4039143.230	595 m	Razga Spring	

3. Results and Discussions

Collected data on water temperature, pH, EC, salinity, calcium, magnesium, nitrate, phosphate and sulfate for each sample of water sites have been represented in Tables 2 and 3. In the current study a total 11 new species records of Cyanophyta, Pyrrophyta, Xanthopyta and Cryptophyta species were identified from Shaqlawa district, within Erbil Province during September-2019 till August-2020 in Tables 4 and 5, these species are related to 10 genera belonging to 11 family, 8 order and 4 class, [5,6]. In this study *Ophiocytium* is considered the dominant new genera recorded with18.1% followed by remaining others genera with 9.1% table5. 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 we will add them in the list of algal flora of Iraq and we will appear it as follows.

Three new records Cyanophyta reported in various sites in this study in summer and autumn seasons in along stream and springs and considered wide distributed because this may due to that blue-green algae are tolerance to bad or unsuitable environmental conditions [8]. Also the successful growth of Cyanophyta in current survey because possess different uses of metabolism[20]. Also it can in grow bright light condition and exhibit a wide range of diversity and can tolerate a wide range of temperature(22-32 ^{o}C) [17]. Xanthopyta are much or less species-diverse than Cyanophyta with about 600 species and many of the 100 known genera and show wide range of form, species frequent in spring water in cold and warm water temperature and also in hard water[16]. This confirm with the results of this survey. Most of Pyrrophyta relatively little known of the ecology of fresh water, some species migrate vertically in water column during summer moving toward to light in day and to the bottom during night, also found in small water system and in pool was temporary, and some genera found or live in water is cold < 15 ^{o}C, while most of the species are only recorded or thrive in summer when water temperature more than 15 ^{o}C [17], similar conclusions observed in the current study. About 200 Cryptophyta species have been described and it is likely that many more species still await formal description. About 100 known species occur in freshwater, also some occur smaller water bodies and rivers especially in the presence of lower temperatures[21]. *Cryptomonas reflex* identified in Sard spring in February-2021, this genus found in small water bodies and becomes more available in cold environment [17].

Table 2. Mean value of some water properties in study sites during the studied period.

Site	Place of Collection name	Habitat type	Air Temperature ^{o}C	Water Temperature ^{o}C	pH	EC $\mu s.cm^{-1}$	Salinity ppt
1	Sard	Spring	17.536	14.942	7.233	988.111	0.065
2	Piawan	Spring	17.664	15.439	7.249	1124.778	0.056
3	Zhnan	Spring	17.792	15.700	7.367	830.111	0.058
4	Darmanawa	Spring	18.275	14.108	7.479	1611.667	0.052
5	Mink Spring	Spring	18.211	14.039	7.764	627.472	0.059
6	Along Stream	Stream 1	20.583	16.211	7.844	786.250	0.072
7	Along Stream	Stream 2	21.333	17.517	7.875	785.222	0.071
8	Along Stream	Stream 3	21.892	17.381	7.894	782.972	0.076
9	Along Stream	Stream 4	22.200	17.272	7.992	764.056	0.078
10	Prenga	Spring	22.364	18.231	7.401	810.639	0.059
11	Along Stream	Stream 5	21.483	17.397	7.823	841.778	0.077
12	Nawkand	Spring	20.550	17.917	7.235	1392.583	0.110
13	Benwan	Spring	20.633	18.475	7.309	1419.139	0.085
14	Along Stream	Stream 6	21.400	17.542	7.816	911.167	0.080
15	Sarkand	Spring	21.133	18.033	7.330	924.972	0.059
16	Benwan	Spring	21.942	18.169	7.372	975.639	0.055
17	Azarian	Spring	22.317	16.108	7.297	2092.306	0.155
18	Razga	Spring	23.067	16.628	7.817	989.222	0.084

Table 3. Mean value of some water properties in study sites during the studied period.

