DISTRIBUTION OF HETEROCYSTOUS AND NON- HETEROCYSTOUS SOIL MICROFLORA AND RELATED PHYSICO-CHEMICAL PARAMETERS OF THE PADDY FIELDS OF GUNTUR DISTRICT, ANDHRA PRADESH.

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Abstract
Cyanobacterial diversity occurring in some local rice fields of Guntur District, Andra Pradesh has been studied. A total of 38 cyanobacteria were observed among which 18 taxa were determined and characterized as non-heterocystous, unicellular, colonial and filamentous forms and 20 were identified as heterocystous. For each taxon, a description based on morphological and reproductive characters were made and recorded along with information on the geographical distribution in the study area. This study is aimed to describe the Morphological features and distribution of cyanobacteria in various rice fields of Guntur district areas. The present study concludes that the distribution of heterocystous and non-heterocystous forms of algae enhances soil fertility so as to increase the rice yield. The physico-chemical parameters such as temperature, pH, salinity, dissolved oxygen and total dissolved solids were analysed during June 2010 to November 2010. The temperature, pH and salinity were increased during summer season and dissolved oxygen and total dissolved solids were decreased in summer season. The chemical parameter, Biological oxygen Demand(BOD), Chemical oxygen Demand, Carbonate and Chloride were also estimated.

Keywords: Paddy fields, Cyanobacteria, Physico-chemical Parameters and heterocystous.

INTRODUCTION
Cyanobacteria (Blue green algae) are photoautotrophic organisms possess the twin abilities of photosynthesis and biological nitrogen fixation. These organisms, endowed with tremendous genome plasticity, are distributed in all possible biotypes of the world. The rice field environment provides suitable conditions for the growth and multiplication of blue green algae with respect their requirements for light, water, high temperature and nutrients. In rice soils cyanobacteria are the most important nitrogen fixing organisms because of their autotrophic nutrition. The rice ecosystem allows cyanobacteria to function properly, selectively and effectively. Heterocystous blue green algae carry out nitrogen fixation in special cells, heterocysts and photosynthesis in vegetative cells. Non–heterocystous blue green algae separate photosynthesis and nitrogen fixation in time, day and night respectively. Cyanobacteria have a remarkable suite of attributes and strategies, which enable them to colonize and survive under extreme habitats. These organisms are able to interact with their niche, develop certain survival mechanisms and either exploit or modify their attributes to make them more suitable under water stress conditions. Cyanobacteria are one of the major components of the nitrogen fixing biomass in paddy fields. Distribution of these organisms in diverse habitats has always attracted attention of scientists for evolving suitable methods for their ecological investigations. In addition their ecological significance, cyanobacteria are great potential tools as organisms for the biotechnological attention (Subramaniyan and Uma, 1996). Due to the pivotal role played by these organisms, it was considered worthwhile to examine the distribution of heterocystous and non-heterocystous cyanobacteria. Therefore, the present work was carried out in paddy fields of Guntur District in Andra Pradesh.

MATERIALS AND METHODS
Study area
Tenali Mandal is one of the significant and prominent town in the Guntur district of Andhra Pradesh situated with distance of 13 km of Krishna River (Fig. 1) with a total annual rainfall of 60-75 cm and temperature ranging between 30-40°C. Soil samples were analysed from June 2010 to November 2010 at monthly intervals during forenoon hour (8.00 A.M to 11.00 am). The soil samples
were analysed immediately on the spot for temperature, pH, salinity, electrical conductivity (EC), dissolved oxygen (DO) and total dissolved solids (TDS) by using water and soil analysis kit model 1160-E and data were also recorded. Other parameters were estimated in the laboratory by using standard methods prescribed by Trivedi and Goel (1986), NEERI (1986), Adoni (1985) and APHA (1998).

