



A STUDY ON FILAMENTOUS ALGAE IN KUTTANADU RICE AGROECOSYSTEM

Botany

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ABSTRACT

Kuttanadu agroecosystem is a complex mosaic of fragmented agricultural landscape which has a concave relief and slopes towards northwest and reaches below sea level towards west where it joins Vembanadu Lake- a Ramsar site. The landscape composition, structure, management and the regional context of Kuttanadu are unique and significant, as the region is a larger mosaic of fragmented landscape patches and varied ecosystems such as coastal backwaters, rivers, vast stretches of paddy fields, marshes, ponds, garden lands, edges and corridors. Algal population in this landscape was screened and observed 32 species of blue-green algae and 5 species of green algae with much difference in diversity and occurrence across the landscape. Algal diversities are natural occurrences, and may occur with stability depending on vegetation type, nutrient level, soil properties, humidity and climatic conditions of particular habitat. The uniqueness of certain varieties in relation with soil regions, seasons and growth stages are also unveiled. Immediate measures to conserve algal genetic resources in the unique ecologically fragile and Globally Important Agricultural Heritage System – Kuttanadu - are recommended.

KEYWORDS:

KUTTANADU RICE AGROECOSYSTEM; BLUE-GREEN ALGAE; GREEN ALGAE; ALGAL DIVERSITY

INTRODUCTION

Algae are the discrete autotrophic micro community of all wet soils which carry out lion part of the photosynthetic activities. Algae are the fastest growing plants in the world are critical to the functioning of global ecosystems (Shayler and Siver, 2006). Algae contain numerous bioactive compounds that can be harnessed for commercial use and have applications in the biological assay for crop response to both fertilizers and pesticides. Inundated paddy soils represent unparalleled wetland soil ecosystem with motleying amounts of light, water, temperature and nutrients in accordance with regions, seasons and growth stages of the crop. However studies on algal diversity in Kuttanadu paddy fields are rather meager and hence the present study. Kuttanadu is a region of about 900 sq. km situated in the west coast of Kerala which was formed through a deltaic formation of Meenachil, Pamba, Manimala, Muvattupuzha, and Achencovil rivers and partly by the skillful and ingenious efforts of local communities. The area has a concave relief and slopes towards northwest and reaches below sea level towards west where it joins Vembanadu Lake- a Ramsar site. It is estimated that about 500 km² of the area with agricultural fields are situated below sea level (MSSRF, 2007). The region is a unique ecologically fragile bio-geographical unit recognized as a Globally Important Agricultural Heritage System (GIAHS) by FAO and contributing nearly 20% of total rice production of the state, and popularly called 'Rice Bowl of Kerala' (Narayanan *et al.*, 2011). Eventhough biodiversity in the region are studied, algal community in wetland rice agroecosystem remains unexplored. The present study is mooted in this background.

MATERIALS AND METHODS

Samples were collected from the paddy fields of Kuttanadu during the cropping period of December 2010 to February 2011 and from November 2011 to February 2012. Algae were collected once in a month from all locations by taking soil surface layer (0-2cm) using a clean scoop. Twenty soil samples were collected randomly from different places at each location, and combined together for observing the algae. The algae were also scrapped off any rock, and concrete structure and submerged vegetation, as well as filtered out from stagnant water. The samples were placed in clean polythene bags, and carried to the laboratory where they were processed immediately or after short term storage in dark at 4°C. The algae present in the samples were observed by following two methods: direct observation and enrichment method.

Identification and classification of algae was carried out based on morpho-taxonomic description with the help of monographs, taxonomic keys and standard publications like Desikachary (1959), Randhawa (1959), Prescott (1962), Gonzalves (1981), Anand and Hopper (1987), Anand (1989), Krishnamurthy (2000), Mahendrapurumal and Anand (2008) and Guiry and Guiry (2014).

RESULTS AND DISCUSSION

The pattern of cultivation in Kuttanad is related to the rainfall and salt water intrusion from the adjoining Vembanad estuary. Paddy is cultivated either once, twice or thrice in a year depending upon the location of the paddy fields. The sampling locations of this study were those paddy fields cultivated once a year *i.e.*, the puncha crop in summer. The first phase of sampling of soil algae in this study at Kuttanad was during December 2010 to February 2011. The sampling began in the month of December when the crop was at the seedling stage and continued till harvest in February 2011.

The second phase of sampling in Kuttanadu was from November 2011 to February 2012. The sampling started as the field was prepared for sowing and continued till the harvest. During this phase, algal growth was observed as green and blue-green patches on the soil surface. Progressing towards harvest, blooms of algae were observed in the waterlogged areas in the field, and in canals running along the sides of paddy fields. They appeared as surface mats on soil within the waterlogged areas in the fields and as surface scum and benthic mats in the adjacent canals.

