



ORIGINAL ARTICLE

New records of green-algae (chlorophyceae) from the Punjab state of India

Yadvinder Singh* and Komal

Abstract

This study is the first report on Chlorophyceae members at species level from Ropar wetland (Ramsar site), Punjab (India). During this study, the algal samples were collected from different locations of the wetland, and were identified on the basis of their morphological characteristics. A total of 16 species of 14 genera (*Ankistrodesmus*, *Cladophora*, *Coelastrum*, *Cylindrocapsa*, *Golenkinia*, *Gonium*, *Hydrodictyon*, *Micractinium*, *Monoraphidium*, *Oedogonium*, *Pediastrum*, *Scenedesmus*, *Spirogyra* and *Tetraedron*) belonging to 6 orders of 10 families of the class Chlorophyceae were recorded from the study area. All the members of Chlorophyceae documented during this study at species level, except *Cylindrocapsa geminella* are new records for Punjab state of India.

Keywords: Algae, Chlorophyceae, new records, Punjab, Ropar wetland.

Introduction

Algae are oxygenic-photosynthetic organisms, including both prokaryotic as well as eukaryotic forms, and are considered as first autotrophic plants on earth (Lone *et al.* 2017, Khalil *et al.* 2021). Algae are diverse and highly specialized group of varied micro- & macro-organisms in terms of size, shape, color, structure and habitat, and are adapted to wide range of ecological conditions. In any aquatic ecosystem, algae are primary producers and play an important role in aquatic food chain, on which fishes and zooplanktons depend for their food (Severes *et al.* 2018). Algae are one of the significant organisms which help CO₂ sequestration and water purification, due to their ability to absorb various organic and inorganic pollutants along with heavy metals (Khalil *et al.* 2021). On the basis of their habitat, the freshwater algae can be categorized into two groups: lotic (growing in flowing water) and lentic (growing

in stagnant water). The lotic system includes streams, rivulets, rivers, waterfalls whereas, lentic system comprises small ponds, ditches, lakes, puddles etc. All the members of algae are not fresh water algae, but members of Cyanophyta, Chlorophyta, Charophyta and Bacillariophyta display their high diversity and abundance in fresh water (Leliaert *et al.* 2012, Whitton 2012, Sharma *et al.* 2018).

Chlorophyceae is one of the ecologically diverse and largest assemblages of algae found to grow abundantly in lakes, ponds, rivers and streams etc. (Rai *et al.* 2020). This group comprises eukaryotic, motile or non-motile organisms occurring in different forms as solitary unicells, colonies or in filamentous forms. Chlorophycean members are found in all types of habitats including aquatic, terrestrial, subaerial, endophytic and symbiotic, but some algae may have different ecological preferences (Leliaert *et al.* 2012). The distribution of Chlorophyceae in India is very wide, and thousands of species are recorded from different water bodies across different regions of the country (Anand 1998, Kant and Gupta 1998, Sau and Gupta 2005, Jena and Adhikary 2007, Mallick and Keshri 2008). Therefore, very comprehensive work has been done on occurrence and distribution Chlorophyceae around the country.

From time to time members of algae have also been reported from different habitats of Punjab including, lakes, rivers, wetlands, ponds, ditches, puddles and paddy fields (Rattan 1963a-c, 1964a, b, 1967, 1968a,b, 1971, 1989; Sharma *et al.* 2013, Prabha and Dua 2018, Komal *et al.* 2021) and new algal species are reported every time. It indicates that knowledge about the diversity and distribution of

Department of Botany and Environmental Science, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India.

***Corresponding Author:** Yadvinder Singh, Department of Botany and Environmental Science, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India, E-Mail: yadbotany@gmail.com

How to cite this article: Singh Y, Komal (2023). New records of green-algae (chlorophyceae) from the Punjab state of India. *J. Indian bot. Soc.*, 103 (4): 274-280 Doi: [10.61289/jibs2023.27.09.1172](https://doi.org/10.61289/jibs2023.27.09.1172)

Source of support: Nil

Conflict of interest: None.

Chlorophyceae in Punjab is not fully known and remains unexplored. In the present study, an attempt has been made to study the diversity and distribution of Chlorophyceae for the addition of more knowledge to algal flora of Punjab region of India.