Site	Place of Collection name	Habitat type	NO_3 mg /L	PO_4 µg.P-PO_4/L	SO_4 mg/L	Calcium mg/L	Magnesium Mg/L
1	Sard	Spring	5.286	0.617	96.278	102.143	52.664
2	Piawan	Spring	9.192	0.604	296.389	112.848	64.489
3	Zhnan	Spring	15.197	0.706	132.333	89.819	42.591
4	Darmanawa	Spring	5.078	0.868	353.889	257.005	72.586
5	Mink Spring	Spring	7.167	0.740	110.944	73.920	50.442
6	Along Stream	Stream 1	11.611	1.503	102.667	72.171	46.704
7	Along Stream	Stream 2	12.458	1.627	113.111	68.199	50.601
8	Along Stream	Stream 3	12.894	1.354	107.333	70.012	47.719
9	Along Stream	Stream 4	11.336	1.199	131.056	71.195	49.098
10	Prenga	Spring	38.008	0.974	71.028	73.737	53.105
11	Along Stream	Stream 5	13.497	1.226	120.639	71.323	50.825
12	Nawkand	Spring	5.761	1.248	345.000	148.301	95.862
13	Benwan	Spring	30.714	0.954	519.722	147.043	106.578
14	Along Stream	Stream 6	14.511	1.058	155.083	78.712	49.062
15	Sarkand	Spring	38.614	1.054	172.222	98.945	50.722
16	Benwan	Spring	39.025	1.126	239.722	91.624	53.590
17	Azarian	Spring	1.986	0.957	978.306	294.848	80.455
18	Razga	Spring	18.483	1.214	276.389	83.757	58.062

Table 4. List of new Algal records species in the study sites during the studied period.

Phylum: Cyanophyta (Cyanobacteria)	*Tetraedriella* Pascher 1930
Class: Cyanophyceae	6-*Tetraedriella polychloris* Skuja 1964
Order: Chroococcales	Phylum: Cryptophyta (Cryptomonads)
Family Entophysalidaceae	Class Cryptophyceae
Marssoniella Lemmermann 1900	Order Cryptomonadales
1-*Marssoniella elegans* Lemmermann 1900	Family Cryptomonadaceae
Order: Oscillatoriales	*Cryptomonas* Ehrenberg 1838
Family: Oscillatoriaceae	7-*Cryptomonas reflex* Skuja 1868
Pseudoanabaena Lauterborn 1914	Phylum: Pyrrophyta (Dinoflagellates)
2-*Pseudoanabaena catenata* Lauterborn 1914	Class: Dinophyceae
Family: Cyanothecaceae	Order: Gymnodiniales
Cyanotheca (Naegeli) Komárek 1976	Family: Tovelliaceae
3-Cyanotheca aeroginosa Komárek 1976	*Woloszynskia* R.H.Thompson 1950
Phylum: Xanthopyta	8-*Woloszynskia tenuissima* R.H.Thompson 1950
Class Xanthophyceae	Order: Peridiniales
Order Mischococcales	Family: Peridiniaceae
Family Characiopsidaceae	*Peridinium* Ehrenberg 1832
Characiopsis Borzi 1895	9-*Peridinium goslaviense* Woloszynska 1916
Family Ophiocytiaceae	Order: Phytodiniales
Ophiocytium Naegeli 1849	Family: Hemidiniaceae
4-*Ophiocytium arbuscula* Rebenhorst 1868	*Hemidinium* F.Stein 1878
5-*Ophiocytium parvulum* A.Braun 1855	10-*Hemidinium naustum* Stein 1883
Family Botryochloridaceae	Gymnodium Nygaard 1949
Order Goniochloridales	11- Gymnodinium inversum Nygaard 1949
Family Goniochloridaceae	

Table 5. New records with their percentages in the study sites during the studied period.

	Name of Algal species	Genera	Species	%	Number of New species	%
	Phylum: Cyanophyta					
	Class: Cyanophyceae					
1	Marssoniella Lemmermann 1900	1	1	7.7	1	9.1
2	Pseudoanabaena Lauterborn 1914	1	1	7.7	1	9.1
3	*Cyanotheca* (Naegeli) Komárek 1976	1	1	7.7	1	9.1
	Phylum: Xanthopyta					
	Class Xanthophyceae					
4	*Ophiocytium* Naegeli 1849	1	4	30.7	2	18.1
5	*Tetraedriella* Pascher 1930	1	1	7.7	1	9.1
	Phylum: Cryptophyta					
	Class Cryptophyceae					
6	*Cryptomonas* Ehrenberg 1838	1	1	7.7	1	9.1
	Phylum: Pyrrophyta					
	Class: Dinophyceae					
7	*Woloszynskia* R.H.Thompson 1950	1	1	7.7	1	9.1
8	*Peridinium* Ehrenberg 1832	1	1	7.7	1	9.1
9	*Hemidinium* F.Stein 1878	1	1	7.7	1	9.1
10	*Gymnodium* Nygaard 1949	1	1	7.7	1	9.1
	Total	10	13	100	11	100

Descriptions new records

***Marssoniella elegans* Lemmermann 1900 (Pl.1, Figure 1):** Cells 1.3-5 μm width, 4-6 μm length at 40X magnification, colony comprise or content 8-12 pyriform to oval cell, arrangement is radiate (P.471, Pl.107, Figure 12) [15]. Found in along stream at site 7 during September-2019.

