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Research article

Green algae from the paddy field water of Bramhapuri taluka, Chandrapur district, Maharashtra, India

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Abstract: During the study of the micro and macro flora of some green algae in paddy field water of Bramhapuri taluka, Chandrapur district, Maharashtra, 32 taxa of chlorophycean algae were encountered. Among these species, 10 are Cosmarium, 6 Scenedesmus, 4 Spirogyra, 3 Closterium, 2 Oedogonium, and one each of Pediastrum, Docidium**,** Pandorina, Sperocystis, Chlamydocapsa, Eustrum and Chlorococcum. This paper deals with the systematic study and distribution of these green algal taxa in paddy field water in Bramhapuri taluka of Chandrapur district.
Keywords: Bramhapuri taluka - Paddy water - Green algae - Systematic study.

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INTRODUCTION

Paddy (*Oryza sativa* L.), the staple diet of about 50% of the world population (Kogel-Knabner *et al*. 2010) is cultivated over 150 million hectares belonging to 114 countries in the world (Gayatri & Raveendran 2009). Out of the total area of paddy fields, 75% is under water. Paddy is the major crop grown under flood conditions (Roger *et al*. 1993). The unique habitats of wetland soils was flooded paddy field soil (Sahrawat 2008). Such submerged anaerobic soil environments (Kumar & Sahu 2012) with varying amounts of light, water, temperature and nutrients are variable in accordance with soil regions, seasons and growth stages of the crop. Most of the algal diversity is found in paddy fields, which are considered precious environments (Inubushi & Acquaye 2004).

MATERIAL AND METHOD

Study site

Bramhapuri is one of the six divisions located in the northeastern part of Chandrapur district, Maharashtra at 20.36° N and 79.51° E and it extends over an area 814.75 km^2 (Fig. 1). Average rainfall of the taluka is 15,000 mm with the maximum temperature is 45°C in summer and it is about 10°C in winter. In Bramhapuri taluka there is one biggest river Wainganga flow from north to southern part of Taluka and lakes are also present. The aquatic flora is dominant in this water body. The forest area in Bramhapuri taluka covers 364.24 km^2, but the actual crop area is 294.23 km^2. The vegetative cultivation is also taken and total vegetable area is 0.82 km^2. Paddy is mainly cultivated in rainy season from July to October and irrigation system is available from river Wainganga, lakes and tube wells etc. During the early stage of crop a number of algal species occur in paddy field and they become dry during the summer season.

Methodology

Samples were collected from all 5 sites during different seasons of 2021–22 periods (Table 1). The specimen tubes was used for the algal samples collection from surfaces of waterlogged and moist soil. The wide mouthed bottles was used for the collection of filamentous algae which are epiphytic in nature and their filaments float on the water surface. They can be directly grasped with fingers and forceps. Surface water was also taken for the study of phytoplankton and desmids. The snails were directly collected which shows green surface and collection also taken from the aquatic plants surface and near paddy plants by scarping the surface. The collected specimens were brought to the Laboratory, carefully washed and preserved in 4% formaldehyde

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solution. The algal specimen temporary slide were prepared by use of suitable stain and observed under microscope. Plants were identified with the help of standard books, floras, monographs and research papers (Delponte 1876, West & West 1904, 1905, 1908, 1912, West *et al*. 1923, Smith 1924, Prescott 1951, Suxena & Venkateswarlu 1966, Philipose 1967, Iyangar & Deshikachary 1981, Pham *et al*. 2011); were used in the identification of species. Green algae identification was done to species level by use of algal flora.