**Materials preparation for light microscopic studies**

Blue green algae were removed from this substratum using sharp blades, epiphytic algae were collected with their hosts and shells of snails were scrapped to collect episodic algae. To collect cyanobacteria, one litre of water was collected from its locality, to which was added lugol's iodine (to get the final concentration of 1%) and left undisturbed for 24 hours. The latter was prepared by mixing 5 ml of formalin, 10 ml of glycerine in 85 ml of distilled water. Macroscopic and microscopic forms of algae brought to the laboratory were preserved in 4% formalin. All the samples were given serial number and deposited in the Laboratory of Phycology, Department of Botany, Annamalai University, Annamalainagar, and Tamil Nadu. Algal samples were examined immediately after collection whenever possible. Other samples were examined after some time. Cyanobacteria that had lost their colour due to preservation were examined after staining with cotton blue in lactophenol and other suitable stains, samples were examined using calibrated student research microscope and measurements were taken. Photomicrographs were taken using Nikon, automatic photomicrographic unit.

**Lugol's solutions**

This was prepared by dissolving 10 g of iodine and 20 g of potassium iodine in 200 ml of water. To this was added 20 ml of glacial acetic acid. Lugol's iodine solution prepared in this method was stored in a darkened bottle; it was mixed with plankton samples to yield a final concentration of 1% to preserve the sample better. Lugol's iodine fixed samples were mixed with equal amount of formalin and glycerine preservative. Blue green algae was identified by referring to the standard keys to Desikachary (1959), Prescott (1964), Bongale and Bharathi (1980), Gonvalves (1981); Cox (1996) and Anand (1998) Wilhr and Sheath (2003).

**ANALYSIS**

The data obtained on the soil during the study period were given in Table(1). The following physico-chemical parameters were recorded during the study period atmospheric temperature, soil temperature, pH, salinity, EC, DO, TDS, BOD, COD, Chloride and Carbonate (table no 1 and figs 1-11 ). The results depicted above on the growth physical and biological characteristics of the different species on blue green algae shown that in their growth responses to different pH, temperature, salinity and nutritional conditions. The amount of dissolved oxygen reflects the physical and biological processes prevailing in the water, its presence in the soil is essential to maintain the aquatic life in the soil.
Table 1. Physico-chemical parameters of soil during July 2010 to November 2010.

<table>
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<th>Parameters</th>
<th>June</th>
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<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
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<td>Surface temperature</td>
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<td>8.0</td>
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<td>5.0</td>
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<td>25.8</td>
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<td>Carbonate (mg/l)</td>
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<td>19.17</td>
<td>20.08</td>
<td>21.02</td>
<td>20.08</td>
<td>19.07</td>
<td>0.761</td>
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Fig: 1 Water temperature Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 2 Soil temperature Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 3 pH Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 4 Salinity Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010
Fig: 5 Electrical conductivity Variation (ms) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 6 Dissolved oxygen Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 7 Total dissolved solids Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 8 Biological oxygen Demand (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 8 Chemical oxygen Demand Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 8 Chloride Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010

Fig: 8 Carbonate Variation (mg/l) in the Tenali area Rice fields of Andhra Pradesh, India from June 2010-November 2010
Andhra Pradesh, India from June 2010-November 2010

**Fig's (a-e)** Tenali area rice field shows Blue green algal Association.

Description of all the taxa is as follows:

**NON-HETEROCYSTOUS FORMS.**

**Chroococcus minor** (kützing) Nägeli
- **Order:** Chroococcales
- **Family:** Chroococcaceae
- Thallus slimy-gelatinous, dirty blue green; cells spherical, 3-4 μ in diameter, irregularly scattered, singly; sheath thin and colourless, hardly visible.

**Aphanothece bullosa** (Menegh.) Rabenh.
- **Order:** Chroococcales
- **Family:** Chroococcaceae
- Thallus more or less spherical, irregularly lobed, up to 15cm diameter, greenish to yellow, soft; cells cylindrical, 3.5-5. μ broad, without individual envelopes, blue green in colour.

**Aphanothece microscopica** Nag.
- **Order:** Chroococcales
- **Family:** Chroococcaceae
- Thallus small, gelatinous, at first rounded later amorphous, upto 2mm diameter; cells oblong cylindrical, more or less 4.5 μ broad, 1½-2 times as long as broad, with sometimes distinct, individual sheath, blue green, colourless nonocyst present.

**Arthrospira jenneri** Stizenb. ex Gomont
- **Order:** Nostocales
- **Family:** Oscillatioriaceae
- Trichome blue green, unconstructed at the cross walls or only very little constricted, 5-8μm broad, more or less regularly spirally coiled, spirals 7-13 μm broad, distance between two spirals 31 μm ; end cells broadly rounded and cross wall granulated.

