



## Note on taxonomy of *Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey with soil analysis, collected from a rice field in West Bengal, India

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### Abstract

While studying on paddy field blue green algae, author for the first time recorded a blue green algal species *Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey from rice field soil in summer during 2013 in Hooghly, West Bengal, India. In the present paper, taxonomical description with microphotographs of the species has been provided. In addition to that, soil which was collected from the algal occurrence site has been analyzed. The different physico-chemical parameters of soil were as followed: pH: 7.1; EC: 0.142 dSm<sup>-1</sup>; OC: 6.6 mgkg<sup>-1</sup>; Ca<sup>2+</sup>: 4.6 cmol<sup>+</sup>kg<sup>-1</sup>; Na<sup>+</sup>: 0.71 cmol<sup>+</sup>kg<sup>-1</sup>; K<sup>+</sup>: 0.15 cmol<sup>+</sup>kg<sup>-1</sup>; CEC: 12.6 cmol<sup>+</sup>kg<sup>-1</sup>; WHC: 45%. Soil textures were as: sand: 36.2%, slit: 28.1% and clay: 35.7%. This study of soil showed its nature and present nutrient content. As the alga contains heterocyst and can fix atmospheric nitrogen to soil so, it can apply in rice fields as biofertilizer to enhance the yield of rice and increase of soil fertility.

**Key words:** Green algae, Hooghly, Physico-chemical parameters, Rice field

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### Introduction

Cyanobacteria are an ancient group of photosynthetic prokaryotes (Seal *et al.*, 2014) and Gram negative bacteria (Seal *et al.*, 2015) that exist continuously since the early

evolution of biosphere in the earth (Barghoorn, 1992; Řezanka *et al.*, 2003) and are able to grow in diverse habitats (Halder and Sinha, 2013a, b).

The members of Nostocaceae are tri-chomatous, mucilaginous, odoriferous, bluish-green, with or without sheath, heterocystous or non-heterocystous, unbranched. Tropical hot, dry and, humid conditions help their luxuriant growth in various ecosystems (Halder, 2015). *Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey is a filamentous heterocystous cyanobacterium and shows variations in morphology and diversities of functions. It can also tolerate varieties of climatic conditions required for growth and survival (Evans *et al.*, 1976) like that of other blue green algal species (Halder and Sinha, 2013a). This blue-green alga can fix atmospheric nitrogen to a limited extent in soil (Fay, 1965) and nitrogen-fixing activity is found greatest during exponential growth in small-celled filaments that developed from the endospores (Fay *et al.*, 1964). Nitrogenase activity in the heterocyst of this species under aerobic condition was documented earlier (Kenyon *et al.*, 1972). Besides these, the alga is very important regarding synthesis of photo-pigmentations and few biochemical products. It has been recognized that chlorophyll (chl.) a along with chl. b and c, phycobilins, and carotenoids contribute to oxygenic photosynthesis by harvesting the light energy (Grossman *et al.*, 1995). Study of scientific literature showed that the alga produced chl f and chl d pigments when cultured under natural and near-infrared (IR) lights in a column photobioreactor (Airs *et al.*, 2014). Chlorophylls f and d are red-light inducible chlorophylls and play significant role as an accessory pigments in far-red type of oxygenic photosynthesis by absorbing red light. Chlorophyll f is the most recently discovered longest wavelength absorbing chlorophyll, although its structure and biophysical prop-

erties are resolved, and has only been reported from this cyanobacterial strain in wet environments (Behrendt *et al.*, 2015). Chemical analysis of fatty acid composition of this species exhibited low content of poly-unsaturated (mono and tri) fatty acids (Kenyon, 1972). The occurrence of poly- $\beta$ -hydroxybutyrate (PHB) in this blue-green alga was reported earlier (Carr, 1966). PHB is a polymer belonging to the polyester class that is used for biodegradation of plastics. The existence of the glyoxylate cycle, a variant of the TCA cycle, has been documented from the type *Chlorogloeopsis fritschii* PCC 9212 and the genes responsible for encoding isocitrate lyase and malate synthase enzymes are also identified. The glyoxylate cycle helps to coordinate carbon and nitrogen metabolism under condition of nitrogen fixation (Zhang and Bryant, 2015).