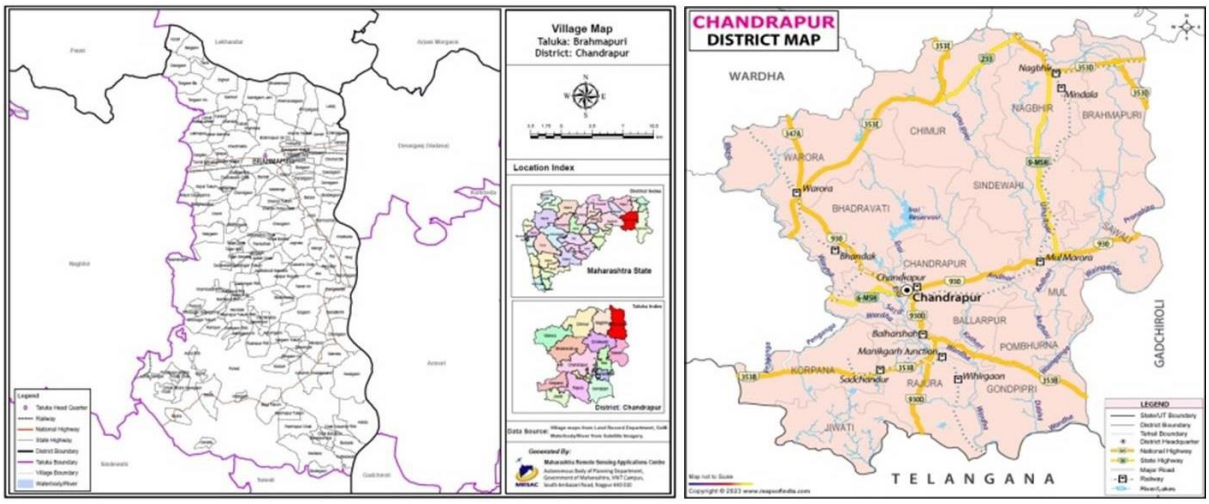

Figure 1. Location of Bramhapuri taluka in Chandrapur district, Maharashttra, India.

Table 1. Sample collection sites.

S.N.	Sites	Area	Co-ordinates
1	P1	Surbodi	Lat 20.620831°; Long 79.921347°
2	P2	Kurza	Lat 20.640157°; Long 79.863207°
3	P3	Bondegaon	Lat 20.634808°; Long 79.854036°
4	P4	Kahali	Lat 20.645672°; Long 79.850799°
5	P5	Chandali	Lat 20.642507°; Long 79.853758°

RESULT AND DISCUSSION

In the present study, total 32 green algal taxa were encountered. Among these, 10 are Cosmarium, 6 Scenedesmus, 4 Spirogyra, 3 Closterium, 2 Oedogonium, and one each of *Pediastrum*, *Docidium*, *Pandorina*, *Sperocystis*, *Chlamydocapsa*, *Eustrum* and *Chlorococcum* sp. were isolated from the paddy water. The following are the taxonomic, character, and distribution details of them.

Taxonomic enumeration

Order - Chroococales

1. Stauridium tetras (Ehrenberg) Hegewald in Buccheim *et al.* 2005, p. 1051). **[Fig. 2A]**

Colonies entire, 4–8 celled; inner cells with 4–6 straight sides but with one margin deeply incised; peripheral cells crenate with a deep incision in the outer free margin, their lateral margins adjoined along 2/3 of their length; cells 8–12 (16) µ in diameter.

2. Scenedesmus acunae Comas Gonzales 1980:7, fig. 7 d–f. **[Fig. 2B]**

Cells linear Cylindrical of inner cells, convex outer cell, round apices, Smooth cell walls

3. Scenedesmusn bicaudatus Dedusenko 1925:72, pl. 1: fig. 14 (as 'bicaudata'). **[Fig. 2C]**

Colonies of 8 cells arranging linearly; cell body ellipsoidal, both ends rounded, 8–13 µm long, 2.0–4.5 µm wide; outer cells with a spiny projection (3–13 µm long) at one end .

4. Scenedesmus denticulatus (Lagerheim) Hegewald 1882: 61, pl. II [2]: fig. 13. **[Fig. 2D]**

Colonies of 2 cells attached side by side, arranged linearly or zigzag; cell body elliptical or spindle or crescent in shape; terminal cells with spiny projections in many species; cell wall usually smooth, but in some species granulated or dented.

