THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Survey of Colonial Green Algae from Four Perennial Tanks of Haliyal Taluk-Karnataka State

S. G. D. Rajan
Research Student, Department of Botany, Karnatak Science College, Dharwad, Karnataka, India
Doris M. Singh
Associate Professor, Department of Botany, Karnatak Science College, Dharwad, Karnataka, India

Abstract:
The paper deals with thirty-six taxa of colonial green algae recorded from four perennial tanks of Haliyal Taluk. These taxa are distributed over six Families, Chlorellaceae (8), Coelastraceae (3), Hydrodictyaceae (4), Oocystaceae (3), Radiococcaceae (3) and Scenedesmaceae (15). Pachycladella zatoriensis (Bedn. & Mroz. -Webb) Kom., a rare alga was recorded in this survey. Principal component analysis (PCA) revealed, water spread area as an important morphometric parameter in the distribution of colonial green algae. PCA also recognised, the ratio of nitrates and phosphates, as a limiting nutrient concentration gradient in determining the distribution of colonial green algae, values pitched near 25, positively influences the distribution of these taxa. Shannon diversity index also validated PCA, indicating comparative higher distribution in Neelavani tank followed by Mothikeri.

Keywords: *Haliyal, PCA, Nitrates, Phosphates*

1. Introduction

Colonial green algae are ubiquitous and widely distributed in aquatic habitats. They represent a polyphyletic group of photosynthetic organisms belonging to the divisions Chlorophyta and Streptophyta. Majority of these forms are aquatic and live free floating or attached to submerged plants or rocks. Some of the algae are considered "green weeds" (e.g., Scenedesmus and Desmodesmus), due to their ability to produce blooms in the field (Shubert and Gärtner, 2015). In shallow eutrophic bodies, larger forms such as Ceolastrum, Pediastrum and Scenedesmus may dominate during the summer (Reynolds, 1998). With respect to phytoplankton succession in oligotrophic and mesotrophic environments, colonial green algae appear to be restricted to a relatively short period defined by a narrow range of environmental conditions within which to successfully compete with a mixed assemblage of phytoplankton (Reynolds, 1998). Many of the colonial green algae are effective colonizers of newly formed water bodies. Thus, they play an important role in primary and secondary processes (Happey-Wood, 1988).

Most of these forms are diagnostic in exposed shallow basins of nutrient rich ponds, thus they are indicative of particular limnetic habitats (Reynolds, 1998) and morphometry of water bodies (Anonymous, 2001). Surveys of these multiphyletic floral components are crucial for developing biological information, which is reliable, cost-effective and valid for water quality monitoring.

In this paper, survey of colonial green algae is coupled with analysis of environmental factors responsible for their distribution and occurrence.

2.1. Materials and Methods

Despite the variable morphology, the inconsistent appearance of reproductive cells and the similarity of morphological forms, it is possible to identify most genera of colonial green algae (live or fixed) with a classical taxonomic key and a Light microscope (LM) (Shubert and Gärtner, 2015).

Samples were collected from four perennial tanks of Haliyal taluk during the post-winter for the period 2014-15. The details of the sampling areas are given below. After collection, samples were immediately fixed by 4% M3 fixative and transported to the laboratory in 1litre sterile amber polypropelene bottles. For morpho-taxonomic documentation, wet mounts of fixed samples were subjected for LM analysis. Cell shape, chloroplast structure, presence or absence of pyrenoids and habitat were considered as important characters for morpho-taxonomic enumeration. For the Generic identification, manuals of Prescott (1978) and Shubert and Gärtner (2015) were referred. Further investigations to species level, monographs of Prescott (1951), Komarek and Fott (1983) and Philipose (1967) were consulted.

