RESEARCH PAPER

Twenty-five new records of algae in eight artificial fish ponds in Erbil

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ABSTRACT:
This study was carried out from March to October 2018 in eight artificial fish ponds within Erbil province Kurdistan region of Iraq which is the first work in such ponds. A total of 116 algal species belong to 58 genera, 31 families, 19 orders, 9 class and 8 divisions were identified. The dominant division was Chlorophyta with 58 species (50%), followed by Cyanophyta with 31 species (26.72%), Euglenophyta with 19 species (16.37%), Chrysophyta with 4 species with (3.45%) and each of Charophyta, Pyrrophyta, Rhodophyta and Cryptophyta was with one species (0.58%). The dominant species were Euglena, Cosmarium, and Oscillatoria. Among identified taxa, 25 species were new records to Iraqi algal flora.

KEY WORDS: Algae; new records; Ponds; Erbil; Iraq
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INTRODUCTION:
Algae are an important component of aquatic ecosystems because they reflect environmental health through their distribution and abundance (Stevenson, 1996). The algal diversity in an ecosystem depends upon the physical and chemical water properties (Aziz and Rasheed, 2017). The presence of algae in the fresh pond is extremely important as it is a source of food for the aquatic organisms (Bellinger and Sigee, 2010). In Iraqi Kurdistan Region phyco-limnological studies were carried out from 1978 to 2012. A total of 1341 species were recorded and reported in the algal checklist of Kurdistan region (Aziz, 2011).

More recently, a number of algae added to Iraqi algal flora (Rasoul, 2013, Toma, 2013, Bilbas, 2014, Goran, 2014, Aziz, 2015, Hamadamen, 2015, Sdiq, 2015, Ahmed, 2016, Sharif, 2016, Aziz and Rasoul, 2016, Aziz and Muhammed, 2016, Najmadden, 2017) etc. Since there is no study on artificial fish ponds in Kurdistan, this study was carried out to known algal composition, abundance, distribution, spatial variation and periodicity as affected by related environmental conditions.

1. MATERIALS AND METHODS
1.1. Study area
Erbil district is situated on a plain area with a chain of hills from East. On the west side of the region, there is Greater Zab River, which separates Erbil from Dahuk province. Ainkawa, Qushtapa, Bahrka, Bnaslawa, and Khabat are the major towns. The study area consists of two sub-districts around Erbil province which are: Bahrka and Qushtapa. Bahrka sub-district consists of
three villages which are: Jazhnikan, Grdaraq and Kawrasor. It is an open area located about 14 km from northwest of Erbil city; its height reaches about 472 m.a.s.l., 36°32'02.8'' N latitude and 44°03’88.2’’ E longitudes and is characterised by agriculture. Qushtapa district located about 23 Km from south of Erbil city at 36°00’09.7’’ N latitude and 44°03’40.4’’ E longitudes and it has an elevation of 393 m.a.s.l. (Erbil Governorate, 2018).

The study areas were comprised of 8 sites, four sites (1, 2, 3 and 4) are located within Bahrka sub-districts which are Jazhnikan-concrete pond, Jazhnikan-soil pond, Grdaraq and Kawrasor, and other sites (5, 6, 7 and 8) were selected from Qushtapa sub-districts which are Masi xweyy-concret pond, Masi xweyy-soil pond, Baban, Kani. All sites are built of soil except site number one and five was constructed of concrete. The source of water is from deep well (see figure 1) (KRSO, 2018).
Figure 1: Erbil City, Kurdistan of Iraq.