5. Scenedesmus disciformis (Chodat) Fott et Komárek 1960: 129, *Preslia* 32: 113–141. **[Fig. 2E]**

Colonies 2, 4, usually 8 celled; cells arrange in two rows, each joined together without distinct openings; each cell cylindrical with rounded tops slightly arcuated, on the margin with concave or convex outer sides; cell wall Dimension: Cells 17–20 µm long, 8.0–9.5 µm broad.

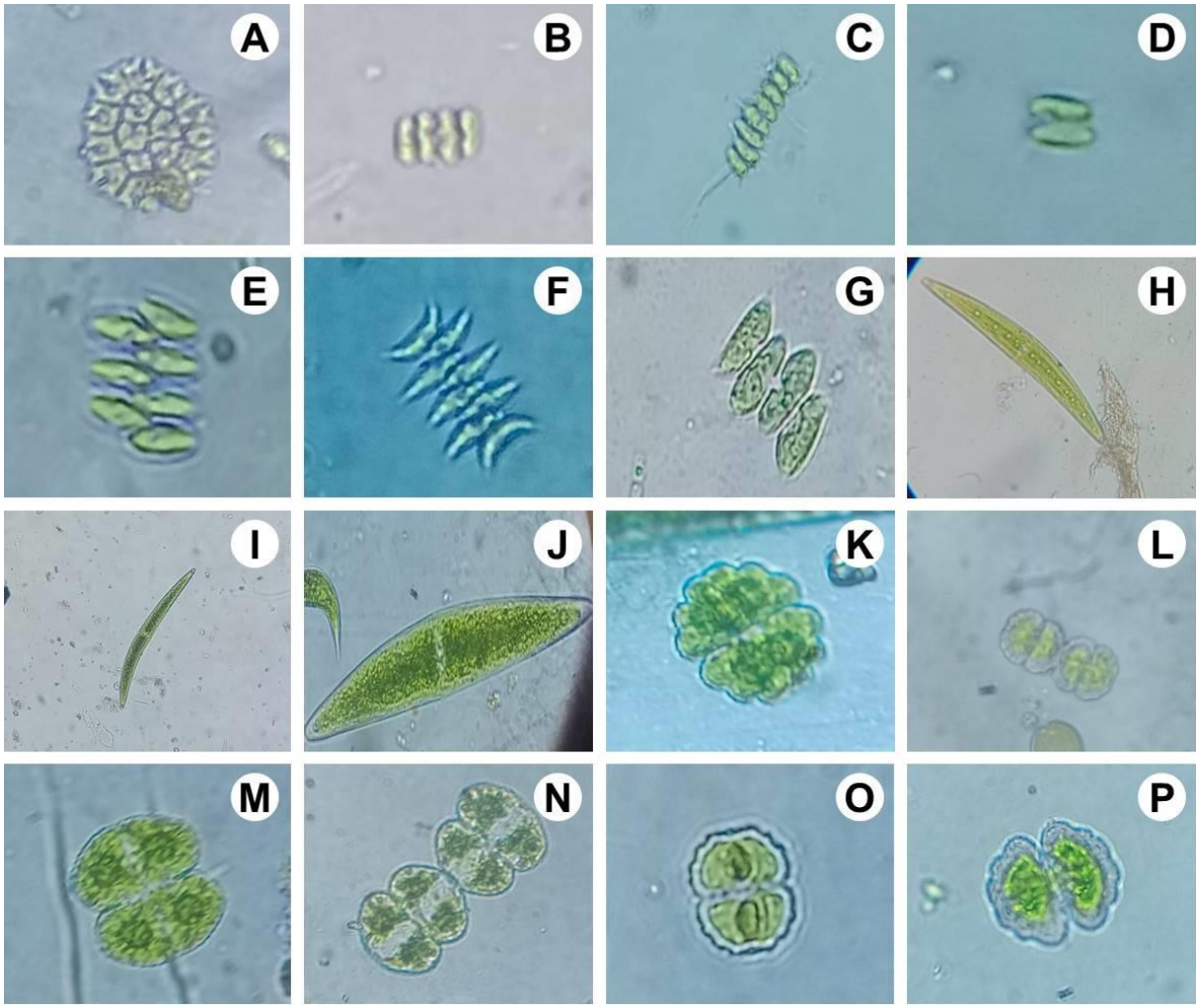

Figure 2. A, *Stauridium tetras* (Ehrenberg) Hegewald; **B,** *Scenedesmus acunae* Comas; **C,** *Scenedesmusn bicaudatus* Dedusenko; **D,** *Scenedesmus denticulatus* (Lagerheim) Hegewald; **E,** *Scenedesmus disciformis* (Chodat) Fott et Komárek; **F,** *Scenedesmus dimorphus* (Turpin) Kuetzing; **G,** *Scenedesmus acutiformis* Schröder; **H,** *Closterium acerosum* Ehrenberg ex Ralfs; **I,** *Closterium lunula* Ehrenberg & Hemprich ex Ralfs; **J,** *Closterium lunula* var. *biconvexum* Schmidle; **K,** *Euastrum spinulosum* var. *inermius* (Nordstedt) Bernard; **L,** *Cosmarium awadhense* Prasad & Mehrotra; **M,** *Cosmarium costatum* Nordstedt; **N,** *Cosmarium connatum* Breb.; **O,** *Cosmarium impressulum* Elfving; **P,** *Cosmarium meneghinii* Brebisson ex Ralfs.

6. Scenedesmus dimorphus (Turpin) Kuetzing 1834: 608, *Linnaea* 8: 529–620, pls XII–XIX, fig. 79. **[Fig. 2F]**

Colonies of four to eight celled with the cells arranged in sub-alternating series, outer cells are lunate and the apices being attenuated, cells 3–8 µm broad, 10–17 µm long.perceived in algal collections from wet soil as well as in culture.