2.2. Description of the Study Areas (Table 1)

Name of the Perennial tank	GPS Location	Elevation (m)	Water Spread Area in Hectares (Ha)
Ambadga	Longitude: $15^0$21'17.3'' & Latitude: $74^0$41'45.2''	536	25.4
Belwatgi	Longitude: $15^0$16'11.9'' & Latitude: $74^0$52'29.5''	551	85
Mothikeri	Longitude:$15^0$19'15.7'' & Latitude: $74^0$45'49.5''	558	5.7
Neelavani	Longitude: $15^0$13'47.3'' & Latitude: $74^0$46'26.7''	550	3

Table 1

The GPS and elevation data was acquired by GARMIN GPS meter and information on water spread area was collected from Anonymous (2010), Minor Irrigation Division, Haliyal Uttar Kannada District

2.3. Analysis of Environmental Factors

2.3.1. Field Analysis
pH, Conductivity & Temperature was analysed by Eutech field meters (Germany)

2.3.2. Laboratory Analysis
To analyse the nutrient load, Nitrate (NO_3^{3-}) was analysed by Phenol di-sulphonic acid method (NEERI, 2011) and Ortho-phosphate (PO_4^{3-}) by Stannous Chloride Method (NEERI, 2011)

2.3.3. Statistical Analysis:
To calculate the comparative diversity Shannon Weiner Diversity index (Shannon and Weaver, 1986) was calculated
To determine the factors responsible for the distribution and occurrence of colonial green algae, Principal Component Analysis (PCA) was applied, using the software xl-Stat.2014

3. Results and Discussions
The survey data (Table 2) of Colonial green algae reveals 36 taxa belonging to 8 members of Chlorellaceae, 3 of Coelastraceae, 4 of Hydrodictyaceae, 3 of Oocystaceae, 3 of Radiococcaceae and 15 of Scenedesmaceae, which clearly indicates dominant distribution of Scenedesmaceae in the four perennial tanks. *Pachycladella zatoriensis* (Bedn. & Mroz. -Webb) Kom., a rare taxa was documented in the Mothikeri tank. Due to the past taxonomic confusions it is difficult to interpret all historical records with certainty, continuing survey studies will be necessary to understand the occurrence patterns of Pachycladella and its species (Fucikova, 2015)

Sl. No	Taxa	Study area (Perennial tank)	Family
1	*Ankistrodesmus spiralis* (Turn.) Lemm.	Neelavani	Chlorellaceae
2	*Elakatothrix viridis* (Snow.) Printz	Mothikeri	Chlorellaceae
3	*Kirchneriella irregularis* (G. S. Smith) Korš.	Neelavani	Chlorellaceae
4	*Selenastrum westii* G. M. Smith	Mothikeri	Chlorellaceae
5	*Tetraedron gracile* (Reinsch.) Hansg.	Mothikeri	Chlorellaceae
6	*Tetraedron minimum* (A. Braun) Hansg.	Ambadga	Chlorellaceae
7	*Tetraedron regulare* (Kutz.)	Belwatgi	Chlorellaceae
8	*Tetraedron tumidilum* (Reinsch.) Hansg.	Ambadga	Chlorellaceae
9	*Actinastrumgracillimum* G. M. Smith.	Mothikeri	Coelastraceae
10	*Pediastrum duplex* var. *subgranulatum* Racib.	Neelavani	Hydrodictyaceae
11	*Pediastrum ovatum* (Ehr.) A. Braun.	Ambadga	Hydrodictyaceae
12	*Pediastrum tetras* (Ehr.) Ralfs.	Ambadga	Hydrodictyaceae
13	*Sorastrum americanum* (Bohn.) Schm.	Neelavani	Hydrodictyaceae
14	*Gloeotaenium loitlesbergerianm* Hansg.	Mothikeri	Oocystaceae
15	*Nephrocytium lunatum*. W. West	Neelavani	Oocystaceae
16	*Oocystis borgei* Snow.	Neelavani	Oocystaceae
17	*Eutetramorus fottii* (Hind.) Kom.	Mothikeri	Radiococcaceae
18	*Pachycladella zatoriensis* (Bedn. & Mroz. -Webb) Kom.	Mothikeri	Radiococcaceae
19	*Palmodictyon viride* Kütz.	Neelavani	Radiococcaceae
20	*Crucigeniella crucifera (Wolle) Kom.*	Ambadga	Scenedesmaceae
21	*Coelastrum microporum* Näg.	Neelavani	Scenedesmaceae
22	*Tetrallanthos lagerheimii Teil.*	Ambadga	Scenedesmaceae
23	*Coelastrum scabrum* Reinsch.	Neelavani	Scenedesmaceae

