



Phycological Investigation on Algal Diversity and Nitrogen-Fixing Forms in Paddy Fields

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Abstract: The present research investigates the diversity, distribution, and ecological significance of algae in paddy field ecosystems, with special reference to heterocystous and non- heterocystous forms. Paddy fields are semi-aquatic habitats where algal communities play a crucial role in soil fertility, nutrient cycling, and biological nitrogen fixation. Water and soil samples were analyzed microscopically to determine algal composition. The results revealed a dominance of *Cyanophyceae* (*blue-green algae*). Among these, heterocystous forms such as *Anabaena*, *Nostoc*, *Pseudoanabaena constircta*, *Pseudoanabaena catenata* and *Cylindrospermum* were identified as major nitrogen fixers, while non-heterocystous forms such as *Oscillatoria* and *lyngbya* contributed to organic matter production. The findings highlight the significant ecological role of both groups in maintaining soil fertility and enhancing rice productivity. Total 15 Heterocystous and 12 Non-heterocystous Blue-green algae was recorded. Total 27 Cyanobacterial algae were studied.

Keywords: *Paddy algae, paddy field, heterocystous forms, Non-heterocystous forms.*

Introduction

Algae constitute an important component of the paddy field ecosystem, contributing to primary productivity and soil nutrient dynamics. Their ability to perform photosynthesis and, in some cases, fix atmospheric nitrogen makes them indispensable to sustainable agriculture. Paddy fields, being flooded during most of the cultivation period, provide ideal conditions for the proliferation of both aquatic and terrestrial algal species.

Cyanobacteria (*blue-green algae*) are the most important group of algae in rice fields due to their capacity for biological nitrogen fixation. Nitrogen is a major limiting nutrient in paddy cultivation, and the ability of certain *cyanobacteria* to fix atmospheric nitrogen reduces dependence on chemical fertilizers. These algae occur either as heterocystous forms (possessing specialized nitrogen- fixing cells called heterocysts) or non-heterocystous forms (lacking heterocysts but capable of nitrogen fixation under specific microaerobic conditions).

Some species of cyanobacteria able to fix the nitrogen in paddy fields (Singh et al, 2014). The present study aims to explore the diversity of algal species in paddy fields, emphasizing the presence and functional roles of heterocystous and non-heterocystous forms.

Materials and Methods

Study area

Samples were collected from selected paddy fields during the active growing season. The sites were characterized by standing water, moderate sunlight, and rich organic content- ideal for algal growth. The total six paddy field sites of Warora taluka were taken for the algal study namely Shegaon, Salori, Mesa, Chargaon, Jamani, Sumthana.

Sample collection



- The sample collection was carried out during May 2024 to November 2024.
- The fresh paddy field water samples and algal material were collected monthly from the selected paddy field area of Warora taluka.
- The paddy field water samples were collected in plastic bottles of one liters capacity.
- Floating Algal samples was collected with the help of sterilized forceps into small plastic bottles. Filamentous algae are collected through picking by hands, the algae were attached on to surface of soil were collected by using scalpel and forceps and stored into the small plastic container.
- Samples were brought into the laboratory and analyzed.
- Collected samples were preserved in 4% formalin.
- Before sampling to avoid external contamination was minimized by rinsing these bottles three times with source water. (Rajput, 2020).
- The paddy field water sample was centrifuged at 3000rpm at room temperature and then fix into the 4% formalin then used for algal identification.

Microscopic identification

- Algae were identified under a compound light microscope using standard taxonomic keys (Prescott, 1962; Desikachary, 1959). Morphological features such as cell shape, colony structure, presence or absence of heterocysts, and pigmentation were considered.
- Observe the glass slides under the proper magnification i.e. 40x. Under the electronic compound light Microscope (Car) ZEISS primo star and then take a photograph.
- Fresh and preserved algal material were observed under the microscope.
- Algae were identified with the help of standard books, floras (Desikachary, 1959); Textbook of algae (Kamat, 1975); the fresh water Algae (Prescott, 1954).

Observations:-

Sr. no.	Heterocystous forms	Family	Non Heterocystous forms	Family
1	<i>Anabaena iyengarii sp.</i>	<i>Nostocaceae</i>	<i>Phormidium sp.</i>	<i>Oscillatoriaceae</i>
2	<i>Anabaena torulosa sp.</i>	<i>Nostocaceae</i>	<i>Chroococcus turgidus sp.</i>	<i>Chroococcaceae</i>
3	<i>Anabaena circularis</i>	<i>Nostocaceae</i>	<i>Gloeocapsa sp.</i>	<i>Chroococcaceae</i>
4	<i>Anabaena circinalis sp.</i>	<i>Nostocaceae</i>	<i>Microcystis sp.</i>	<i>Microcystisaceae</i>
5	<i>Nostoc carneum sp.</i>	<i>Nostocaceae</i>	<i>Spirulina sp.</i>	<i>Spirulinaceae</i>
6	<i>Nostoc linckia sp.</i>	<i>Nostocaceae</i>	<i>Leptolyngbya sp.</i>	<i>Leptolyngbyaceae</i>