Materials and Methods

Collection and Identification of algal samples

Algal samples were collected from the Ropar wetland (Ramsar site) located at 30° 57' - 31°06' North latitude and 76° 25' - 76° 36' East longitude in Roopnagar district of Punjab state of India during 2018 and 2020 (Figure 1). The photographs of some habitats of algae of the collection sites are shown in Figure 2. All collected samples were preserved in 4% formalin solution on spot during collection and were brought to the laboratory for further analysis. Each sample was assigned with a particular herbarium number (WUA) of Sri Guru Granth Sahib World University. The temporary slides were prepared from collected algal samples and observed under OlympusCH20i microscope at 40X and 100X using immersion oil. The algal representatives were identified on the basis of morphological features viz. shape of cell, size, number of chloroplasts, number and arrangement of pyrenoids, spines etc. by following standard literatures (West 1892, Prescott 1951, Philipose 1967, Prasad and Misra, 1992, Yamagishi 2010).

Results

During the present study a total of 16 members of chlorophyceae belonging to 14 genera (*Micractinium*, *Gonium*, *Ankistrodesmus*, *Monoraphidium*, *Tetraedron*, *Hydrodictyon*, *Pediastrum*, *Scenedesmus*, *Coelastrum*, *Golenkinia*, *Cylindrocapsa*, *Spirogyra*, *Cladophora* and *Oedogonium*) of 6 orders (Chlamydomonadales, Chlorellales, Cladophorales, Oedogoniales, Sphaeropleales and Zygnematales) of class Chlorophyceae were recorded. Out of 16 chlorophycean taxa, fifteen are new reports for Ropar wetland as well for the Punjab state of India. The microphotographs of recorded species are shown in Figures 3 and 4.

Order: Chlorellales

Family: Chlorellaceae

***Micractinium pusillum* Fresenius 1858: 236, pl. XI [11]: figs 46-49**

Plate 1 (a)

Description

Colonies 4-8 celled with triangular shape, easily collapsed into uni-cells; cell diameter 4-8µm, setae 30-50µm in length; cells spherical; spines attenuated towards tip, 2-7 in number; cup-shaped chloroplast having one pyrenoid.

Collection No.: WUA 12, WUA 19, WUA 27, WUA 52 and WUA 55.

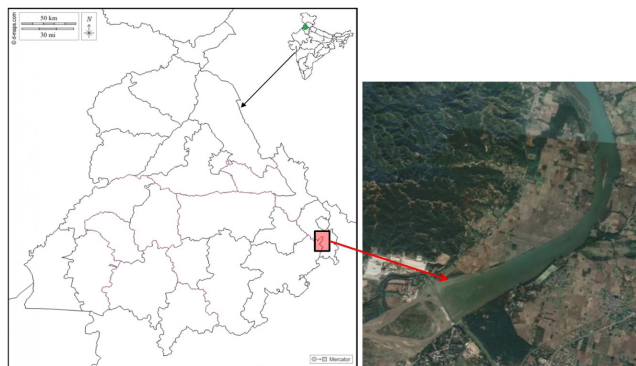


Figure 1: Map of the study area (Ropar wetland, Punjab) (source: Google Map).

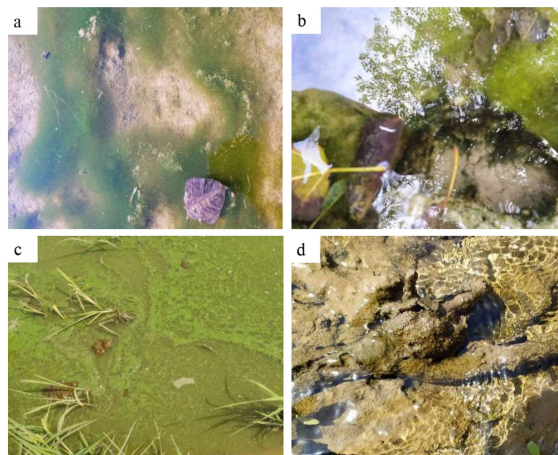


Figure 2: Field photograph showing different algal habitats.

Distribution

Jammu and Kashmir (Kant and Gupta 1998), Tamil Nadu (Philipose 1967).

Order: Chlamydomonadales

Family: Goniaceae

***Gonium pectorale* O.F. Müller 1773: 60**

Plate 1 (b)

Description

Cells in colonies; embedded with gelatinous sheath; 16-32-celled colonies with octagonal shape, with 4 central, 10 intermediate and 18 peripheral cells, cells 15-19µm in length, 10-12 µm in breadth; almost globose; embedded in gelatinous sheath;

Distribution

Jammu and Kashmir (Anand 1998), Maharashtra (Patil *et al.* 2012).