Table (1) The percentage of studied algal division (Boldand Wynne, 1985)

| Division     | Classes | Orders | Families | Genera | Species | %    |
|--------------|---------|--------|----------|--------|---------|------|
| Cyanophyta   | 1       | 3      | 5        | 17     | 31      | 26.724 |
| Chlorophyta  | 1       | 8      | 18       | 30     | 58      | 50   |
| Charophyta   | 1       | 1      | 1        | 1      | 1       | 0.862 |
| Euglenophyta | 1       | 1      | 1        | 4      | 19      | 16.379 |
| Chrysophyta  | 2       | 3      | 3        | 3      | 4       | 3.448 |
| Pyrrophyta   | 1       | 1      | 1        | 1      | 1       | 0.862 |
| Rhodophyta   | 1       | 1      | 1        | 1      | 1       | 0.862 |
| Cryptophyta  | 1       | 1      | 1        | 1      | 1       | 0.862 |
| Total        | 9       | 19     | 31       | 58     | 116     | 100  |
1.2. Sample collection and algal identification

Algal samples were collected monthly in special containers by phytoplankton network. Whereas, algal forms were identified before algal fixation as soon as possible because of their loss of taxonomic characters. Using the most common and new available references (West and West, 1908, West and West, 1912, Desikachary, 1959, Randhawa, 1959, Ramanathan, 1964, Prescott, 1968, Prescott, 1970, Prescott, 1975, Benson, 1975, Lang et al., 1987, Komarek, 2005, John et al., 2011, Wehr et al., 2015) and supported by Google websites. The classification and arrangement of algal taxa done according to (Bold and Wynne, 1985) and the new records determined according to the last checklist of Iraqi and Kurdistan algal flora (Maulood et al., 2013).

2. RESULTS AND DISCUSSION

In the current study, as shown in Table (1) a total of 116 species were recorded belong to 58 genera, 31 families, 19 orders, 9 class and 8 divisions in the studied sites. Moreover; among identified algal species, the Chlorophyta was dominant division in species composition 58 species with 50%, followed by Cyanophyta 31 species with 26.72% and Euglenophyta 19 species with 16.37%. Chrysophyta 4 species with 3.45% and each of Charophyta, Pyrrophyta, Rhodophyta and Cryptophyta was with one species (0.58%). In the present study, 25 species of algal flora were new records for Iraqi algal flora according to (Maulood et al., 2013), four belong to Cyanophyta, eleven belong to Chlorophyta, seven belong to Euglenophyta, two belong to Chrysophyta, and one belongs to Pyrrophyta. As in this study, the dominancy of Chlorophyta over Cyanophyta was also observed by (Aziz, 1997, Al-Saadi et al., 2000, Bapper, 2004, Goran, 2006, Zewayee, 2011, Hamadamen, 2015) this is may be due to the environmental condition and water properties of the area which is hard and alkaline toward neutrality and the recording of such new species contributed to the habitat and nature of the study ponds, which was the first study carried out in the area (Aziz, 2011). However, a contrast sequence observed by (Al-Barzingy, 1995) which recorded the dominancy of Cyanophyta due to environmental stress especially temperature.

3. DESCRIPTIONS OF ALGAL NEW RECORDS

Gloeocapsa alpina (Naeg.) Brand 1900 (Plate 1, Fig 1):

Colonies microscopic, 2-8-celled, but frequently aggregated in to macroscopic, irregular blackish mass. Cells of (sub) colony lamellate, with the mucilage blue to dark violet; (sub) colony up to 40 μm (John et al., 2013). Recorded in May, June and July at sites three, four and six.

Arthrospira jenneri (Kuetz.) Stizen. 1852 (Plate 1, Fig 2):

Trichome width 4-8 μm, width of spiral 9-17 μm; distance between spirals 12-25(-31) μm. Frequently with granules at cross walls; trichome end cell rounded (John et al., 2013). Recorded at sites four, six and eight in May, June and August.

Cylindrospermum licheniforme {Bory 1825 Kuetz. 1847} (Plate 1, Fig3):

Colonial mucilaginous, dark green. Cells 3.5-4.2(-4.8) μm wide, slightly longer than wide, quadratic to cylindrical, narrowed at the cross wall. Heterocyst elongate, (-4)-5-6 μm wide, 7-12 μm long, Akinete 10-14 μm wide, 20-30(-40) μm long (John et al., 2013). This species was recorded at sites one, seven and eight in March, April, August and October.