Pseudanabaena catenata Lauterborn 1914 (Pl.1, Figure 2): Cells 1.8-2.2 μm width and 2-5 μm length at 40X magnification, single trichome, not observed any attenuated towards both ends, narrowed cross-wall, appeared rectangular from side viewed, not found any gas vacuoles. (P.84, Pl.13A) [16]. Recorded in Darmanawa spring during August-2020.

Cyanotheca aeroginosa Komárek 1976 (Pl.1, Figure 3): Cells 10-30μm width and 10-45 μm length at 40X magnification, large cells, solitary live, ovoid to elliptical shaped, color of cell blue-green or olive green and is bright, movement is slightly. (P.214, Figure 4.32) [22]. Found in Nawkand spring during July-2020.

***Ophiocytium arbuscula (A.Braun) Rebenhorst* 1868(Pl.1, Figure 4):** Cell attached or connected by short stalk, form colony comprise a cylindrical cell, slightly straight or curved, 2-5 μm width, up to 60 μm length at 40X magnification, attached by stalk. (P.258, Pl.70A) [16]. Recorded in Azarian spring during February-2020.

***Ophiocytium parvulum* (Perty) A. Braun 1855 (Pl.1, Figure 5):** Cells 3-9 μm width and up to 500 μm length at 40X magnification. Cylindrical cells curved or may be straight, spines absent and rounded apices, one swollen than others. (P.258, Pl.70B) [16]. Found in Benwan spring during February-2020

***Tetraedriella polychloris* Skuja (Pl.1, Figure 6):** Cells 20-42 μm width at 40X magnification, tetrahedral, central body is small, chloroplast tended, oil droplet present [16] (P.259, Pl.66D). Found in Darmanawa spring during August-2020.

***Cryptomonas reflex* Skuja 1868 (Pl.2, Figure 1):** Cells 12-16 μm width, 27-37 μm length at 40X magnification, ovoid broadly to ellipsoidal to spindle form, curve at anterior end, pointed at posterior end, chromatophore parietal and elongateP.58, Figure 40) [23]. Recorded in Sard spring during February-2020.

***Woloszynskia tenuissima* R.H.Thompson 1950 (Pl.2, Figure 2):** Cells 32-36 μm width and 32-40 μm length at 40X magnification. Cells is quadrate form in ventral view and flattened at dorsiventrally, concave form in ventrally and curved laterally, short point at apex and pointed or found a deep furrow in antapex. Hypocone slightly shorter than epicone, dividing by cingulum. Chloroplast ovoid or irregular, yellow brown to yellow in colour. (P.198, Pl. L, M) [16]. Recorded in Darmanawa spring during August-2020.

***Peridinium goslaviense* Woloszynska 1916 (Pl.2, Figure 3):** Cells 11-22 μm width and 12-24 μm length at 40X magnification. Ovoid and elongated cells, flattened at dorsiventrally but weakly, epivalve pointed with pore apical, hypovalve have circle but half and spines found (P. 9070, Pl.10) [24]. Recorded in along stream at site 8 during August-2020.

***Hemidinium naustum* Stein 1883 (Pl.2, Figure 4):** Cells 14-30μm width and 22-36μm length at 40X magnification, cell elliptical to round in ventral view, flattened dorso-ventrally, cingulum started from ventral to left side, Chloroplast many and colors changed yellow brown to brown. (P.207, Pl.52K-M) [16]. Found along stream at site 9 during August-2020.

***Gymnodinium inversum* Nygaard 1949 (Pl.2, Figure 5):** Cell 16-26 μm width, 20-30 μm length at 40X magnification, elongated and ellipsoidal form, compressed dorsiventrally, rounded and broadly at both apexes, epicone slightly smaller than Hypocone, extend of sulcus of length of hypocone and epicone. (P.191, Pl.47, Figures E,F) [16]. Observed in the Nawkand spring through October-2020.