The flora of filamentous algae collected from paddy fields of Kuttanad belonged to blue-green and green algae. Altogether 32 species of blue-green algae and 5 species of green algae were obtained. Four different morpho types of *Spirogyra* were distinguished based on the filament width, number chloroplast and type of end wall. These were named as *Spirogyra* type 1, type 2, type 3, and type 4 (Photo plate 1). The taxonomic description of the species are given below.

1. *Lyngbya bergi* Smith, G.M.

Filaments straight, 16-18µm broad, sheath firm, colourless, trichome not constricted at the cross walls, cells 15-20µm broad, ends rounded, not attenuated, not capitate; cells shorter than broad.

2. *Lyngbya magnifica* Gardner

Filaments long, straight 30-36µm broad, sheath 1.5-2µm thick, colourless; trichome 28-32µm broad, not attenuated at the ends, not constricted at cross-walls, cells 3-4µm long, end cell rounded.

3. *Lyngbya hieronymusii* Lemm

Filaments straight or slightly bent, 12-13µm broad; sheath firm, colourless; cells 10-12µm broad, 2-3µm long, not constricted at the cross-walls, granulated, with gas- vacuoles, not attenuated; end cell rounded.

4. *Lyngbya major* Menegh ex Gomont

Filaments long, straight, cells 17-20µm broad, 2-3µm long, granulated at the septa, not constricted at the cross-walls, sheath thick, end cell rounded.

5. *Lyngbya shackletonii* W.et G.S.West

Filaments straight, 12-12.5µm broad; sheath firm, colourless;

trichome not constricted at the cross walls; not attenuated at the ends; cells 2-3µm long.

6. *Lyngbya martensiana* Menegh ex Gomont

Trichome 8-11µm broad, not constricted at the cross-walls; sheath, colourless; apices not attenuated; cells 1-2 µm long; end cell rounded.

7. *Lyngbya semiplena* (G.Ag.) J. Ag.ex Gomont

Trichome yellowish green, not constricted at the cross-walls, 8-10 µm broad; sheath thick, colourless; at the ends slightly attenuated, capitate, 2-3 µm long cells, end cell rounded.

8. *Oscillatoria splendida* Grev. ex Gomont

Trichome straight, not constricted at the cross-walls, at the ends gradually attenuated, cells 2-5µm broad, 3-7µm long, end cells capitate, nearly rounded, without calyptra.

9. *Oscillatoria acuminata* Gomont

Trichome more or less straight, not constricted at the cross-walls, 4-6µm broad, at the ends briefly tapering, sharply pointed, cells longer than broad, 6-8 µm long, end cell mucronate, without calyptra.

10. *Oscillatoria princeps* Vaucher ex Gomont

Trichome 14-18µm broad, straight, not constricted at the cross-walls; cells 3-4µm long, apices slightly attenuated; end-cells rounded, slightly capitate, without thickened membrane.

11. *Oscillatoria subbrevis* Schmidle.

Trichome 4-6µm broad, straight, not attenuated at the apices, cells 0.5-1µm long, end-cells rounded.

12. *Oscillatoria tenuis* Ag. ex Gomont

Trichome straight, slightly constricted at the cross-walls; not attenuated at the apices; cells 10-14µm broad, 2-3µm long, at the septa mostly granulated, end cell more or less hemispherical.

13. *Oscillatoria limosa* Ag. ex Gomont

Trichome more or less straight; not constricted at the cross-walls, 10-12µm broad, cells 2-4 µm long, cross walls frequently granulated; end cell flatly rounded.

14. *Oscillatoria sancta* (kutz) Gomont

Thallus dark blue-green, trichome straight, slightly constricted at the cross walls, ends briefly attenuated, cells 14-17µm broad, cells 2-3 µm long, cross walls frequently granulated, end cell hemispherical, capitate.

15. *Oscillatoria vizagapatensis* Rao, C.B.

Trichome straight, uniformly broad except at the extreme apex, 8-9 µm broad; without constrictions at the cross walls, cells 2-1 µm long, and end cell broadly rounded forming a cap.

16. *Oscillatoria perornata* skuja

Trichomes 14-15µm broad; well constricted at the cross-walls, cell 3-5µm long, end cells hemispherical, calyptra absent.

17. *Oscillatoria proboscidea* Gomont

Trichome more or less straight, not constricted at the cross-walls, bent at the end, slightly attenuated, 9-12µm broad, cells 1-2 µm long, end cells flatly rounded, capitate.