24	*Crucigenia tetrapedia* (Kirchn.) W. et G. S. West	Ambadga	Scenedesmaceae
25	*Dimorphococcus lunatus* A. Br.	Mothikeri and Neelavani	Scenedesmaceae
26	*Scenedesmus acuminatus var acuminatus* (Lagerh.) Chod.	Ambadga	Scenedesmaceae
27	*Scenedesmus armatus* (Chodsat) G. M. Smith	Mothikeri	Scenedesmaceae
28	*Scenedesmus denticulatus* var *australis* Play.	Ambadga	Scenedesmaceae
29	*Scenedesmus dimorphus* (Turpin) Kuetzing	Mothikeri	Scenedesmaceae
30	*Scenedesmus indicus* M. T. Phillopose	Mothikeri	Scenedesmaceae
31	*Scenedesmus obliquus* (Turpin) Kuetz.	Mothikeri	Scenedesmaceae
32	*Scenedesmus opoliensis* Richt.	Neelavani	Scenedesmaceae
33	*Scenedesmus quadricauda* var *bicaudatus*. Hansg.	Belwatgi	Scenedesmaceae
34	*Scenedesmus quadricauda* var *longispina* (Chodat.) G. M. Smith	Ambadga	Scenedesmaceae
35	*Scenedesmus smithii* Teil.	Ambadga	Scenedesmaceae
36	*Scenedesmus spinulutus* Bisw.	Ambadga	Scenedesmaceae

Table 2

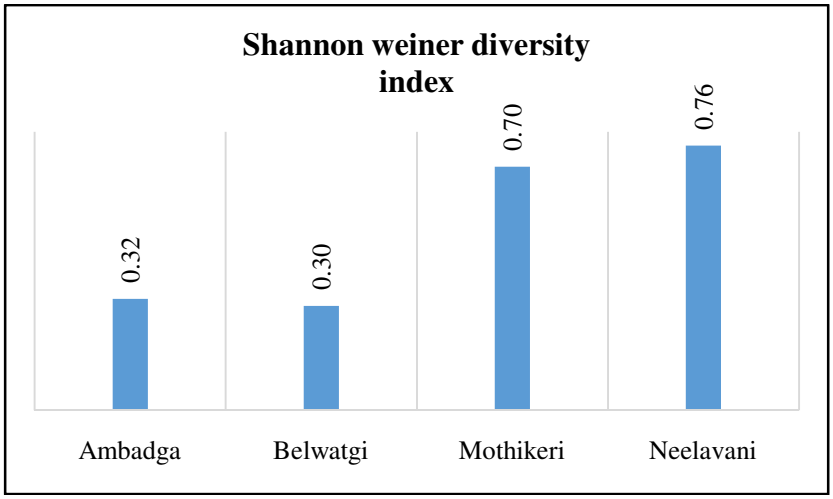

Figure 1: Shannon diversity Index

When the data (Table 2) subjected to Shannon diversity index, it revealed (Fig 1), comparatively high diversity in Neelavani (0.76), followed by Mothikeri (0.70) and low diversity in Belwatgi (0.30), followed by Ambadga (0.32).