Soil is a valuable resource in our planet and one of the most significant ecological factors, on which plants dependent for their nutrients, water and mineral supply (Shaikh and Bhosle, 2013). The soil of Hooghly district, West Bengal in India is new alluvial type, most fertile and found along the Indo-Gangetic belt. As, it harbors the algal flora hence different parameters of the soil sample of the sampling site has been analyzed using the standard methods to find out soil profile characteristics and the relationships between algae and soil properties. As scanty information is available regarding physico-chemical parameters of soil and taxonomic work on this species therefore, the present study was undertaken.

#### Materials and methods

The Algal sample was collected in plastic and glass containers from a paddy field during puddling stage of rice from Balagarh (N 23°12', E 88°46'), in Hooghly, West Ben-

gal, India. Microscopic examination was made under Olympus microscope (Model-CH20i). Algal sample was preserved in 4% formalin solution and the voucher specimen was deposited in the Departmental Herbarium of the Department of Botany, Raja Peary Mohan College, Uttarpara, West Bengal. Identification of the taxa had been made following scientific literature viz. Mitra and Pandey (1966) and Guiry and Guiry (2015). For soil analysis, surface soil sample about 500 gm from a depth of 10 cm was collected, air dried, brought up in the laboratory, grounded and homogenized with a mortar and pestle and pass through a 2.0 mm sieve. Various physico-chemical parameters of soils were analyzed by different techniques. To obtain clear supernatant of soil sample centrifugation was done using a Remi centrifuge (model, R-23). The standard Munsell colour charts (Munsell colour Co., 1975) was used for identifying the colour of soil sample. The pH of the sample as soil suspension was recorded with the help of a pH meter (Jenway, 3510) in the ratio of soil: water = 1:2.5 (w/v). Electrical conductivity (EC) value of soil suspension (soil: water = 1: 2.5) was measured at room temperature by a direct reading conductivity meter (Systronic, 303). The organic carbon (OC) content of the soil sample was determined as procedure of Walkey and Black (1934) and outlined by Jackson (1967, 1973) while calcium ( $\text{Ca}^{2+}$ ) was determined by EDTA titration method (Chapman, 1965). Sodium ( $\text{Na}^+$ ) and potassium ( $\text{K}^+$ ) cations were determined with the help of a flame photometer (Systronic, 121). Water holding capacity (WHC) was determined by Keen box method following Piper (1966). Soil texture (particles size distribution) as percentages of sand, silt and clay fractions was determined by the hy-

drometer method adapted by Bouyoucos (1962). All the statistical analyses were done using the statistical package for social sciences (SPSS v. 13, Inc., USA).

### Results and discussion

Morpho-taxonomic description of *Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey under light microscopy had been provided here. The alga was collected in the month of March during summer from a paddy field in a locality of Hooghly district, West Bengal, India. Systematic position of the species was mentioned according to Mitra and Pandey (1966).

Phylum- Cyanophyta; Class- Cyanophyceae; Family- Chlorogloeopsidaceae; Order- Stigonematales; Genus- *Chlorogloeopsis* A.K. Mitra et D.C. Pandey (1967)

*Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey in Phykos 5(1-2): 111-113, figs.1-29, 30-40, 41-54, 1966 (Figs. A-C)

*Chlorogloea fritschii* Mitra (1950)

Description: Thallus blue-green, forms a crust or compact stratum of indefinite size and composed of rounded or irregular cell packets; cells arranged in vertical and horizontal rows, rounded or angular without any distinct mucilaginous sheath with pale blue-green granular contents; usually 6.0-8.0  $\mu\text{m}$  in diameter; reproduction takes place by separation of single cell or cells in groups of two or more; heterocysts terminal and intercalary; 2.0-4.5  $\mu\text{m}$  broad and 2.0-4.0  $\mu\text{m}$  long and irregularly disposed; endospores naked, spherical, 4.0-9.0  $\mu\text{m}$  in diameter, formed singly or more (upto four) within the cells and released by the rupture of mother wall; germination of endospore forms uniseriate filament of 3-16 (-20) cells which divides to produce cell packets.