18. *Oscillatoria laete-virens* (crouan) Gomont

Thallus thin, trichome yellowish green, straight, slightly constricted at the cross-walls, 2-3µm broad, apices attenuated, cells 2-3 µm long, end cells not capitate, more or less conical.

19. *Oscillatoria formosa* Bory ex Gomont

Trichome straight, slightly constricted at the cross-walls, 7-8 µm broad, attenuated at the ends; cells 3-4 µm long, end cell obtuse, not capitate.

20. *Oscillatoria rubescens* Dc ex Gomont

Trichome straight, at the ends gradually attenuated, 6-7 µm broad, not constricted at the cross-walls, cells 2 µm long, and end cell capitate.

21. *Spirulina princeps* W. et G.S. West

Trichome 4-5 µm broad; regularly spirally coiled, spirals 10-12 µm broad.

22. *Spirulina gigantea* Schmidle

Trichome 3-4 µm broad; regularly spirally coiled, at the end conical attenuated, spirals 10-12 µm broad.

23. *Phormidium tenue* (Menegh.) Gomont

Thallus thin, membranous, trichome straight, slightly constricted at the cross walls, 2-3µm broad; sheath thin; cells 4-5µm long, cells up to three times longer than broad.

24. *Phormidium retzii* (Ag.) Gomont

Filaments more or less straight, mostly constricted at the cross walls, not attenuated at the ends, not capitate, 11-13µm broad, sheath thin, cells 6-9µ long.

25. *Phormidium uncinatum* (Ag.) Gomont

Filaments straight or slightly bent, not constricted at the cross walls, 6-9µm broad, ends briefly attenuated, capitate, end cell with a round or depressed conical calyptra.

26. *Nostoc linckia* (Roth) Bornet ex Born. et Flah.

Thallus gelatinous, yellowish brown to blue green, trichome 3-4µm broad, cells barrel-shaped, 3-4µm long, heterocysts almost spherical, 5-6µ broad; spores in long chains, more or less spherical 6-7µm broad.

27. *Nostoc commune* Vaucher ex Born. et Flah.

Thallus globose, sheath yellowish, distinct at the periphery, trichome 5-6µm broad; cells barrel-shaped, 4-5µm long, heterocysts almost spherical, 6-7µm broad.

28. *Anabaena naviculoides* Fritsch

Trichome thin, gelatinous, apices acuminate; cells more or less barrel-shaped, 3-4 µm broad; heterocysts intercalary, 5-6 µm broad, broader than the vegetative cells, apices acuminate, apical cell conical.

29. *Anabaena sphaerica* Bornet et Flahault

Thallus blue-green, trichomes straight, 6-9µm broad; cells spherical to short barrel-shaped; heterocysts subspherical, 8-10µm broad, 9-11µm long.

30. *Anabaena ballyganglii* Banerji

Trichome circinate; cells compressed, spherical, 7-9µm broad, 5-6µm long, contents granular, heterocysts somewhat spherical, 8-9µm broad.

31. *Scytonema cincinnatum* Thuret ex Born. et Flah.

Filaments 30-35µm broad, false branches mostly germinate; sheath firm, brownish; trichomes 15-18µm broad, slightly constricted at the cross walls; heterocysts single, quadrate.

32. *Cladotrix contarenii* (Zanard.) Bornet et Flah.

Filaments long, swollen at the base, 7-10µm broad; sheath colourless, heterocyst basal.

33. *Sirogonium* Kutzing

Unbranched uniseriate filaments; up to several times as long, lacks outer mucilage layer and non slimy to touch; cells cylindrical, 15-18µm broad, 42-45µm long, chloroplast ribbon like, straight, with pyrenoids; sexual reproduction by scalariform conjugation.

34. *Spirogyra* Link

Thalli comprised of unbranched uniseriate filaments, slimy to touch; cells cylindrical, 10 to 200 µm in diameter, most 20 to 60 µm, up to several times as long; end walls plane; chloroplasts from 1-15 per cell; plastids ribbon like, coiled, pressed against cell wall within parietal layer of cytoplasm, Sexual reproduction by conjugation.

34.1. *Spirogyra* type 1

Unbranched uniseriate filaments; slimy to touch; cells cylindrical, 28-31 µm broad, 142-145 µm long, chloroplasts two, six to seven turns per cell, ribbon like, coiled, end wall plane.

34.2. *Spirogyra* type 2

Unbranched uniseriate filaments; slimy to touch, cells cylindrical, 16-18 µm broad, 95-100 µm long; chloroplasts one, five to six turns per cell, ribbon like, coiled, end wall plane.