7. Scenedesmus acutiformis Schröder 1897: 45, pl. II [2]: fig. 4 a, b. **[Fig 2G]**

Coenobia of 2, 4 or 8 linearly or slightly alternately arranged cells; cells (3–)3.5–8.0 mm wide and (9–)11–21 (–22.4) mm long, broadly spindle-shaped to narrowly ellipsoid, bearing on convex side 1–3(–4) longitudinal ridges of thickened wall material, tapering to obtuse or rounded apices.

8. Closterium acerosum Ehrenberg ex Ralfs 1848: 164, pl. XXVII [27]: fig. 2 a, b, d-e. **[Fig. 2H]**

Cells 12–13 times longer than broad, very slightly curved, with 10–20 arc. inner margin almost straight or slightly convex, semi-cells gradually tapering towards the apices, which are narrow and rounded-truncate; chloroplast with 5 ridges and 7 pyrenoids arranged in a row. Long. cell 220 µm; lat. cell 18 µm; lat. apex 4 µm.

9. Closterium lunula Ehrenberg & Hemprich ex Ralfs 1848: 163, pl. XXVII [27]: fig. 1 (as 'Lunula'). [**Fig. 2I]**

Cells 88.1–102 µm in diameter 494.8–607.8 µm long; large, almost straight, broad abruptly but slightly attenuated near the poles which are truncately rounded; chloroplast with 4–5 ridges and containing 6 pyrenoids in a row in each semicells.

10. Closterium lunula var. biconvexum Schmidle Kossinkaja 1960:150, pl. 9: fig. 6. **[Fig. 2J]**

Cell body large, inner side nearly straight, tapering at both ends, outer side convex. Cell wall mostly smooth, without bands and transparent. Chloroplast with many pyrenoids. Length of cell body 825 µm and breadth 118 µm.