Order: Sphaeropleales

Family: Selenastraceae

(i) *Ankistrodesmus falcatus* (Corda) Ralfs 1848: 180, pl. XXXIV [34]: figs a-c

Plate 1 (c)

Description

Cells 10-20µm in length, 1.5-2.0 µm in breadth; acute to hardly lanceolar; tapering to acute apices; typically in 4-8

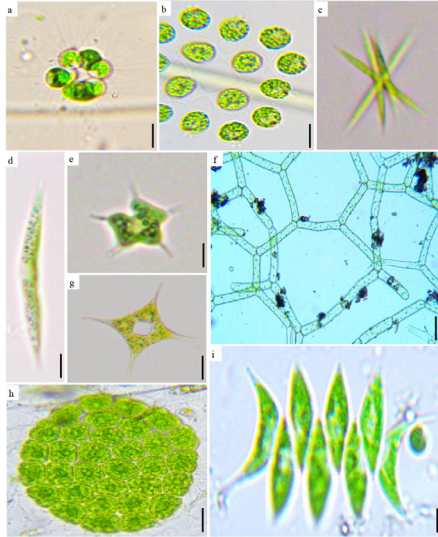


Figure 3: Micro-photographs of green algal species identified from study area. (a): *Micractinium pusillum*; (b): *Gonium pectorale*; (c): *Ankistrodesmus falcatus*; (d): *Monoraphidium contortum*; (e): *Tetraedron caudatum*; (f): *Hydrodictyon reticulatum*; (g): *Pediastrum tetras*; (h): *Pediastrum araneosum*; (i): *Scenedesmus acuminatus* (Scale= 10 µm)

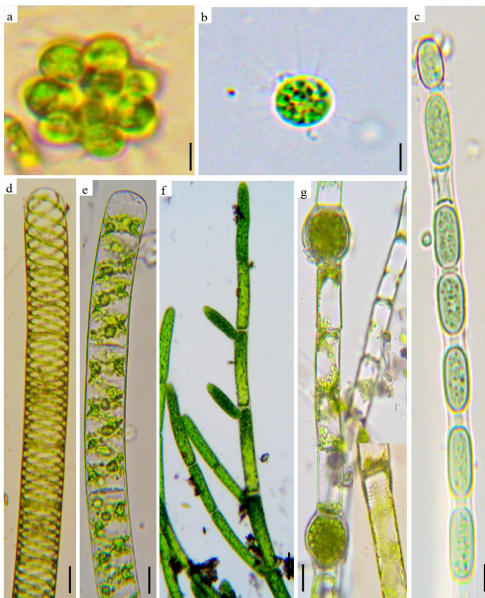


Figure 4: Micro-photographs of green algal species identified from study area; (a): *Coelastrum proboscideum*; (b): *Golenkinia radiata*; (c): *Cyndrocapsa geminella*; (d): *Spirogyra crassa*; (e): *Spirogyra hyalina*; (f): *Cladophora glomerata*; (g): *Oedogonium globosum* (Scale= 10 µm)

cells fasciculate bundle; one parietal chloroplast

Collection No.: WUA 08, WUA 17, WUA 28 and WUA 34.

Distribution

Bhopal (Bhat *et al.* 2015), Eastern and North-eastern States of India (Jena and Adhikary 2007), Jammu (Paul and Anand

2009), Kerala (Vijayan and Ray 2015), Manipur (Jena and Adhikary 2011), Rajasthan (Meena 2017).

(ii) *Monoraphidium contortum* (Thuret) Komárková-Legnerová in Fott 1969: 104, pl. 18: figs 1-5 Plate 1 (d)

Description

Cells 25-40µm in length, 3-6µm in breadth; extended, solitary and fusiform; almost straight to somewhat slender; sigmoid; thin cell wall; cell ends pointed; single chloroplast having no distinct pyrenoids.

Collection No.: WUA 12, WUA 19, WUA 27, WUA 52 and WUA 55.

Distribution

Eastern and North-eastern States of India (Jena and Adhikary 2007), Odisha (Behera *et al.* 2020).

Order: Sphaeropleales

Family: Hydrodictyaceae

(i) *Tetraedron caudatum* (Corda) Hansgirg 1888: 131 Plate 1 (e)

Description

Cell 12-14µm in diameter; small, cells having five sides, four sides concave whereas fifth forms the notch of varied depth; having rounded angles that produces short and fine spines.