34.3. *Spirogyra* type 3

Unbranched uniseriate filaments; slimy to touch, cells cylindrical, 15-18 µm broad, 170-185 µm long; chloroplasts two, eight to ten turns per cell, ribbon like, coiled, end wall plane.

34.4. *Spirogyra* type 4

Unbranched uniseriate filaments, slimy to touch; cells cylindrical, 25-28 µm broad, 130-140 µm long; chloroplasts two, eighteen to twenty turns per cell, ribbon like, coiled, end wall plane.

35. *Zygnema* C. Agardh

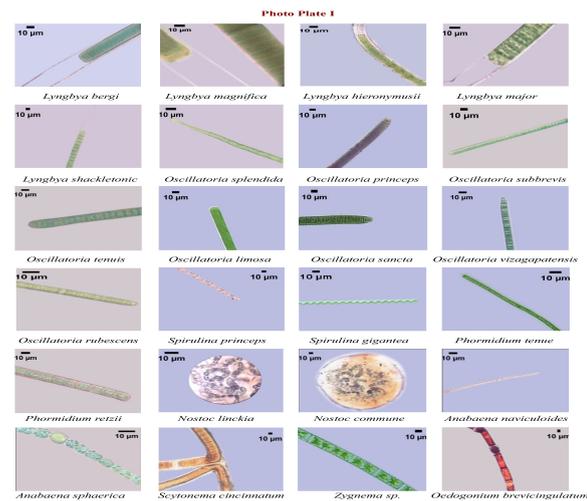
Thalli comprised of unbranched uniseriate filaments, Cells cylindrical, 15-17µm broad, 42-45µm long, and chloroplast two per cell, stellate.

36. *Oedogonium brevicingulatum* Jao

Cells cylindrical, 95-120µm long, 22-24µm broad; oogonium single, obovoid to globose, 70-75µm long, oospore globose.

37. *Rizoclonium* Kutzing

Unbranched uniseriate filaments; Cells cylindrical, 14-16µm broad, 45-48 µm long, Chloroplast parietal with pyrenoids, often packed with starch.



The differences and diversity in cultivation in the Kuttanadu region in the monsoon and non-monsoon seasons create discrete local wetland environmental conditions suitable for algae. Regional variations in water quality and differences in crop growth stages add further specificities to local environmental conditions are the factors most contributing to uniqueness of algal community of Kuttanadu. The diversity of filamentous algae was restricted to blue-green and green algae of which the higher species spectrum was exhibited by blue-green algae (Fig. 1).

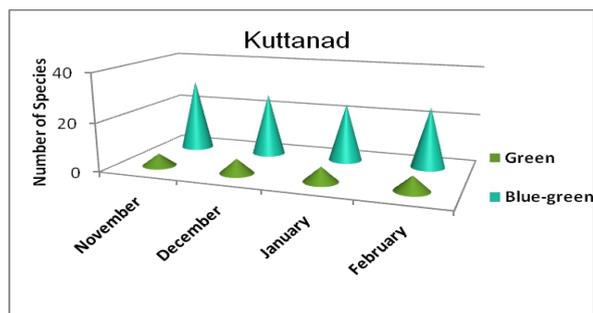


Fig.1 Occurrence of filamentous algae in Kuttanadu agroecosystem

Algal diversities are natural occurrences, and may occur with stability depending on vegetation type, nutrient level, soil properties, humidity and climatic conditions of particular habitat (Kumar and Sahu, 2012). The paddy fields of India are reported to support a variety of algae both unicellular and filamentous comprising members of Cyanophyceae, Chloro-phyceae, Euglenophyceae and Bacillariophyceae (Ahmed et al., 2013). In this investigation the majority of filamentous algae observed comprised of blue-green. Among the thirty two species of blue-green algae collected from Kuttanadu, twenty five species are

non-heterocystous, and only seven species are heterocystous. Earlier reports from this region has documented the presence of heterocystous (Nayak and Prasanna, 2004) and non-heterocystous members (Prasanna and Nayak, 2007). The most widespread genus of blue-green in this study is *Oscillatoria*, followed by *Lyngbya*, *Phormidium* and *Anabaena*. Anand and Hopper (1995) reported predominance of genus *Oscillatoria*, *Phormidium* and *Lyngbya* in rice fields of Kerala. Thus the present observations are in tune with previous studies, and only confirm the temporal stability of the biodiversity.