11. Euastrum spinulosum var. inermius (Nordstedt) C. Bernard 1908: 126. **[Fig. 2K]**

Broadly rounded to flattened lateral lobes and somewhat trapezoid polar lobe; cell wall with granules, arranged in more or less circular fashion, central protuberance with 10 big peripheral and 4 large internal granules. Length of cell 59.5–670.0 µm and breadth 51.0–54.5 µm.

12. Cosmarium awadhense B. N. Prasad & R. K. Mehrotra 1977: 55. **[Fig. 2L]**

Cells small, slightly longer than broad, sinus slightly open outwards semi cells sub-semicircular, sides 45 crenate, apex truncate with more or less straight margin, cell wall smooth, each semi cell with one massive chloroplast, containing one pyrenoid. Cells 22.5 µ broad, 28.5 µ long, isthmus 9 µ broad.

13. Cosmarium costatum Nordstedt. West and West 1905, p. 239. pl. 87. f. 13–16. **[Fig. 2M]**

Cell size medium, 1.12–1.20 times longer than broad; constriction deep, sinus closed; semi cells trapeziform with undulated margins; undulations with 1–2 acute granules; granules arranged below margins and in central part of semi-cell; Length 30–38 µm, width is 23–30 µm, and isthmus is 7–14 µm

14. Cosmarium connatum Breb. West &West, 1908. Vol. 3, P. 25, Pl. 67, figs. 15–17. **[Fig. 2N]**

Length 70 µm, breadth 49 µm, isthmus 40 µm.

15. Cosmarium impressulum Elfving. West and West 1908, p.86, pl. 72, figs. 14–18. **[Fig. 2O]**
Euastrum impressulum (Elving) F.Gay; *Cosmarium meneghinii* f. *latiusculum* Jacobsen

Cells small, 1.5 times as long as broad,sinus deep, linear, semi cells semi-circular; margin 8 undulate; cell wall smooth; length 15–20 µm, breadth 12–15 µm, isthmus 4–5 µm.

16. Cosmarium meneghinii Brebisson ex Ralfs. West and West, 1908. vol. 3, p. 90, pl. 72, figs. 29–32. L:20, W: 10, I: 5, Plate 2-J. **[Fig. 2P]**

Very minute, relatively longer than broad, constriction linear, semi cells subquadrate, bicrenate side and ends smooth.

17. Cosmarium ocellatum Eichler & Gutwinski 1894. Vol II, pp: 144, f. 6, p. 58; Freitas & Kamat in Phykos 18(1–2): 100, 1978: Plate VIII, fig. 98. **[Fig. 3A]**

Length of the cell 25.65 µm long, 14.25 µm breadth. Epiphytic in paddy water.

18. *Cosmarium perforatum* P. Lundell *et al.* 1871:40, Plate II: fig. 16. **[Fig. 3B]**

Cells large sized, cell sinus shows acute angle, cell wall shows distinct pores, smoothed walled. species can be readily recognized by its shallow, acute angle, open cell sinus. In frontal view, semicells are about semicircular with a truncate apex and papillate basal angle. Length: 60.8 µ,Width: 54.72 µ.

19. Cosmarium subcostatum var. minus (West & West) Kurt Förster. West and West 1908, p. 238, pl. 87; Förster 1981, p. 236–251. **[Fig. 3C]**

Cells small, almost as long as broad; constriction deep, sinus linear, closed; semi cell semi-circular, rounded, convex; length 19–24 µm, breadth 20–22 µm, isthmus 4–7 µm. Habitat: Freshwater tank; salinity: 1.2 ppt Location: Deolo, Kalimpong (27.0891045º N, 88.5025472º E).