Collection No.: WUA 07, WUA 15, WUA 24, WUA 27 and WUA 32.

Distribution

Bhopal (Bhat *et al.* 2015), Karnataka (Gupta 2012), Andhra Pradesh (Mallikarjuna *et al.* 2019).

(ii) *Hydrodictyon reticulatum* (Linnaeus) Bory 1824: 506 Plate 1 (f)

Description

Cells 51.6-54.4µm in length, 9.3-10µm in breadth; extended; tubular; coenocytic; 6 cells together interconnected at their ending walls to form polygonal network; cell wall smooth; reticulate chloroplast with numerous pyrenoids.

Collection No.: WUA 06, WUA 17, WUA 25 and WUA 42.

Distribution

Eastern and North-eastern States of India (Jena and Adhikary 2007), Maharashtra (Patil *et al.* 2012), Meghalaya (Kalita *et al.* 2015), Rajasthan (Meena 2017).

(iii) *Pediastrum tetras* (Ehrenberg) Ralfs 1845: 469 Plate 1 (g)

Description

Cells in colonies; colonies without perforations; marginal cells 6-14µm in length, 6-15µm in breadth; marginal cells of basal parts triangular to trapezoidal; 2 triangular processes

produce deep incision; cell walls smooth; reticulate chloroplast with single pyrenoid.

Collection No.: WUA 10, WUA 18, WUA 24, WUA 33 and WUA 52.

Distribution

Bhopal (Bhat *et al.* 2015), Eastern and North-eastern States of India (Jena and Adhikary 2007), Rajasthan (Meena 2017).

(iv) *Pediastrum araneosum* (Raciborski) G. M. Smith 1916: 476

Plate 1 (h)

Description

Cells in colonies: colonies with slight perforations; cells 17-23µm in length, marginal cells flat at the basal portion, ranged from quadrate to trapezoid in shape; development of hollow incision due to two opposite short lobes; inner cells hexagonal to trapezoid in shape; minute undulation in the cell walls due to rough reticulated edges; net like chloroplast with one large pyrenoid.

Collection No.: WUA 09, WUA 16, WUA 25 and WUA 43.

Distribution

Jammu and Kashmir (Kant and Gupta, 1998), Karnataka (Suxena 1984), Tamil Nadu (Philipose 1967), West Bengal (Mallick and Keshri 2008).

Order: Sphaeropleales

Family: Scenedesmaceae

(i) *Scenedesmus acuminatus* (Lagerheim) Chodat 1902: 211

Plate 1 (i)

Description

Cells 10-15µm in length, 2-7µm in breadth; bowed and fusiform; arranged linearly in a series of 4-celled or in 8-celled colony by contacting with the side; smooth cell wall; plate like chloroplast with parietal position having single pyrenoid.

Collection No.: WUA 12, WUA 19, WUA 27, WUA 52, WUA 97 and WUA 107.

Distribution

Bhopal (Bhat *et al.* 2015), Himachal Pradesh (Seth *et al.* 2005), Jammu and Kashmir (Kant and Gupta 1998), Maharashtra (Patil *et al.* 2012), Orissa (Padhi 2006; Ratha *et al.* 2006), Tamil Nadu (Philipose 1967), Uttarakhand (Gupta 2005), West Bengal (Sau and Gupta 2005).

(ii) *Coelastrum proboscideum* Bohlin in Wittrock, Nordstedt and Lagerheim 1896: no. 1240

Plate 2 (a)

Description

Cells in colonies; colony consists of 8-16 cells; 44-98µm in diameter; spherical or hollow in shape; cells spherical to polygonal shaped; attached by small interconnecting

protuberances made of mucilaginous sheaths, with sharp spines; parietal chloroplast with single pyrenoid.

Collection No.: WUA 15, WUA 21, WUA 28, WUA 44 and WUA 54.

Distribution

Eastern and North-eastern States of India (Jena and Adhikary 2007), Odisha (Behera *et al.* 2020).

Order: Sphaeropleales

Family: Neochloridaceae

***Golenkinia radiata* Chodat 1894: 305, pl. III [3]**

Plate 2 (b)

Description

cells circular; Cell diameter 8-13µm, setae 20-26µm long; possess spines 2-3 times longer than the diameter of cell; chloroplast cup shaped.

Collection No.: WUA 05, WUA 14, WUA 26, WUA 32 and WUA 55.

Distribution

Meghalaya (Hajong and Ramajunam 2021), Tamil Nadu (Philipose 1967), West Bengal (Smith 1920).