Dhanya and Ray (2015) reported high green algal diversity of 87 species, with *Zygnematales* as the dominant (33%) group from Kuttanadu – a unique tropical wetland. Rice fields are places of intensive anthropogenic activity, including tillage and the application of fertilizers, pesticides, and herbicides. Such activities affect the physico-chemical environment of soils and thus lower the diversity of soil algae. The geochemistry of Kuttanadu agroecosystem has been affected by the stoppage of natural flooding due to the construction of barrage. Hence the natural flush out ceased and artificial flooding and dewatering has caused accumulation of more anthropogenic materials in the system.

The geographic feature and complexity of the area and position of agricultural landscapes below mean sea level makes its environmental services exclusive. The hydrological relationship between the various matrices of the system landscape and its sources of surface and ground water plays a significant role in determining the algal diversity. Understanding of algae in wet agroecosystem soils are important for sustainable management of soil fertility, as the overall ecological benefits of algae to soils are highly complex, important and multifaceted.

CONCLUSION

The present investigation revealed the extensive diversity of algae in Kuttanadu paddy agroecosystem soils. The uniqueness of certain varieties in relation with soil regions, seasons and growth stages are also unveiled. However, specific role of algal association with crops are the need of the hour, as it immensely help towards development of sustainable agriculture. Moreover, measures to conserve algal genetic resources in the unique ecologically fragile and Globally Important Agricultural Heritage System – Kuttanadu - are recommended.

REFERENCES

- Ahmed, S., Arifur Rahman, A.F.M. and Belal Hossain, M. 2013. Phytoplankton Biodiversity in Seasonal Waterlogged Paddy Fields, Bangladesh. *Ecologia*, 3: 1-8.
- Anand, N. 1989. Handbook of blue-green algae. Bishen Singh Mahendra Pal Singh, 23-A, Connaught Place, Dehra Dun, India. 1-79.
- Anand, N. and Hopper, R.S.S. 1987. Blue green algae from rice fields in Kerala state, India. *Hydrobiologia*. 144:226-240.
- Anand, N., Hopper, R. S. and Shanthakumar, H. 1995. Distribution of blue green algae in rice fields of Kerala State, India. *Phykos*, 35:55-64.
- Desikachary, T.V. 1959. A monograph on Cyanophyta. Indian Council of Agricultural Research Publication, New Delhi, India.
- Dhanya, V. and Ray, J.G. 2015. Green algae of a unique tropical wetland, Kuttanadu, Kerala, India, in relation to soil regions, seasons, and paddy growth stages. *International Journal of Science, Environment and Technology*. 4(3):770-803.
- Gonzalves, F.A. 1981. *Oedogoniales*. Indian Council of Agricultural Research Publication, New Delhi.
- Guiry, M.D. and Guiry, G.M. 2014. *Algae Base*, World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>
- Krishnamurthy, V. 2000. *Algae of India and neighbouring Countries I*. Chlorophycota. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Kumar A. and Sahu R. 2012. Diversity of Algae (Chlorophyceae) in Paddy Fields of Lalagutwa Area, Ranchi, Jharkhand. *J. App. Pharm Sci*, 2 (11): 092-095.
- Mahendrapuram, G. and Anand, N. 2008. *Manual of fresh water algae of Tamilnadu*. Bisen Singh and Mahendrapal Singh Publ, Dehra Dun, India.
- MSSRF. 2007. Measures to mitigate agrarian distress in Alappuzha and Kuttanad Wetland Ecosystem, Kerala. M. S. Swaminathan Research Foundation, Chennai 600113.
- Narayanan, P. S., Thomas A.P. and Sreekumar, B. 2011. Ornithofauna and its conservation in the Kuttanad wetlands, southern portion of Vembanad-Kole Ramsar site, India, *Journal of Threatened Taxa*, 3(4): 1663–1676.
- Nayak, S. and Prasanna, R. 2007. Soil pH and its role in cyanobacterial abundance and diversity in rice field soils. *Applied Ecology and Environmental Research*, 5(2):103-113
- Prasanna, R. and Nayak, S. 2007. Influence of diverse rice soil ecologies on cyanobacterial diversity and abundance. *Wetlands Ecol. Manage*; 15:127-134.
- Prescott, G.W. 1962. *Algae of the Western Great Lakes Area*. Wm. C. Brown Co., Dubuque, Iowa.
- Randhawa, M.S. 1959. *Zygnematales*. Indian Council of Agricultural Research, New Delhi.
- Shayler, H.A. and Siver, P.A. 2006. Key to fresh water algae: A web based tool to enhance understanding of microscopic biodiversity. *Journal of Science Education and Technology*. 15(3):298-303.