Summary of Colonial Green Algae surveyed				
Families	Ambadga	Belwatgi	Mothikeri	Neelavani
Chlorellaceae	1	1	3	2
Coelastraceae	0	0	1	2
Hydrodictyaceae	2	0	2	2
Occystaceae	0	0	1	2
Radiococcaceae	0	0	2	1
Scenedesmaceae	8	1	5	2
Analysis of Environmental factors				
pH	7.7	7.9	8.4	8.1
Cond (µmhos)	210	230	520	248
Temp (^{0}C)	26.6	27.1	28.2	28
Water Spread area (Hectares)	25.4	85	5.7	3
Nitrate (NO_3^{3-}) (mg/l)	3.4	4.5	7.8	6.4
Phosphate (PO_4^{3-}) (mg/l)	0.04	0.09	0.42	0.25
N/P	85	50	18.5	25.6

Table 2: Data subjected for PCA and Shannon diversity index

For the PCA Bi-plot, Factors (F), F1 and F2 were chosen, because the eigen value of F1 was highest (3.68), followed by F2 (1.61) and lowest for F3 (0.70). Hence applying F1 and F2, maximum variablility (88.26%) and thus better interpretation. The survey data on families of colonial green algae, Scenedesmaceae (Sce), Hydrodictyaceae (Hydr), Chlorellaceae (Chl,), Radiococcaceae (Rad), Oocystaceae (Occ) and Coelastraceae (Coe) were obviously chosen as active variables, and Nitrogen and Phosphate ratio (N/P),

Conductivity (Cond), pH, surface water temperature (Temp) and water surface area (WSA) were chosen as supplementary variables. The results of PCA are mentioned below.

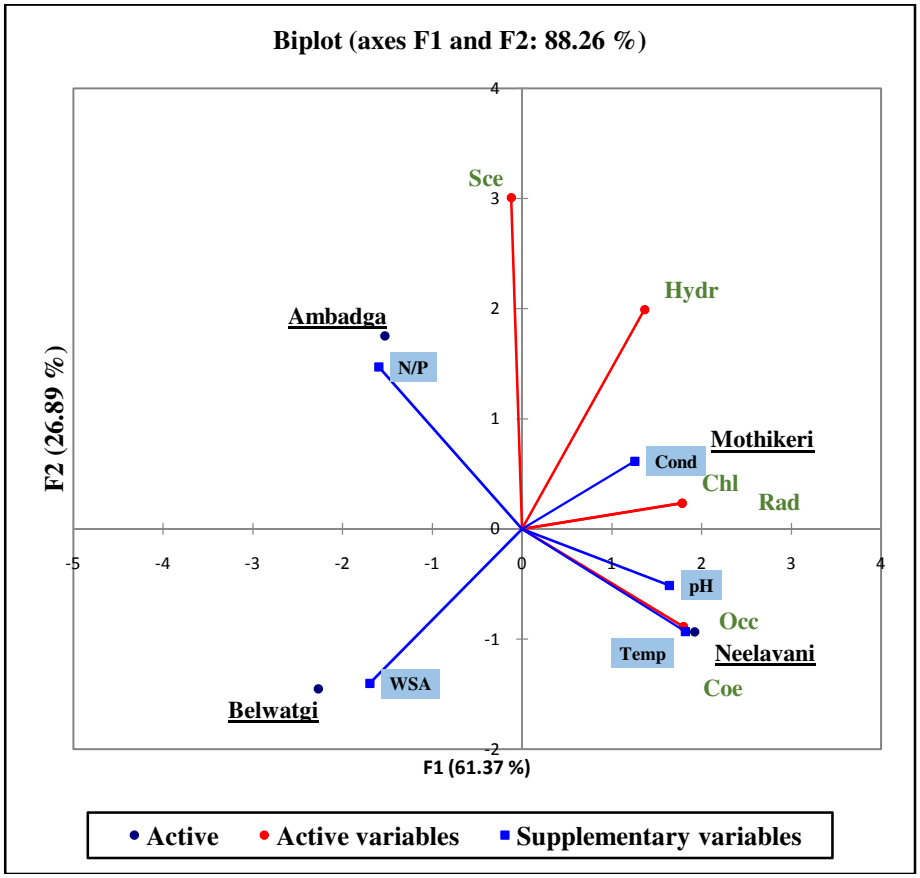

Figure 2: PCA Biplot.