**Spirulina meneghiniana** Zanard.ex Gomont
- **Order:** Nostocales
- **Family:** Oscillatoriaceae
- Trichome 1-2μm broad flexible, irregularly spirally coiled, bright blue green, forming a thick blue green thallus; spirals 4- 5 μm broad and 4 μm distant from each other.

**Merismopedia Punctata meyen**
- **Order:** Chroococcales
- **Family:** Chroococcaceae
- Colonies small, 4-64 cells about 60 μm broad; cells not closely packed, ovoid, 2.5-3.5 μm broad, pale blue green. Groups widely separated within a broad gelatinous envelope, cell content homogenous, blue green.

**Spirulina gigantea** Schmidle
- **Order:** Nostocales
- **Family:** Oscillitoniaeae
- Trichome 3-4 μm broad, deep blue green, regularly spirally coiled, at the end conical attenuated, spirals 11-16 μm broad.
Gloeocapsa Punctata nag.
Order: Chroococcales
Family: Chroococcaceae
Desikachary 1959, p115, Prescott 1951, p.452,
Thallus gelatinous, light blue green; cells without sheath 0.7 - 1.5 μm diameter, with sheath 3.5-5 μm broad, blue green; sheath thick, colourless, cells 2-4 in groups, about 25 μm diameter.

Lyngbya martensiana Menegh.ex Gomont
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P. 318,
Thallus caespitose, blue green, when dried violet, filament long, flexible; sheath colourless, thick, trichome 6-10 μm broad, not constricted at the cross walls, cross wall granulated, apices not attenuated, pale blue green; cells ½-¾ times as long as broad, 1.75-3.3 μm in length; end cell without calyptra.

Oscillatoria curviceps Ag. ex Gomont
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P.209,
Thallus light blue-green; trichomes more or less straight, bent at the end, not attenuated, not constricted at the cross-walls, 10-17 μm broad, 2-5 μm long, cross-walls granulated; end-cells flat rounded, not capitulate.

Spirulina major kuetzing
Order: Nostocales
Family: Oscillatoriaceae
Desikachary, 1959, P.196,
Prescott 1951, P.487,
Trichomes loosely spiraled, scattered among other algae, blue green mass; trichome 1.2-1.7 μm in diameter, spiral 2.5-4 μm wide; distance between spirals 2.7-5 μm.

Lyngbya versicolor (Wartm.) Gom.
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P.311,
Prescott 1951, p.504,
Thallus at first adherent, later free floating, lubricous, somewhat soft, rusty on the outside and inside olive green; filaments long, tortuous, closely entangled; sheath colourless, slightly mucilaginous, upto 2 μm thick, trichomes not constricted at the cross walls, 2.8-3.2 μm broad, apices not attenuated, not capitulates, cross walls not granulated; cells blue green, 2-6.4 μm long, end cells rounded, calyptra absent.

Oscillatoria princeps Vaucher ex Gomont
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P.210,
Prescott 1951, p.190,
Trichomes blue-green, not constricted at the cross-walls, 16- 60 μm broad, blue-green to dirty green, slightly attenuated at the apices and bent; trichome 27-32.5μm broad, tip 20- 75 μm; end-cells flatly rounded, with slightly thickened membrane.

Phormidium pachydermaticum Fremy
Order: Nostocales
Family: Oscillatoriaceae
Desikachary ,1959, P.267,
Thallus outer surface dull blue green, inside brown; filaments 6-9 μm broad, straight or undulating; sheath at first thin, later thick, irregularly lamellated, lamellae short, irregularly disposed, trichome blue green, 6-7.5 μm broad, not constricted at the cross walls, cells 5.7 μm in length; end cells slightly obtuse conical, with slightly thickened outer membrane.

Oscillatoria margaritifera (kutz.) Gomont.
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P.202,
Trichome olive green ,20-32 μm broad, constricted at the cross walls, cells 19-30 μm broad and 5-8 μm long, cross walls granulated, end cells capitates with slightly convex calyptra.

Oscillatoria tenuis Ag. ex Gomont.
Order: Nostocales
Family: Oscillatoriaceae
Desikachary 1959, P. 222,
Prescott 1951, p.221,
Thallus thin blue green, slimy; trichome straight, fragile slightly constricted at the cross walls, 4-10 μm broad, not attenuated at the apices, not capitulates; cells up to 1/3 broad, 2.6-5 μm long, apex convex, end cells more or less hemispherical with thickened outer membrane.