Order: Sphaeropleales

Family: Cyndrocapsaceae

***Cyndrocapsa geminella* Wolle 1887: 104**

Plate 2 (c)

Description

Filaments green, long and unbranched; cells 24-45µm long, 14-17µm wide; cells oblong to ellipsoid, arranged in uniseriate manner, surrounded by tough gelatinous cell wall as a whole; massive chloroplast with single pyrenoid.

Collection No.: WUA 03, WUA 14, WUA 28, WUA 38 and WUA 57.

Distribution

Jammu and Kashmir (Anand 1998), Maharashtra (Kamat 1963), Punjab (Sarma and Bala 1985), Tamil Nadu (Iyengar 1939), Uttar Pradesh (Kamat 1973; Srivastava and Sarma 1981), Uttarakhand (Khan 1970), West Bengal (Kargupta 1987a; Sikdar *et al.* 2012).

Order: Zygnematales

Family: Zygnemataceae

(i) *Spirogyra crassa* (Kützing) Kützing 1843: 280, pl. 14: fig. 4

Plate 2 (d)

Description

Filaments green, long and unbranched, slimy to touch; vegetative cells 150-220µm long, 35-40µm wide; plane end walls; Single chloroplast making 4-5 spiral turns.

Collection No.: WUA 06, WUA 17, WUA 29, WUA 40 and WUA 53.

Distribution

Kerala (Ushadevi and Panikkar 1994), Meghalaya (Hajong and Ramajunam 2021).

(ii) *Spirogyra hyalina* Cleve 1868: 17, pl. 2; pl. 3: figs 1-6 Plate 2 (e)**Description**

Filaments green, long, unbranched; vegetative cells 80-240µm long, and 47-56 µm wide; end walls plane; range of chloroplasts 2-4 making 1-3spiral turns.

Collection No.: WUA 08, WUA 16, WUA 29, WUA 41 and WUA 43.

Distribution

Arunachal Pradesh (Gupta *et al.* 2002), Himachal Pradesh (Seth 2005), Jammu and Kashmir (Kant and Gupta 1998), Maharashtra (Barhate and Tarar 1985; Patil *et al.* 2012), West Bengal (Sikdar *et al.* 2012).

Order: Cladophorales

Family: Cladophoraceae

Cladophora glomerata* (Linnaeus) Kützing 1843: 266 Plate 2 (f)*Description**

Macroscopic; filaments uni-seriate; slight to profusely branched; entangled filaments; slender; green; upper parts crowded; long terminal branches; cells 30-60µm long, 10-15µm wide; cells cylindrical to barrel shaped; each cell with parietal net like chloroplast with numerous pyrenoids.

Collection No.: WUA 04, WUA 13, WUA 27, WUA 45 and WUA 55.

Distribution

Jammu and Kashmir (Kant and Gupta 1998), Kerala (Vijayan and Ray 2015), Maharashtra (Maharashtra (Patil *et al.* 2012; Dhupal *et al.* 2020), Manipur (Gupta 2002), Odisha (Behera *et al.* 2020), Uttarakhand (Gupta 2005), Uttar Pradesh (Chadha and Pandey 1984; Misra *et al.* 2002).

Order: Oedogoniales

Family: Oedogoniaceae

***Oedogonium globosum* Nordstedt ex Hirn 1900: 94, pl. V [5]: fig. 30**

Plate 2 (h)

Description

Filaments long uni-seriate and unbranched; cells long, cylindrical, 25-45 µm long; 8-13.2 µm wide; large single swollen oogonium; oogonium globose to sub globose; 12-15 µm in diameter; thick spore wall; smooth; chloroplast reticulate with numerous pyrenoids.

Collection No.: WUA 06, WUA 13, WUA 25, WUA 44 and WUA 55.

Distribution

Meghalaya (Hajong and Ramajunam 2021), Odisha (Behera *et al.* 2020).