20. Cosmarium speciosum Lund 1988. **[Fig. 3D]**

Cells of medium size, moderately constricted, sinus narrowly linear, semi cells sub-pyramidate with rounded angles, side convex with crenate margin, truncate crenated apex. Cells 37.5–39.0 µ broad, 45–51 µ broad, isthmus 12 µ broad

21. Cosmarium turpinii Brébisson 1856: 137, pl. I [1]. **[Fig. 3E]**

Cells of medium size, a little longer than broad, very deeply constricted, sinus narrowly linear with a slightly dilated extremity, somewhat open outwards; semicells pyramidate-trapeziform, rapidly narrowed from a broad base, basal angles rounded, sides very slightly concave (more especially in the upper part).

22. Docidium undulatum J.W.Bailey Kant & Gupta. Alg. Fl. Ladakh; 131; 1998: Plate X, fig. 131. **[Fig. 3F]**

Cells comparatively long, narrow, 15 µm broad, 178.5 µm long; semicells with 7–8 undulations down each lateral margin; apices 12 µm broad, truncate with rounded angles; walls smooth.

Order – Zygnematales

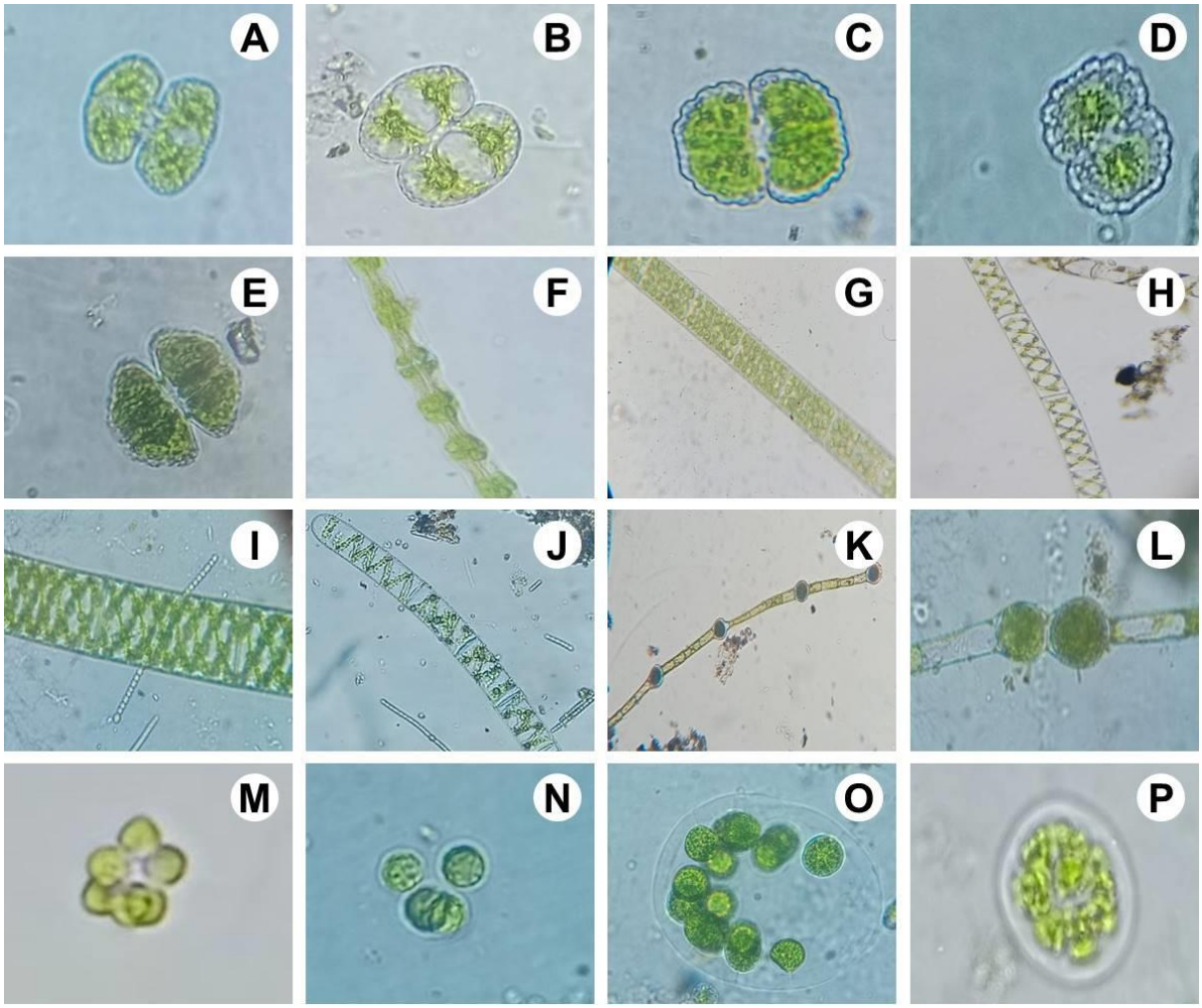

Figure 3. A, *Cosmarium ocellatum* Eichler & Gutwinski; **B,** *Cosmarium perforatum* Lundell; **C,** *Cosmarium subcostatum* var. *minus* (West & West) Förster.; **D,** *Cosmarium speciosum* Lund; **E,** *Cosmarium turpinii* Brébisson; **F,** *Docidium undulatum* Kant & Gupta; **G,** *Spirogyra ternata* Ripart; **H,** *Spirogyra exilis* West & West; **I,** *Spirogyra ellipsospora* Transeau; **J,** *Spirogyra decimina* var. *juergensii* (Kützing) Petlovany; **K,** *Oedogonium cardiacum* f. *minus* Roll; **L,** *Oedogonium crassum* f. *indicum* Goyal; **M,** *Sphaerocystis schroeteri* Chodat; **N,** *Chlorococcum infusionum* (Schrank) Meneghini; **O,** *Chlamydocapsa planctonica* (West & West) Fott.; **P,** *Pandorina morum* (Muller) Broy.