Oscillatoria laetevirens (Grouan) Gomont.
Order: Nostocales
Family: Oscillatoriaceae
Desikachary, 1959, P.213,
Thallus thin, membranous, green; trichome yellowish green, straight, slightly constricted at the cross walls, 3-5 μm broad, apices attenuated, bent; cells nearly as long as broad, 2.5-5 μm long, more or less conical, end cells not capitulates, without calyptra.

Phormidium papyraceum (Ag.)
Order: Nostocales
Family: Oscillatoriaceae
Desikachary, 1959, P.271,
Thallus dark green, listening, expanding, thin, leathery, when dry fragile; filaments elongate, very flexuous, densely entangled; sheath thin, papery, persistent, coloured violet by chlo-zic-iodide; trichomes blue green, not constricted at the cross walls, 3-5 μm broad, ends straight, briefly attenuated not capitulates; cells subquadrate or mostly shorter than broad, 2-4 μ long; cross walls conspicuous, not granulated, end cell obtuse conical, calyptra absent.

HETEROCYSTOUS FORMS
Descriptions of taxa heterocystous
Anabaena aequalis Borge plate 2, fig c.
Order: Nostocales
Family: Nostocaceae
Prescott 1951, Page. 512, Plate 115, Figs 1, 2.
Trichomes straight, forming a small plant mass or scattered among other algae; cells somewhat heterocyst ovate to subcylindric, heterocyst 8 μm in diameter, 10 μm long; gonedia cylindrical remote from the heterocyst, the wall smooth and colorless, 5-7 μm in diameter.

Anabaena constricta (szafer) Geitler
Order: Nostocales
Family: Nostocaceae
Desikachary 1959, page 394, Plate 71, Figs 1 to 3. Thallus dull olive or brown; trichome 4.5-5.5 μm broad; cells are constricted, barrel shaped to cylindrical, 5-8 μm long, heterocyst nearly spherical 5-7 μm broad.
Anabaena laxa (Raben h.)

Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 413, Plate 5, Figs 2 to 7. Thallus floccose, free floating blue green; trichomes 4-5 μm broad, straight, parallel, sometimes free and sometimes with a mucilaginous sheath; cells barrel shaped, 5-6 μm long, apices hardly attenuated, end cells rounded, heterocyst spherical, 6 μm broad, 10 μm long, epispore smooth and yellowish.

Cylindrospermum sphaerica Prasad, B.N. plate1, Fig a.

Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 363, Plant mass soft, mucilaginous, pale brown, and forming a mat; trichome single, curved, often entangled with each other, 4.8-5.6 μm broad, cells barrel shaped, 4-8 μm long, constricted at the septa; heterocyst sub conical to ellipsoidal, rounded at the distal ends, one at each end of the trichome, 4.8-5.6 μm broad and 7.2-11.2 μm long; spores spherical, 16-19.2 μm broad, sub terminal, at the both end of the trichome, formed singly, occasionally in pairs, the sub-terminal ones maturing first, thick brown exosphere and then, smooth and hyaline endospore.

Anabaena oryzea Fritsch

Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 396, Thallus soft green, gelatinous, membranous, trichome short, straight, densely aggregated, generally parallel cells 2.5-3 μm broad, more or less barrel shaped, 1½-2 times as long as broad; heterocysts terminal and intercalary, broader than the vegetative cells.

Anabaena volzii Lemm.

Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 403,
Thallus expanded, mucilaginous, blackish green; trichome 4.5 μm long; heterocyst oblong, somewhat depressed, 6 μm long, with gas vacuoles; heterocyst terminal, two together rarely one, heterocyst spherical in shape 5-7 μm broad, 8-10 long.

Cylindrospermum majus Kutzing ex Born. et Flah.

Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 360,
Thallus expanded, mucilaginous, blackish green; trichome 4-5 μm broad, cells cylindrical, 5-6 μm long; heterocyst oblong, somewhat broader then the trichome, epispore brownish with distinct papillae.