7	<i>Nostoc calcicola sp.</i>	<i>Nostocaceae</i>	<i>Lyngbya majuscula sp.</i>	<i>Microcoleaceae</i>
8	<i>Cylindrospermum sp.</i>	<i>Nostocaceae</i>	<i>Lyngbya sp.</i>	<i>Oscillatoriaceae</i>
9	<i>Gloeotrichia sp.</i>	<i>Rivulariaceae</i>	<i>Oscillatoria princeps sp.</i>	<i>Oscillatoriaceae</i>
10	<i>Calothrix sp.</i>	<i>Rivulariaceae</i>	<i>Oscillatoria limosa sp.</i>	<i>Oscillatoriaceae</i>
11	<i>Rivularia sp.</i>	<i>Rivulariaceae</i>	<i>Asterocapsa sp.</i>	<i>Microcystaceae</i>
12	<i>Stigonema sp.</i>	<i>Stigonemataceae</i>	<i>Merismopedia sp.</i>	<i>Merismopediaceae</i>
13	<i>Pseudoanabaena constricta sp</i>	<i>Pseudoanabaenaceae</i>		
14	<i>Pseudanabaena sp.</i>	<i>Pseudoanabaenaceae</i>		
15	<i>Pseudanabaena catenata sp.</i>	<i>Pseudoanabaenaceae</i>		
Total	15		12	

Table no. 1:- Showing Heterocystous forms and Non Heterocystous forms of *Cyanophycean algae*.

The study revealed a rich algal flora belonging to major groups of *Cyanophyceae*. *Cyanophyceae* were dominant in all sites.

Heterocystous Cyanobacteria

Heterocystous forms such as *Anabaena torulosa sp.*, *Anabaena circularis*, *Anabaena circinalis sp.*, *Nostoc species*, *Cylindrospermum*, *Gloeotrichia sp.*, *Calothrix sp.*, *Scytonema sp.*, *Rivularia sp.*, *Stigonema sp.*, *Pseudoanabaena constricta sp*, *Pseudanabaena sp.*, *Pseudanabaena catenata sp.* were abundant. These genera developed distinct heterocysts- thick-walled specialized cells that create an anaerobic microenvironment for the nitrogenase enzyme, enabling atmospheric nitrogen fixation.

Nostoc commune formed gelatinous colonies attached to soil particles. *Anabaena azollae* was observed in symbiotic association with the aquatic fern *Azolla*, enhancing nitrogen availability. *Cylindrospermum* species occurred as free-floating filaments with terminal heterocysts. *Anabaena species* were help for rice plant for stress tolerance, nitrogen fixation and also used as a biofertilizer.

These heterocystous *cyanobacteria* play a key role in converting atmospheric nitrogen into ammonia, enriching the soil naturally without chemical input.

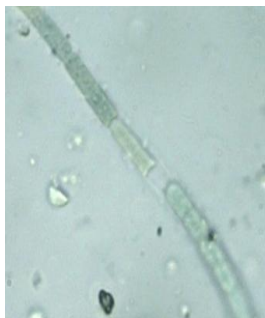
Non-Heterocystous Cyanobacteria

Non-heterocystous forms such as, *Lyngbya*, *Chroococcus turgidus sp.* *Gloeocapsa sp.*, *Microcystis sp.*, *Spirulina sp.*, *Leptolynbya sp.*, *Lyngbya majuscula sp.* *Lyngbya sp.*, *Oscillatoria princeps sp.* *Oscillatoria limosa sp.*,

Merismopedia sp. and *Phormidium* were also recorded. Though lacking heterocysts, they can fix nitrogen under anaerobic or microaerophilic conditions, particularly at night when oxygen levels are low. *Oscillatoria princeps* formed long, motile filaments that contributed to the organic matter of the soil. *Lyngbya* species produced dense mats that stabilized soil particles and reduced erosion.

These species, while less efficient nitrogen fixers than heterocystous types, contribute significantly to soil structure and carbon cycling.

Figures of some Cyanobacterial algae



Anabaena sp.



Anabaena circinalis sp.



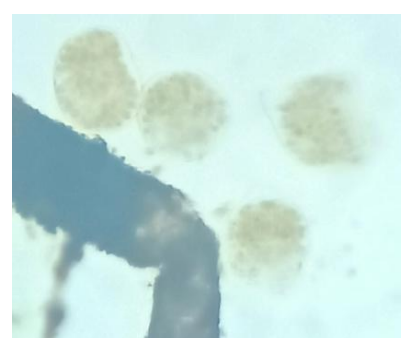
Anabaena torulosa sp.