Homoeothrix fusca Starmach 1934 (Plate 1, Fig 4):

Filaments unbranched, straight or flexuous, 4.5-7.5μm wide at base, 48-85μm long, forming clumps up to 1 cm or single among other blue-green algae. Sheath thick, fimbriated at the apex, dark brown. Trichome 2-3.5 μm wide near the base, 1.5-2.5 μm in the middle, usually ending in hair (John et al., 2013). Recorded at sites three, four and seven in March, May and July.

Haematococcus pluvialis (Flotow) Wille 1903 (Plate 1, Fig 5):

Cells spherical to ellipsoid, (8-)-10-30(-51) μm wide, (10-15-50(-63)μm long, up to 1.5 times as long as broad, papilla absent; protoplasmic
detail was not visible within them (John et al., 2013). This species was presented in sites one and eight during June and August.

**Pectodictyon cubicum** Taft 1945 (Plate 1, Fig 6):

Colony microscopic, an eight-celled unfilled cube, cells situated at the corners of the mucilage outline, cells inter-connected by stout gelatinous strands, often forming complex coenobia. Cells spherical, 3.5–7 µm in diameter; chloroplast parietal with single pyrenoid (Lang et al., 1987). Recorded at sites one and six during June and July.

**Sphaerocystis planktonica** (Korshikov) Bourr. 1966 (Plate 2, Fig 1):

Coenobia of 4, 8 or 16 (-32) cells within a spherical mucilaginous envelope (35)-50—124(-150) µm wide) which sometimes becomes indistinct with age; cells 4-9 µm wide and sporangia up to 12.5 µm wide (John et al., 2013). Recorded at all sites except seven in April, May, June and August.

**Tetraspora lacustris** Lemm. 1898d (Plate 2, Fig 2):

Thallus is free –floating, spherical, or elongate and irregularly shaped, microscopic gelatinous colony containing relatively few spherical cells, the long pseudocilia usually clearly evident. Cells arranged in groups of 2 or 4; 7-10 µm in diameter (Prescot, 1970). Recorded at sites three, four and seven in May, July and September.

**Chlorococcum minutum** (R.C.Starr 1955) (Plate 2, Fig 3):

Cells 4-10(-20) µm wide, spherical to avoid; walls thicker in older cells; chloroplast a hollow sphere with a lateral pore, often 2 contractile vacuoles present in opening, pyrenoid eccentric and covered by a continuous starch sheath; zoospores, alphanospores and gametes produced by successive bipartition, zoospores ellipsoid-ovoid, 3-5µm wide and 6-7µm long (John et al., 2013). This species was recorded at the sites one, three, six, seven and eight during May and June.

**Oedogonium porrectum** Nordst.&Hirn 1900 (Plate 2, Fig 4):

Macrandrous; dioecious. Vegetative cells cylindric, 5.8-8-(10) µm in diameter, 23-29-(55) µm long. Oogonia solitary; ellipsoid or oblong-ellipsoid; operculate; division superior; 19.5-22-(27)µm in diameter, (27.3)-39-44-(53) µm long. Oospores ellipsoid; not filling the oogonia; wall smooth; (17.5)-18-24 µm in diameter, 25-27.3-(28)µm long. Antheridia 6-7µm in diameter, 6-8 µm long (Prescot, 1970). Recorded at sites seven and eight in June.

**Oedogonium mexicanum** Wittrock 1878 (Plate 2, Fig 5):

Macrandrous; dioecious. Vegetative cells cylindric, 34-41µm diameter, 60-140 µm long. Oogonia cylindric-ovoid; opening by a superior pore; 53-63 µm in diameter, 76-110 µm long. Oospores cylindric-ovoid; filling the oogonia; wall smooth; 51-60 µm in diameter, 63-80 µm long. Antheridia 28-35 µm in diameter, 70-17 µm long (Prescot, 1970). Recorded at sites two and three in March.