- The PCA analysis clearly reveals the importance of water spread area in the distribution of Colonial green algae. Mothikeri and Neelavani tanks having smaller water spread area have higher distribution of Colonial green algae, where as Belwatgi of larger water spread area showing lower distribution. Shannon index also validates the PCA analysis, related to higher diversity in Neelavani and low in Belwatgi. Thus water spread area indicates strong negative correlation to the distribution of Colonial green algae.
- Distribution of colonial green algae is also negatively correlated to Nitrate and Phosphate (N: P) ratios. The review of Reynolds (1998), states that the occurrence of Chlorococcales (which also includes colonial green algae) is high when the ratio of limiting concentrations i.e., N: P was pitched nearer 25. PCA analysis, explains high distribution of colonial green algae in Neelavani having N: P ratio of 25.6 (Table 2), followed by Mothikeri having ratio of 18.5
- Conductivity is positively correlated to the diversity of Hydrodictyaceae, Chlorellaceae & Radiococcaceae
- pH is positively correlated to the distribution of Coelastraceae & Oocystaceae
- Distribution of Scenedesmaceace is not influenced by pH or Conductivity, but it clearly indicates moderate negative correlation with N: P ratios.

4. Conclusion

Morphometry of water bodies play a major role in determining the distribution of Colonial green algae, in the study areas, PCA analysis clearly reveals higher distribution of taxa in tanks of smaller water surface areas. The survey of Colonial green algae in the four perennial tanks, clearly indicates the importance of limiting concentrations in determining their diversity and distribution. This work also suggests the importance of conductivity in influencing the distribution of taxa belonging to families of Hydrodictyaceae, Chlorellaceae & Radiococcaceae. The dominance of scenedesmaceae again validates the influence of N: P ratios. Thus the field survey data coupled with nitrogen and phosphate analysis can be a valuable source of information for understanding the distributions of diverse algal assemblages.

5. Acknowledgment

The Authors are indebted to the University Grant Commission, New Delhi, for funding the research (UGC F. No. 39-393/2010, (SR) dated 22nd December, 2010)

6. References

i. Anonymous. (2001). A beginner's guide to water Management-Lake Morphometry, Information Circular 104. Florida lakewatch.
ii. Anonymous. (2010). Details of Minor Irrigation Tanks, Bandharas LI Schemes and Kharland schemes, as on 1-4-2010 in Uttar Kannada District. Government of Karnataka (Minor Irrigation). Ms excel document (2010)
iii. Fucikova, K. (2015). A new record of the rare alga Pachycladella P. C. Silva (Chlorophyceae) in New England. Phytokeys, 56, 19-27. doi: 10.3897/phytokeys.56.6268
iv. Happey-Wood, C. M. (1988). Ecology of freshwater planktonic green algae. In: Sandgren, C.D. (Ed.), Growth and Reproductive Strategies of Freshwater Phytoplankton. Cambridge University Press, Cambridge, pp. 175–226.
v. Komarek, J & B. Fott. (1983). Das Phytoplankton des Süßwassers-Systematik und Biologie. 7(1), Chlorophyceae (Grünalgen). Ordung: Chlorococcales. Stuttgart, pp-1-439.
vi. Philipose, M. T. (1967). Chlorococcales, I.C.A.R., Monographs, New Delhi, 365 pp
vii. Prescott, G. W. (1951). Algae of the Western great lakes area. Cranbook Institute of Science, Michigan.
viii. Reynolds, C. S. (1998). What factors influence the species composition of phytoplankton in lakes of different trophic status. In: M. Alvarez-Cobelas., C. S. Reynolds., P Sanchez-Castillo., J. Kristiansen (Eds.), Phytoplankton and Trophic Gradients. Kluwer Academic Publishers. Hydrobiologia 369/370: 11-26. Doi: 10.1007/978-94-017-2668-9
ix. Shannon, C.E. and Weaver, V. (1963). The Mathematical Theory of Communication, University of Illinois Press, Urbana, Ill, USA. Pp: 117.
x. Shubert, E. and Gärtner, G. (2015). Nonmotile Coccoid and Colonial Green algae. In: Wehr JD; Sheath RG and Kociolek JP. (Ed.), Fresh water algae of North America: Ecology and Classification. Academic Press. Elsevier. UK, pp: 315-379