23. Spirogyra ternata Ripart 1876: 162, no fig. **[Fig. 3G]**

Filament without branching; cell body cylindrical; one or several chloroplasts band-shaped, spirally arranged within the cell, pyrenoids present; septum with or without folded structure Vegetative cells (48-)85–330 µm long, (55-)60–85 µm diam., 3–4 chloroplasts making 1–3 turns in each cell.

24. Spirogyra exilis West & G.S. West 1908: 186, pl. X[10]: fig 11–13. **[Fig. 3H]**

Uniseriate filament without branching, cells cylindrical, Chloroplast 2–8 turns, ribbon like and coiled. Length 170–185 µm and Bredth 15–18 µm.

25. Spirogyra ellipsospora Transeau E.N (1914) New species of green algae. American Journal of Botany 1: 289-301. Prescott 1959, P. 313. Pl. 72, Fig. 12. **[Fig. 3I]**

Filaments of stout cylindric cells 125–150 µ diameter, 125-230 (500) µ long with plane end walls; chloroplast 3–8 narrow bands, making ½ to 5 turns. Conjugation by tubes form both gametangia fertile cell cylindric zygospores ellipsoid or cylindric ellipsoid in age; 100–140 µ in diameter 160–255 µ long.

26. Spirogyra decimina var. juergensii (Kützing) Petlovany 2015: 43 O.A. (2015 '2014') Zygnematales. **[Fig. 3J]**

Vegetative cells 27–34 µm wide, 52–72 µm long; transverse walls plane; chloroplast single, 2–4 turns per cell. Conjugation scalariform, tubes formed by both gametangia with slight predominance by the male gametangium. Donor gametangium not inflated, 30–33 µm wide, 37–67 µm long; recipient gametangium not inflated or slightly inflated on the conjugating side, 27–30 µm wide, 66–97 µm long. Zygospores ellipsoid, sometimes with rounded tops, 26–32 µm