Discussion

In the present study, a total of 16 species of Chlorophyceae has been identified on the basis of morpho-taxonomic characteristics, which included unicellular, colonial and filamentous unbranched and filamentous branched forms. These species belonged to 6 orders of 10 families, out of which majority of the species were of order Sphaeropleales. The diversity as well as the distribution of presently reported Chlorophycean genera has earlier been studied throughout the India. Out of these 16 species, *Ankistrodesmus falcatus*, *Pediastrum* sp, *Cladophora* sp., and *Spirogyra* sp. are reported to be well distributed and as dominant genera in Dodi Tal Wetland and some Northern parts of India (Jindal and Thakur 2013, Sharma and Singh 2018). Whereas, *Coelastrum proboscideum*, *Oedogonium globosum*, *Cladophora glomerata* are well distributed in Eastern zone of Odisha (Behera *et al.* 2020). The present study advocates the cosmopolitan nature of above-mentioned genera. The comparison of present study with other studies conducted in India (Kant and Gupta 1998, Paul and Anand 2009, Harsha *et al.* 2017, Behera *et al.* 2020), revealed comparatively low diversity of Chlorophyceae members from the study area. Though, some of the Chlorophyceae members have earlier been reported from different water bodies of Punjab but these reports are only upto genus level viz. *Spirogyra*, *Scenedesmus*, *Hydrodictyon*, *Pediastrum*, *Coelastrum*, *Cladophora*, *Oedogonium* (Sharma *et al.* 2013, Braich and Saini 2015, Kaur and Singh 2017, Prabha and Dua 2018, Akhter and Braich 2020b). Thus, out of 16 chlorophycean taxa reported during this study are fifteen are first report from Ropar wetland as well as from Punjab. Therefore, the present study added more species to the diversity of the earlier reported algal flora of Punjab.

Conclusions

In present study, the diversity of Chlorophyceae members (up to species level) from the Ropar wetland, Punjab (India) has been investigated for the first time. This wetland does not support rich diversity of green algae may be due to different climatic conditions in comparison to other regions of the country. This is purely speculative and needs further investigation. The present study revealed the cosmopolitan natures of *Coelastrum*, *Cladophora*, *Oedogonium*, *Spirogyra*, *Scenedesmus*, *Hydrodictyon* and *Pediastrum* as these genera are well distributed throughout India. The present study added 15 more members at the species level to the list of known members of Chlorophyceae from Punjab State of India.

Acknowledgement

The authors are thankful to the Vice-Chancellor, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India for providing required facilities.