Order: Nostocales
Family: Nostacaceae
Desikachary 1959, Page 360,
Thallus expanded, mucilaginous, blackish green; trichome 4-5 μm broad, cells cylindrical, 5-6 μm long; heterocyst oblong, somewhat broader then the trichome, epispore smoothness.

Scytonema hofmanni Ag. ex Born et Flah

Order: Nostocales
Family: Scytonemataceae
Desikachary 1959, Page 476,
Stratum cushion-like, broadly expanded, 1-3 mm height, blackish blue green, sometimes impregnated with calcium carbonate, amethyst green or bluish grey; filaments 7-12 μm broad, aggregated in vertical fascicles; false branches aggregated; sheath firm, membranaceous; trichome 5-10 μm broad, olive to blue green, cells unequal in length; heterocystous oblong.

Scytonema iyengari Bharadwaja.

Order: Nostocales
Family: Scytonemataceae
Desikachary 1959, Page 465,
Thallus thick, dirty green filaments irregularly bent false branch short, single and germinate in equal numbers. Filament 15-20 μm broad. Sheath firm 2-4 μm thick, gradually thinning towards the growing apices. heterocyst's cylindrical.

Calothrix fusca (kuetz.) bornet & flahaut

Order: Nostocales
Family: Rivulariaceae
Desikachary 1959, Page 527,
Prescott 1951, Page 553,
Filaments strongly curved from short horizontal basal portions,
attached in the mucilage of other algae, bulbous at the base, 11-14 μm in diameter, tapering to a long hair; vegetative cells 7-11 μm in diameter, 1/3 as long as wide; heterocyst’s basal, hemispherical, 9-10 μm in diameter.

**Calothrix linearis gardneri J.De Toni**
- **Order:** Nostocales
- **Family:** Rivulariaceae
- **Desikachary 1959, Page 535,**
Filament erect, for the major part straight, 350-500 μm long, cylindrical, but swollen at the base and attenuated at the apex, sheath 2-2.5 μm thick, somewhat slimy, colorless, not lamellated; trichome cylindrical, 5-7 μm broad, in the basal part constricted at the crosswalls, ending in short hair; cells quadrate to ½ as long as broad; heterocyst’s basal, mostly hemispherical.

**Calothrix simplex Ag. Ex Born et Flah**
- **Order:** Nostocales
- **Family:** Rivulariaceae
- **Wehr and Sheath, Page 165,**
The thallus is filamentous, attached to the substratum with heterocyst and occasionally an associated akinete. Heterocyst develops basally; trichomes are unconstructed at the crosswalls and always taper terminally. Sheaths are always present, firm, cells barrel shaped elongated towards the end. Heterocysts are ellipsoidal appearing above basal heterospor and developing from a vegetative portion of a trichome.

**Gloeotrichia raciborskii Woloszynska .**
- **Order:** Nostocales
- **Family:** Rivulariaceae
- **Desikachary 1959, Page 562,**
Thallus spherical, soft, trichome 7-12 μm broad, ending in long hair, sheath at base lamellated, dull brown; cells at the base of the trichome shorter than broad, higher up as long as broad, pale blue green; heterocyst spherical 7-10 μm broad; spores long ellipsoidal.

**Homoeothrix hansgiri (schmidle) lemm.**
- **Order:** Nostocales
- **Family:** Rivulariaceae
- **Desikachary 1959, Page 521, Plate 106,**
Filaments many growing with other algae, unbranched, erect, about 4 μm broad, 20-60 μm long; sheath thin, colourless; trichomes ending in a short hair; cells very short.

**MAJOR FINDINGS**

There are 19 taxa belonging to 10 genera were obtained and characterised are non-heterocystous, unicellular, colonial and filamentous forms. A total of 30 heterocystous forms from 7 genera comes under a singal order with 3 families were recorded. Highest abundance of cyanobacteria was found in order Nostocales which was represented by 17 species. The present study concludes that the density of heterocystous and non-heterocystous forms of algae enhances soil fertility.

**CONCLUSION**

The present study concludes that the distribution of heterocystous and non-heterocystous forms of algae enhances soil fertility so as to increase the rice yield. Cyanobacteria are unique prokaryotic organisms with the ability to perform mutually compatible functions like nitrogen fixation and photosynthesis. Information on the diversity of blue greens is essential to understand the algal dynamics and interaction with other microorganisms.

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**References**