**Closterium praelongum** var. brevius (Nordst.)Willi Krieger 1935 (Plate 2, Fig 6):

Cells significantly shorter and mostly narrower than the type variety, 12-24.6 µm wide, 250-441 µm long, outer margin with curvature similar to the type variety, inner margin straight or slightly tumid, with ends very slightly reflexed, apices 3-7 µm wide; walls with striae, 14-17 in 10, even more indistinct than the type variety (John et al., 2013). Recorded in May at sites two, three, four, five and seven.

**Cosmarium tetragonum** var. ornatum Willi Krieger et Ger. 1965 (Plate 3, Fig 1):

Cells vertically oblong or rectangular, 25-28 µm wide, 43-47 µm long, considerably longer than broad (1.55-1.76 times longer than broad), with a deep sinus open inwardly; semi-cells more or less quadrate, with narrowly rounded basal angles, 2-undulate sides and subtruncate apices having 4 small undulation (John et al., 2013). Recorded in April and August at sites one, five and six.

**Cosmarium zonatum** P.Lundell 1871 (Plate 3, Fig 2):

Cells (22-)25.4-28.5 µm wide, (43.5-)52-54(-58) µm long, 1.8-2.06 times longer than...
broad, with a deep widely open sinus; semi cells subovate, basal margins broadly convex, lateral margins slightly refuse, with apices broadly convex and having an internal thicken (John et al., 2013). Recorded in May and October at sites one and two.

*Mesoetanium caldarium* (Lager.) Hansgirg 1886 (Plate 3, Fig 3):
Cells narrow cylindrical, mostly narrowing abruptly toward the apices so that they appear as sub truncate cones, somewhat curved, 10.5-13 μm wide, 42-64 μm long, chloroplast single, ribbon-like, with 2-4 pyrenoids, mostly extending from end to end of cell but sometimes with a gap between their ends and the apices (John et al., 2013). Recorded at sites seven and eight in May and June.

*Euglena adhaerens* Matvienko 1938 (Plate 3, Fig 4):
Cells 7.5-12 μm wide, 100-165 μm long, longitudinal cylindrical to spindle-shaped, anterior end narrowed and bluntly; posterior end tapering; pellicle slightly striated; flagellum not visible (John et al., 2013). This species recorded at sites five, six, seven and eight during May and September.

*Euglena contabrica* E. G. Pringsheim 1956 (Plate 3, Fig 5):
Cells 20-25 μm wide, 54-62 μm long, spindle-shaped and twice attenuated towards the posterior end, cylindrical in middle part of cell; euglenoid movement present; chloroplast numerous (John et al., 2013). Recorded in July and October at sites one, five and eight.

*Euglena fusiformis* H. J. Carter 1901 (Plate 3, Fig 6):
Cells 15-32.5 μm wide, (15-)35-42.5 μm long, lemon shaped, widely oval, anterior end conically narrowing and small concavity at apex, posterior end narrowing to a short, colourless to yellow (John et al., 2013). Recorded at sites two and three in May and June.

*Lepocinclis acus* (O. F. Muller) Marin et Mel. 2003 (Plate 4, Fig 1):
Cells 7-28.3 μm wide, (52-)60-180(-311) μm long, needle-shaped, elongate spindle shaped, sometimes bent and sometimes assuming an S-shape, anterior end narrowed and apically truncate, posterior end tapered to a long fine point (John et al., 2013). This species was recorded at sites three, six and seven in June, August and October.

*Phacus helicoides* Pochmann 1941 (Plate 4, Fig 2):
Cells 30-45 μm wide, 70-120 μm long, elongated or spindle-shaped to pear shaped, margins with 2 or 3 bluges, strongly spirally twisted through 1.5-7 times, usually 3; anterior end narrowing and bilobed, posterior end tapering in to a twisted (John et al., 2013). Recorded during July and October at site eight.