Order - Oedogoniales

27. Oedogonium cardiacum f. minus Y.V.Roll, nom. illeg. 1948: 50 (as 'minor'). Gauthier-Lièvre 1963–64: 332, pl. 57, fig. 99(a–i); Gonzalves 1981: 261, fig. 9.141D. **[Fig. 3K]**

Plant dioecious, macrandrous, vegetative cells cylindrical, basal cell elongate, terminal cell obtuse; oogonium usually one mostly alternating with two vegetative cells; oogonium single, subglobose, poriferous, pore supramedian; oospore globose, not filling the oogonium. Female vegetative cells 13–15 × 23–66 µ; male vegetative cells 9–12 × 15–40 µ, oogonia 26–28 × 29–33 µ; oospore 20–24 × 23–28 µ

28. Oedogonium crassum f. indicum Goyal 1964: 388, pl. I [1]: figs 14, 15. **[Fig. 3L]**

Plant dioecious, macrandrous, vegetative cells cylindrical, basal cell elongate, suffultory cell not inflated, terminal cell obtuse; oogonium single or in twos, when in twos one of them is shorter, ovoid to suboblong., poriferous, pore superior; oospore ellipsoid, globose, nearly filling the oogonium. Spore wall smooth; female vegetative cells 36.2–42.9 × 143–171 µ; oogonia 71.5–76.2 × 100–107 µ; oospore 67.9–71.5 × 64.3–90.0 µ.

Order - Chlamydomonadales

29. *Sphaerocystis schroeteri* Chodat 1897: 119, Bulletin de l'Herbier Boissier 5: 119–120. **[Fig. 3M]**

Colonies spherical in shape, consisting of 4–16 cells and 30–80um in diameter. clustered in mucilage in groups of four or more. Single cell body spherical. 5–12 um in diameter, a single chloroplast with cup shaped and pyrenoid.

30. Chlorococcum infusionum (Schrank) Meneghini, G. 1842: 27, pl. 2: fig 3. **[Fig. 3N]**

Sizes of cells range from ellipsoidal to spherical. Cell walls are smooth. Parietal chloroplasts can have one or more pyrenoids and a peripheral aperture. Spherical cells, usually solitary but sometimes several cells are congested together to form a cluster of cells, greenish in colour .cells 9–12 µm in diameter.

31. Chlamydocapsa planctonica (West & West) Fott. 1972: 199. **[Fig. 3O]**

Numerous cells surrounded by a hyaline mucilaginous envelope. Cells irregularly distributed, ovoid, 1–14 mm long, 7–9 mm wide. Chloroplast parietal, cup-shaped, with one pyrenoid.

Order - Volvoccales

32. Pandorina morum (O.F.Muller) Broy 1826; 22 (as mora) Iyengar and Desikachary, Volvocales 417.1981. **[Fig. 3P]**

Coenobia sub spherical, consisting of 8–16 cells compressed into a dense spherical aggregate, 25 µm in diameter; cells 10 µm long, with a longitudinally striated chloroplast containing a basal pyrenoid and anterior eye spot.

Discussion

The above mentioned 32 taxa of Chlorophyceae belonging to 5 Orders where, Chlorococcales represent 6 genera and 22 species, Zygnematales 1 genera with 4 species, Oedogoniales with 1 genera and 2 species following Chlamydomonadales 3 genera similarly order Volvoccales have been found with 1 genera. Considering the ecological and economic importance of aquatic microalgae in paddy fields there is a need for maintaining their ecosystems. Anthropogenic activities have decreased the area under cultivation and loss of habitat to various microalgae. The occurrence of rich algal flora is a sign of nutrient availability and favourable weather conditions. Microalgae having great potential are a reservoir of products that are used in the enrichment of paddy fields to increase crop yield and productivity. Their utilization in multiple areas along with their products and byproducts can be studied and the findings could be vital to building the economy of our state.

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