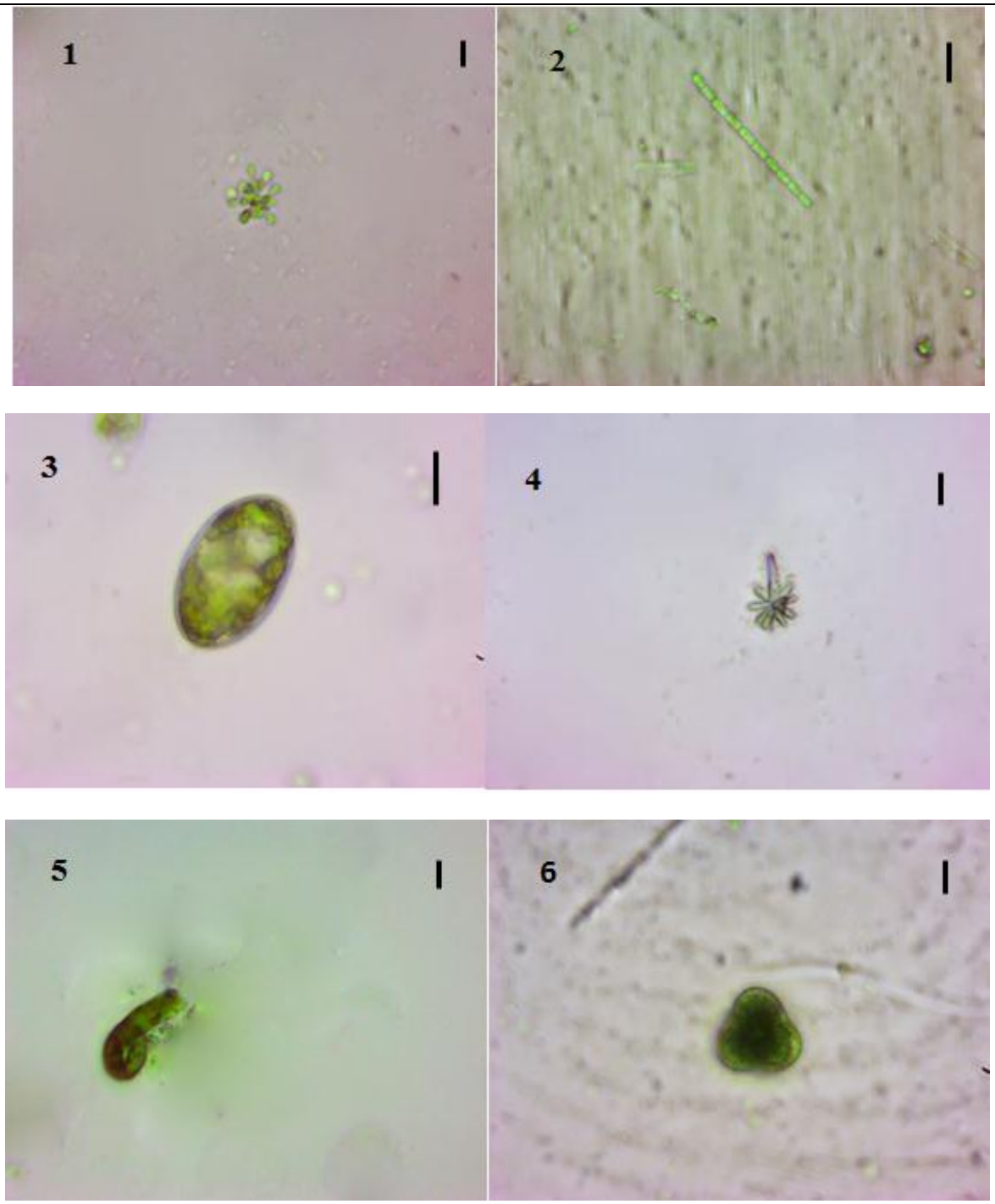

Plate 1. Photomicrographs of Algae species recorded in the study area: 1. *Marssoniella elegans* 2. *Pseudanabaena catenata*, 3. *Cyanotheca aeroginosa*, 4. *Ophiocytium arbuscula*, 5. *Ophiocytium parvulum*, *6. Tetraedriella polychloris* Skuja Scale bar =10 µm.