*Trachelomonas armata* (Her.) F. Stein 1878 (Plate 4, Fig 3):
Lorica 29-32 μm wide, (28-)30-45 μm long, widely ellipsoid to ovoid, thickened around apical pore (6-8 μm in diameter) or with a low and toothed, spiny collar, posterior end widely rounded (John et al., 2013). Recorded at sites one and seven during April and May.

*Trachelomonas horrida* Palmer 1905 (Plate 4, Fig 4):
Test oval, flagellum aperture with a short broad collar; wall uniformly beset with long, stout, bluntly pointed spines interspersed by short, sharp spines; test 27.5 μm in diameter, 35-40 μm long (Prescot, 1970). Recorded in April and September at sites six, seven and eight.

*Ophioctytium cochleare* (Eichw.) A. Braun 1855 (Plate 4, Fig 5):
Cells free-floatting, cylindrical, strongly arched and spirally twisted, one end truncate, the other with astout, sharp spine; cells 5-9.5 μm in diameter (Prescot, 1970). Recorded in May and June at sites three and four.

*Pseudokephryon undulatum* (G. A. Klebs) Pascher 1913 (Plate 4, Fig 6):
Lorical ovoid to barrel-shaped, undulate because of 2-4 transverse constrictions, 18-25 μm long; brownish; chloroplasts parietal, 2 per cell, one with eyespot (John et al., 2013). Recorded in April, June and July at sites three, six, seven and eight.
Ceratium furcoides (Levander) Langhans 1925 (Plate 4, Fig 7):

Cells narrowly spindle-shaped, strongly dorsiventrally flattened, 28-42(-56) μm wide, 123-222 μm long; epitheca formed into a narrow horn without shoulders, hypotheca broad and short, drawn out into 2 posterior horns of different length (John et al., 2013). Recorded at site four in May and August.

4. CONCLUSIONS

1. Present study provides baseline information about the water quality of artificial fish ponds.
2. A total of 116 algal species belong to 58 genera, 31 families, 19 orders, 9 classes and 8 divisions were identified.
3. Chlorophyta (58 species) was the dominant group in the number of identified species, followed by Cyanophyta (31 species), and Euglenophyta (19 species).
4. Among Chlorophyta Scenedesmus, Cosmarium and closterium were dominant, while among Cyanophyta and Euglenophyta Oscillatoria, Euglena and Trachelomonas were dominant.
5. Among 116 taxa of recorded algal species, 25 species were new records to Iraqi algal flora, 4 belonged to Cyanophyta, 11 belonged to Chlorophyta, 7 belonged to Euglenophyta, 2 belonged to Chrysophyta and 1 belonged to Pyrrophyta.
Plate (1): 1. Gloeocapsa alpine, 2. Arthrospira jenneri, 3. Cylindrospermum lichenforme, 4. Homoeothrix fusca, 5. Haematococcus pluvialis, 6. Pectodictyon cubicum. Scale bars: 10 µm
Plate (2): 1. Sphaerocystis planktonica, 2. Tetraspora lacustris, 3. Chlorococcum minutum, 4. Oedogonium porrectum, 5. Oedogonium mexicanum, 6. Closterium praelongum var. brevius. Scale bars: 10 µm
Plate (3): 1. *Cosmarium tetragonum* var. *ornatum*, 2. *Cosmarium zonatum*, 3. *Mesoetanium caldariorum*, 4. *Euglena adhaerens*, 5. *Euglena contabrica*, 6. *Euglena fusiformis*. Scale bars: 10 µm
Plate (4): 1. *Lepocinclis acus*, 2. *Phacus helicoides*, 3. *Tachelomonas armata*, 4. *Trachelomonas horrida*, 5. *Ophiocytium cochleare*, 6. *Pseudokephyrion undulatum*, 7. *Ceratium furcoides*. Scale bars is 10 µm and each bar is 1 µm
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