Habitat: The alga was grown in a rice field at Balagarh, Hooghly, West Bengal, India

Date of collection: 18.03.13; Collection number: NH-1260

Significance: The algal species is nitrogen fixer and increase soil fertility

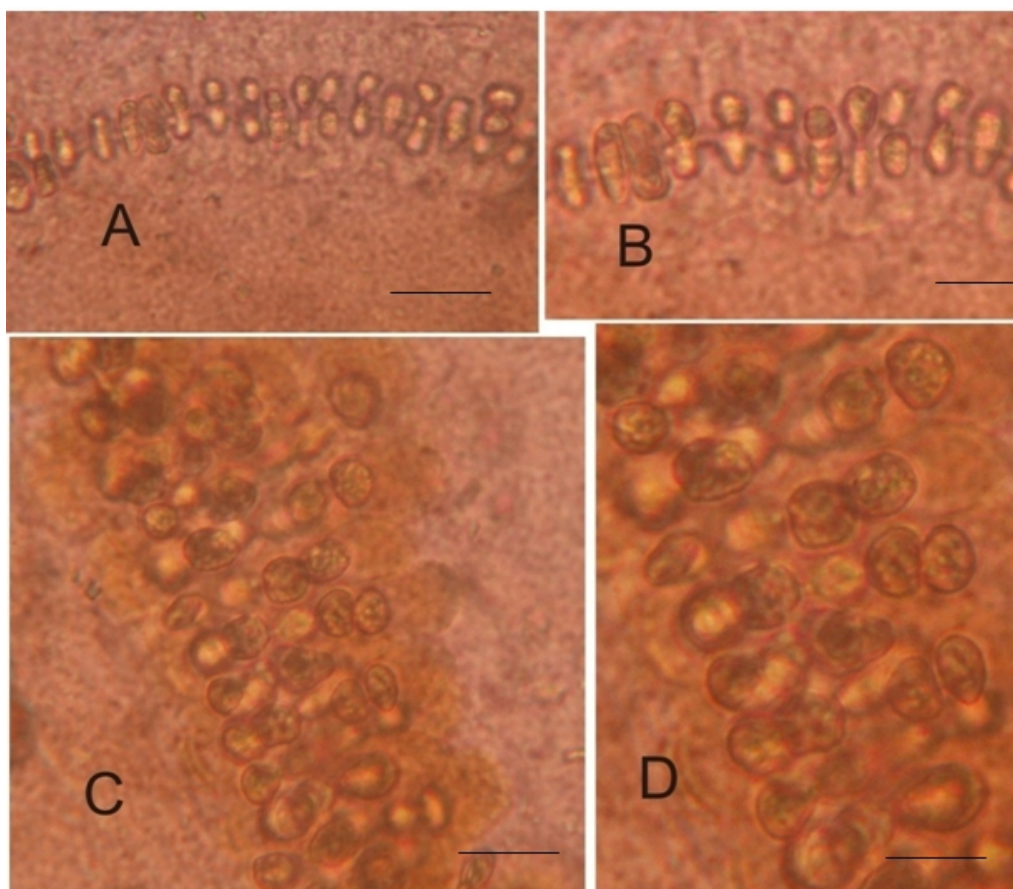
It was Mitra (1950) who first time reported the occurrence of a blue-green algal species *Chlorogloeopsis fritschii* (Mitra) Mitra et Pandey with morphological description and illustrations from cultures of cultivated and uncultivated soils in Allahabad, Uttar Pradesh, India. Previously, he included it as a new species belonging to the family Entophysalidaceae under the order Chroococcales of Cyanophyta but later he found the development of heterocysts in this algal species that led the author to review the morphological features and finally documented it as new taxon in algal science and also changed its taxonomic status. He established it under a separate genus *Chlorogloeopsis* A.K. Mitra et D.C. Pandey of the family Chlorogloeopsidaceae belonging to the order Stigonematales of class Cyanophyceae. The present algal taxon exhibited vertical and horizontal divisions of cells and has a tendency to form filamentous structure. Besides these, some other characters like habitat, colour, measurements and organization of cells were alike with the type species. So, the morphological characteristics agreed with the previous reports by Mitra (1950) and Mitra and Pandey (1966) and the present study also confirmed the earlier taxonomical findings.