References

- Akhter S and Braich O (2020a). Physico-chemical analysis of fresh water of Ropar wetland (Ramsar site), India. *Curr. World Environ.* **15(1)**: 117-126.
- Akhter S and Braich O (2020b). Spatial and temporal distribution of Phytoplankton from Ropar Wetland (Ramsar Site) Punjab, India. *Appl. Ecol. Environ. Sci.* **8(1)**: 25-33.
- Anand N (1998). Indian Freshwater microalgae. Bishen Singh Mahendra Pal Singh, Dehradun.
- Barhate VP and Tarar JL (1985). Additions to the algal flora of Maharashtra: Euglenophyta from Khandesh- I. *Phykos* **24**: 184-185.
- Behera C, Dash SR, Pradhan B, Jena M and Adhikary SP (2020). Algal Diversity of Ansupa lake, Odisha, India. *Nelumbo* **62(2)**: 207-220.
- Braich O and Saini S (2015). Water quality index of Ranjit Sagar Wetland situated on the Ravi River of Indus river system. *Int. J. Adv. Res.* **3**: 1498-1509.
- Chadha A and Pandey DC 1984 Algal flora of Allahabad, Part IV. A general account. *Biblioth. Phycol.* **66** 141-178.
- Gupta RK 2005 Algal flora of Dehradun district, Uttaranchal. Bot. Sur. India, Kolkata.
- Gupta RK 2012 Algae of India. 2. A checklist of Chlorophyceae, Xanthophyceae, Chrysophyceae and Euglenophyceae. Botanical Survey of India, Ministry of Environment & Forests, India, Salt Lake & Kolkata.
- Gupta RK, Singh KP and Singh DK 2002 Algae of the Mehao Wildlife Sanctuary, Arunachal Pradesh, India. *Ann Forest* **10(2)** 237-337.
- Harsha TK, Pradeepkumar G and Kumar GE 2017 Diversity of planktonic algae of selected freshwater ponds of Mahe, U T of Puducherry, India. *J. Algal Biomass Utiln.* **8(3)** 50-55.
- Iyengar MOP 1939 On the life history of *Cylindrocapsa geminella*. *Curr. Sci.* 216-217.
- Jena M and Adhikary SP 2007 Chlorococcales (Chlorophyceae) of Eastern and North-eastern States of India. *Algae* **22(3)** 167-183.
- Jindal R and Thakur RK 2013 Diurnal variations of plankton diversity and physicochemical characteristics of Rewalsar Wetland, Himachal Pradesh, India. *Recent Res. Sci. Tech.* **5(3)** 4-9.
- Kalita J, Bhuyan SI and Das R (2015). An assessment of Green algae (Chlorophyceae) diversity in different habitats of RiBhoi, Meghalaya. *Pharma Innovation.* **4(2)**: 50-55.
- Kamat ND (1963). Algae of Kolhapur, India. *Hydrobiologia* **22**: 209-305.
- Kamat ND (1973). Algae of Nainital. *J. Bombay Nat. Hist. Soc.* **70**: 582-586.
- Kant S and Gupta P (1998). Algal flora of Ladakh, Scientific Publishers (India), Jodhpur, India.
- Kargupta AN (1987a). New records of some members of Ulotrichales from West Bengal. *Phykos* **26**: 47-52.
- Kaur S and Singh P (2017). Studies on plankton diversity of River Sutlej, Punjab. *J. Entomol. Zool. Stud.* **5(6)**: 620-628.
- Khalil S, Mahnashi MH, Hussain M, Zafar N, Waqar-Un-Nisa Khan KS, Afzal U, Shah GM, Niazi UM, Awais M and Irfan M (2021). Exploration and determination of algal role as Bioindicator to evaluate water quality-Probing fresh water algae. *Saudi J. Biol. Sci.* **28**: 5728-5737.
- Khan M (1970). Algal flora of Dehradun II. Chlorophyta. *GKVJ Sci. Res.* **2**: 87-92.
- Komal Khattar JIS Singh DP SinghY (2021). New records of desmids from Ropar wetland (a Ramsar Site) of Punjab, India. *Plant Sci. Today* **8(4)**:1037-1048.
- Ladhari SS (2002). Status of ecological health of wetlands in Punjab, India. *Aquat. Ecosyst. Health Manag.* **5(4)**: 457-465.
- Leliaert F, Smith DR, Moreau H, Herron MD, Verbruggen H, Delwiche CF and De Clarke, O (2012). Phylogeny and molecular evolution of green algae, *Crit. Rev. Plant. Sci. Plant Sci.* **31**: 1-46.
- Lone JA, Lone FA and Suseela MR (2017). A review on phycological studies with special emphasis on Kashmir Himalayan Valley: Algal Biodiversity. *Ann. Plant Sci.* **6(12)**: 1879-1885.
- Mallick, P and Keshri JP (2008). Dinobryon Ehrenberg in West Bengal – New record of three taxa. *J. Appl. Biosci.* **34(1)**: 113-114.
- Mallikarjuna G, Reddy CSK, Raju CP, Reddy PCO and Sekhar AK (2019). Genus *Tetraedron* Kutzing (Algae-Chlorophyta) from Ananthapuramu District, Andhra Pradesh, India. *Ind. Hydrobiol.* **18(1 & 2)**: 218-226.
- Meena L (2017). Freshwater micro-algal diversity-Chlorococcales from Sawaimadhapur, Rajasthan, India. *Intl. J. Bioinformatics and Biological Sci.* **5(1)**: 1-11.
- Misra PK, Prakash J and Srivastava AK (2002). Filamentous green algae from Basti, Uttar Pradesh, India. *Phytotaxonomy* **2**: 130-134.
- Padhi S (2006). Freshwater and marine algal flora of Southern Orrisa. In *Recent trends in algal taxonomy: Taxonomical & Cultural studies vol. 2* (Eds. Vidyavati & A. K. Mahato). Associated Publishing Company, New Delhi. 171-185.
- Paul Y and Anand VK 2009 Unicellular and colonial chlorophycean algal taxa from Jammu and adjoining areas. *J. Plant Dev. Sci.* **1(3&4)**: 99-104.
- Philipose MT (1967). Chlorococcales. Indian Council of Agricultural Research, New Delhi.
- Prabha and Dua A (2018). species diversity and seasonal variations in phytoplankton communities within Harike wetland – a Ramsar site. *IJCRT* **6(2)**: 2320-2882.
- Prescott GW (1951). Algae of the western great lakes area (pp. 977). W.M.C. Brown Publishers, Dubque, Iowa.
- Rai SK, Godar K and Dhakal S (2020). Some freshwater green algae of Raja-Rani Wetland, Letang, Morang: New for Nepal. *J. Plant Resour.* **18(1)**: 6-26.
- Randhawa MS (1959). Zygnemataceae. Indian Council of Agricultural Research New Delhi.
- Rattan RS 1963a Notes on some members of Zygnemaceae from Kapurthala (Punjab). *Res. Bull. Panjab Uni.* **14(I & II)**: 115-118.
- Rattan RS (1963b). Notes on some Zygnemaceae from Kapurthala (Punjab)-II. *Res. Bull. Panjab Uni.* **14(III-IV)**: 257-260.
- Rattan RS (1963c). Notes on some Zygnemaceae from Kapurthala (Punjab)-III. *Res. Bull. Panjab Uni.* **14(III-IV)**: 261-262.
- Rattan RS (1964a). Notes on some Zygnemaceae from Kapurthala (Punjab)-IV. *Res Bull Panjab Uni.* **15(III-IV)**: 265-268.
- Rattan RS (1964b). Notes on some new records of Zygnemaceae from Kapurthala (Punjab)-V. *Res. Bull. Panjab Uni.* **15(III-IV)**: 309-313.
- Rattan RS (1967). Notes on some Zygnemaceae from Panjab.