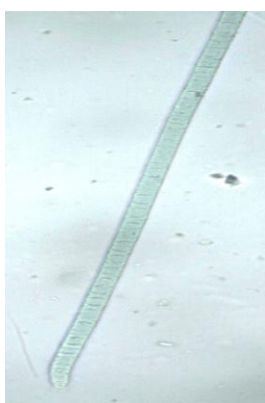
Nostoc carneum sp.



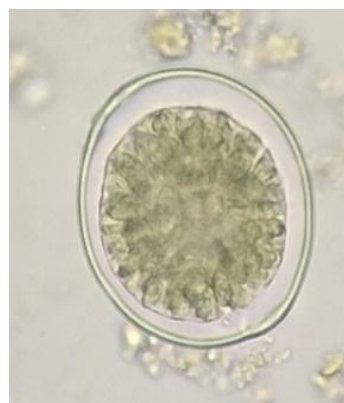
Nostoc linckia sp.



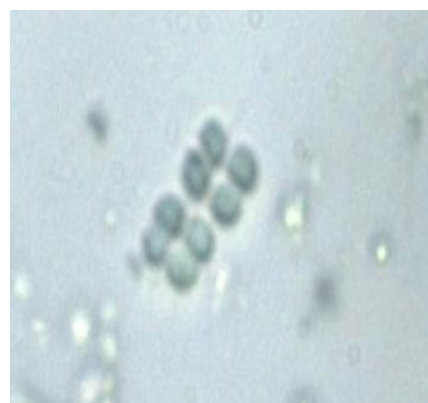
Microcystis sp.



Oscillatoria limosa sp.



Asterocapsa sp.



Merismopedia sp.



Discussion

The results of this investigation confirm that paddy fields support diverse algal communities adapted to fluctuating aquatic conditions. The predominance of *cyanobacteria* agrees with earlier findings by Roger and Kulasooriya (1980), who reported that these organisms are the principal contributors to biological nitrogen fixation in rice fields. Heterocystous *cyanobacteria* are the primary nitrogen fixers, converting atmospheric nitrogen into ammonia through the nitrogenase enzyme system localized in heterocysts. These cells are impermeable to oxygen, protecting nitrogenase from inactivation. The fixed nitrogen is released into the surrounding soil, enhancing nutrient availability for rice plants.

Non-heterocystous *cyanobacteria*, on the other hand, adopt physiological strategies such as temporal separation of photosynthesis and nitrogen fixation. They fix nitrogen under dark or microaerobic conditions, thereby supplementing the nitrogen economy of the field.

Both forms coexist symbiotically with green algae and diatoms, forming biofilms that improve soil aeration and structure. Such microbial consortia enhance soil fertility, reduce dependence on synthetic fertilizers, and contribute to sustainable rice cultivation.

Some researchers were studied in paddy field area in India. 46 species belonging to 21 different genera were identified (Jadhav S. R. and S. M. Talekar 2019) from the soil samples. During the investigation they observed the group of *cyanobacteria Anabaena, Nostoc, Oscillatoria* were dominance. The total 32 species were recorded from four (04) sampling sites of Paddy field from Varanasi (Singh R., Singh R. P., and Singh D.V., 2015). Heterocystous and non-heterocystous forms of cyanophycean algae were recorded. In paddy field 35 heterocystous species were recorded from 15 districts of West Bengal. The author gives the taxonomic description for the above cyanobacterial genera (Banerjee S., et al., 2020). Total 35 genera of blue green algal species were recorded from the Satara and 66 Soil samples of paddy field were studied. (Ghadage, S. J., and Karande, V. C., 2019). Blue-green algae of paddy field were studied (Basavaraja, B., and Naik T.P., 2018) in Hassan, Karnataka recorded 13 species. Total 25 taxa belonging to 8 families were recorded by Odelu, G. in Karimnagar district, Telangana.

Conclusion

The present study demonstrates that paddy fields harbor a rich diversity of algae, particularly *cyanobacteria* belonging to both heterocystous and non-heterocystous forms. Heterocystous genera such as *Nostoc, anabaena*, and *Cylindrospermum* are major biological nitrogen fixers, while non-heterocystous forms like *Oscillatoria* and *Lyngbya* contribute to organic matter production to organic matter production and soil stabilization.

Together, these algal groups maintain soil fertility, improve crop yield, and ensure ecological balance within the rice field ecosystem. Promoting the natural proliferation of such algae or using them as biofertilizers can reduce chemical input costs and support sustainable agriculture. Total twenty-seven (27) *cyanobacterial* algae belonging to 11 family was found and identified. Out of them, fifteen (15) were heterocystous forms and twelve (12) were non-heterocystous forms of *cyanophycean* algae were recorded.

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