The physical and chemical properties of the soil from sampling site at Balagarh, Hooghly, West Bengal were presented in Table 1. The colour of soil was observed as yellowish-brown. Soil pH influences the richness and diversity of plant species by

enhancing the solubility of nutrients as well as availability of nutrient to plant (Gough *et al.*, 2000). In the present study, soil pH was found slightly alkaline. Electrical conductivity (EC) expressed ion contents of soil solution which determined the carrying capacity and thus, giving a clear idea of the soluble salts present in the soil (Addis and Abebaw, 2014). The mean value of EC at the sampling time was  $0.142 \text{ dSm}^{-1}$ . Organic carbon was measured as  $6.6 \text{ mgkg}^{-1}$ . The nutrient contents like  $\text{Ca}^{2+}$ ,  $\text{Na}^{+}$  and  $\text{K}^{+}$  were noticed in appreciable amounts and they were found the most essential elements for the growth and development of this algal species. Cation exchange capacity (CEC) usually depends on the clay fractions and organic carbon/matter present in soil. This value was found to be  $12.6 \text{ cmol}^{+}\text{kg}^{-1}$  which was good indication of fertile soil and nutrients retention capacity. Water holding capacity (WHC) is the amount of water that retains in the soil as soil moisture. It was measured as 45% in soil from the study site. The textural class was clay-sandy loamy at the top of soil. The result of particle size distributions of soil texture composed of different fractions. Sand- 36.2%, slit- 28.1% and clay- 35.7% were determined from soil analysis. On the basis of analysis of soil sample it can be concluded that soil is highly fertile and hence supports the occurrence and growth of algal flora.

### Conclusions

In the young condition, the algal species consist of straight and short filament/s. Vegetative cells were found as singly, 2-celled and many celled or in groups but in older stage, the cells divided vertically and horizontally to form packets of cells and devel-



**Figure 1A.** Filament of *Chlorogloeopsis fritschii* showing vertical divisions, B. Magnified view of same filament, C. Many celled stage of the same species, D. Magnified view of fig. C. Scales = 30 $\mu$ m

**Table 1.** Physico-chemical properties (Mean $\pm$ SE) of soil at the time of algal collection

pH	EC dSm <sup>-1</sup>	OC mgkg <sup>-1</sup>	Ca <sup>2+</sup> cmol <sup>+</sup> kg <sup>-1</sup>	Na <sup>+</sup> cmol <sup>+</sup> kg <sup>-1</sup>	K <sup>+</sup> cmol <sup>+</sup> kg <sup>-1</sup>	CEC cmol <sup>+</sup> kg <sup>-1</sup>	WHC (%)	Sand (%)	Slit (%)	Clay (%)
7.1 $\pm$ 0.05	0.142 $\pm$ 0.1	6.6 $\pm$ 1.1	4.6 $\pm$ 1.7	0.71 $\pm$ 0.05	0.15 $\pm$ 0.2	12.6 $\pm$ 2.3	45 $\pm$ 0.28	36.2 $\pm$ 0.5	28.1 $\pm$ 0.4	35.7 $\pm$ 0.6

Each value was expressed with mean value  $\pm$  standard error of at least four replicates.

oped terminal heterocyst/s. The alga showed different successive stages of divisions during its growth to achieve uniseriate to multiseriate filaments and turned into blue greenish to pale yellowish colour at maturity. As the alga has nitrogen fixing efficiency due to presence of heterocysts in

the thallus so, it could be used as biofertilizer at commercial scale to increase the fertility of habitats such as rice-fields. The soil study has been given some information about the nature of soil and present nutrient status of soil.

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