- Phykos*, **6 (1 & 2)**: 95-99.
- Rattan RS (1968a). Notes Zygnemaceae of the Punjab Plains. *Res. Bull. Panjab Uni.* **19 (I-II)**: 253-254.
- Rattan RS (1968b). Some interesting forms of Zygnemaceae from Punjab (India). *Phykos* **7 (1 & 2)**: 117-125.
- Rattan RS (1971). Some new taxa of *Spirogyra* Link from Punjab. *Phykos* **10 (1 & 2)**: 137-140.
- Rattan RS (1989). Taxonomic studies on Zygnemaceae of Punjab and its adjoining areas. Ph.D. thesis, Punjabi University Patiala.
- Ratha SK, Jena M and Adhikary SP (2006). Euglenophytes from Orissa State, East Coast of India. *Algae* **21(1)**: 61-73.
- Sarma TA and Bala V (1985). On the cytology of *Cylindrocapsa geminella* Wolle from Punjab. *J. Ind. Bot. Soc.* **64**: 406-407.
- Sau A and Gupta RK (2005). Algal flora of Indian Botanic Garden, Howrah, West Bengal. *Bull. Bot. Sur. India* **47 (1-4)**: 63-86.
- Seth A, Seth MK and Misra PK (2005). Review of literature on algal flora of Himachal Pradesh. *Phytotaxonomy* **5**: 35-57.
- Severes A, Nivas S, D'Souza L and Hegde S (2018). Diversity study of freshwater microalgae of some unexplored water bodies of a rapidly developing industrial region in India. *J. Algal Biomass Utiln.* **9(2)**: 31-40.
- Sharma C, Jindal R, Singh UB, Ahluwalia AS and Thakur RK (2013). Population dynamics and species diversity of plankton in relation to hydrobiological characteristics of River Sutlej, Punjab, India. *Ecol. Environ. Conserv.* **19(3)**: 717-724.
- Sharma H, Das D, Sarmah P and Rout J (2018). A study on freshwater algal communities of pond ecosystems from southern Assam. *Vegetos.* <https://doi.org/10.1007/s42535-019-00003-w>
- Sikdar J, Mustafa G and Keshri JP (2012). Some fresh water green algae of West Bengal, India. *J. Appl. Biosci.* **38(2)**: 179-186.
- Smith GM (1920). Phytoplankton of the Wisconsin Lakes. *Bull Wisconsin Geol Nat Hist Surv.* **57** 1-243.
- Srivastava S and Sarma YSRK (1981). Cultural and cytological observations on *Cylindrocapsa geminella* Wolle. *Phykos* **20**: 49-52.
- Suxena MR (1984). Algae from Kodaikanal Hill. *Biblioth. Phycol.* **66**: 43-99.
- Ushadevi K and Panikkar MVN (1994). Species of the genus *Spirogyra* from Kerala, India. (Chlorophyta: Zygnemataceae). *Biblioth. Phycol.* **97**: 1-124.
- Vijayan D and Ray JG (2015). Green algae of a unique tropical wetland, Kuttanadu, Kerala, India, in relation to soil regions, seasons, and paddy growth stages. *Int. J. Sci. Environ. Technol.* **4 (3)**: 770-803.
- West W (1892). Algae of the English lake district. *J. Roy. Microscop. Soc.* **8**: 713-748.
- Whitton BA (Ed.) (2012). *Ecology of Cyanobacteria II. Their diversity in time and space.* Springer Science + Business Media B.V, New York, 760.