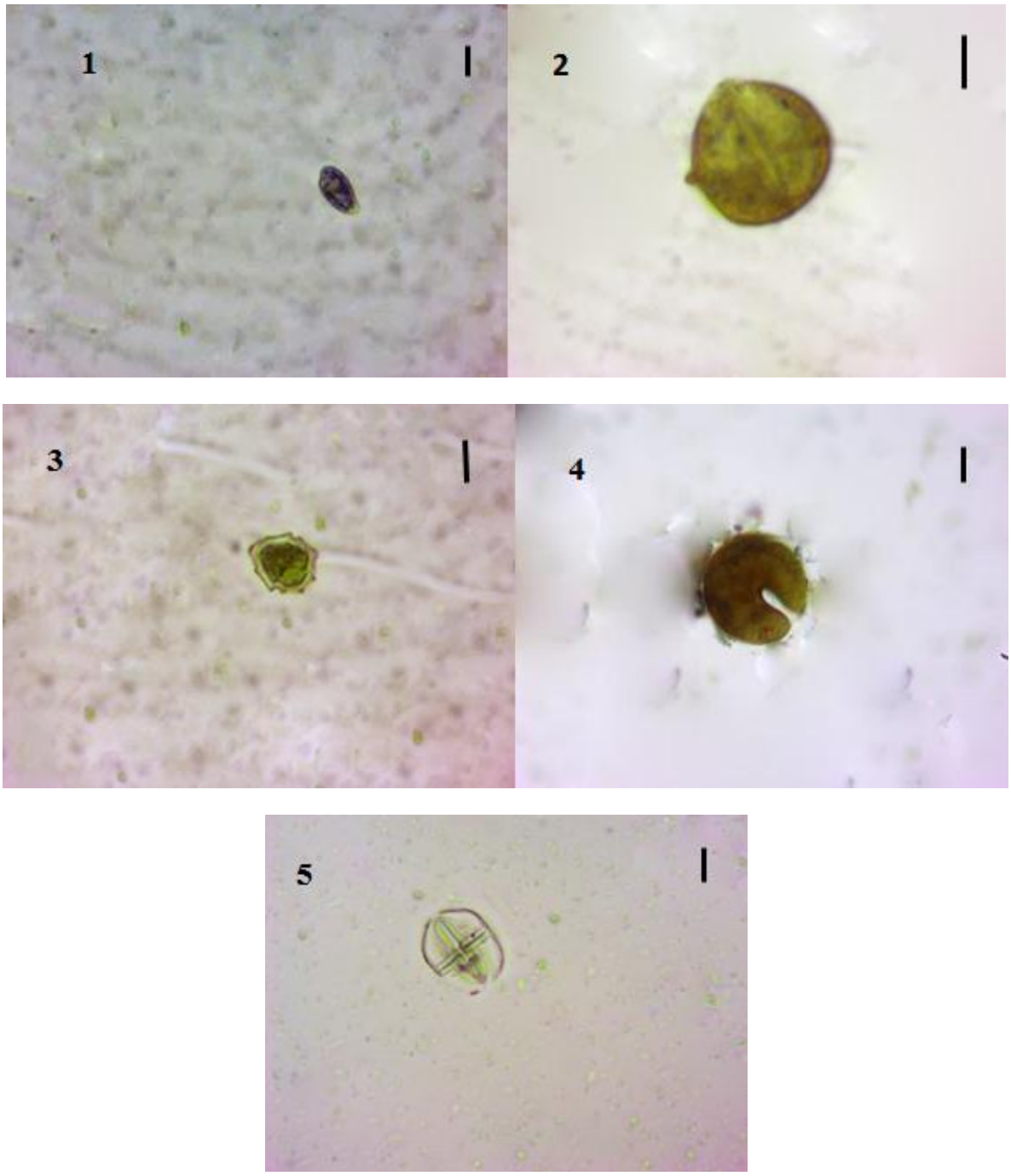

Plate 2. Photomicrographs of Algae species recorded in the study area: 1. *Cryptomonas reflex*, 2. *Woloszynskia tenuissima*, 3. *Peridinium goslaviense*, 4. *Hemidinium naustum*, 5. *Gymnodinium inversum* Scale bar = 10 μm.

4. Conclusions

From the results of the current study, it is clear that the found of phytoplankton, reflected quality of Shaqlawa water resources, and this area is favorable for living others types of organisms. New algal species reported in this survey were not recorded in the all Iraqi area, 16 new algal species belonging to Cyanophyta, Xanthopyta, Cryptophyta Ascomycota were identified.

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