Pigment Variations in Soil-Isolated Cyanobacteria: A Case Study of the Meerut Region

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ABSTRACT

Cyanobacteria, a varied array of photosynthetic microorganisms, play a crucial role in soil ecosystems by participating in biogeochemical processes and maintaining ecosystem stability. This study examines the pigment content of cyanobacteria strains obtained from soils, from different locations of the Meerut region. The objective is to understand the range of pigments present and their ecological importance. Cyanobacterial strains were obtained from various soil environments, cultivated under controlled conditions, and analyzed for pigments using the spectrophotometric technique. The investigation primarily examined prominent pigments such as chlorophylls, carotenoids, and phycobiliproteins, in order to distinguish changes within and across species. The results demonstrated significant variation in pigment profiles among the cyanobacteria strains, indicating their adaptability to specific environmental habitats. In addition, the study investigated the connections between pigment composition and environmental parameters like light availability, soil pH, and nutrient levels, which shed light on the ecological significance of pigment variety. This study improves our comprehension of cyanobacterial ecology in soil ecosystems, which has consequences for the functioning of ecosystems, the cycling of biogeochemical elements, and the development of strategies for environmental management.

KEYWORDS: Physiological parameters, pigments, Cyanobacterial strains, Pigments composition, Chlorophyll, Carotenoids, Phycobiliproteins

INTRODUCTION

Pigments are compounds with specific chemical properties that can absorb light within the visible spectrum. Cyanobacteria are a diverse group of photosynthetic prokaryotes known for their ability to perform oxygenic photosynthesis, making them crucial contributors to Earth's oxygen-rich atmosphere and primary production in aquatic ecosystems (Vidal L, Ballot A, Azevedo SM, Padisák J, Welker M

2021). Their physiological parameters, including growth characteristics, nutrient requirements, and adaptations to environmental conditions, are key factors influencing their ecological roles and potential applications (Abed RM, Dobretsov S, Sudesh K. 2009.).

Understanding the physiological characteristics of cyanobacteria, such as the levels of chlorophyll, carotenoids, and phycobiliproteins, offers valuable knowledge about their methods of adaptability and ecological importance (Jaiswal A, Koli DK, Kumar A, Kumar S, Sagar S. 2018). Chlorophyll is the main pigment that captures light energy during the process of photosynthesis (Zavřel T, Sinetova MA and Červený J. 2015). Cyanobacteria mostly contain chlorophyll-a as their primary photosynthetic pigment, in addition to accessory pigments including carotenoids and phycobiliproteins (Trees CC, Clark DK, Bidigare RR, Ondrusek ME, Mueller JL. 2000) Carotenoids have crucial functions in protecting against damage from excessive light energy and removing reactive oxygen species (Hirschberg J and Chamovitz D.1994). Phycobiliproteins, like phycocyanin and phycoerythrin, serve as pigments that capture light, allowing photosynthesis to occur across a wider range of wavelengths (Pagels F, Guedes AC, Amaro HM, Kijjoa A, Vasconcelos V. 2019). The physiological characteristics of cyanobacteria, including their composition and abundance, can undergo substantial variations Regarding environmental issues, such as light intensity, nutrition availability, temperature, and pH (Alghanmi HA and Jawad HM.2019). Under conditions where nutrients are limited, cyanobacteria can modify their pigment composition to maximize light absorption and optimize energy use (Sukharevich VI, Polyak YM. 2020). The objective of this study is to examine the fluctuation of physiological parameters in cyanobacteria. By analyzing the properties and characteristics of chlorophyll, carotenoids, and phycobiliproteins, we can obtain valuable information about how cyanobacteria adapt to their environment and how they respond to changes in their surroundings.

The present investigations aimed to obtain cyanobacterial isolates from different fields of western Uttar Pradesh (Meerut), which can produce metabolites such as pigments and phycobiliproteins, these chemicals are highly valuable and have the potential to be used in the food, pharmaceutical, and cosmetics industries.

METHOD AND MATERIALS

ISOLATION OF CYANOBACTERIAL STRAINS FROM SOIL SAMPLES

The soil samples were gathered from the inhabited areas of the Meerut region in western Uttar Pradesh, India. 10 grams of soil samples were thoroughly shifted to the flask containing 90ml sterile distilled water and homogenized for 30 minutes at 120 rpm following the serial dilution up to 10^{-4}. 1ml aliquots were spread and grown in a BG-11 medium at 28±2°C under Light:Dark cycle of 16:8 h; light intensity 3-4 Klux for one weak. identified using the keys given by Desikachary 1959 for microscopic parameters. These isolates were examined under controlled conditions for pigment analysis at the exponential growth stage.

List of cyanobacteria isolated from soil from 3 porch areas of Meerut region of Uttar Pradesh.

S. No.	Generic description	Origin/site
As1	*Anabaena*	KANKER KHERA MEERUT
As2	*Nostoc*	KANKER KHERA MEERUT
As3	*Phormidium*	KANKER KHERA MEERUT
As4	*Anabaena*	KANKER KHERA MEERUT
As5	*Nostoc*	BANK ROAD, MEERUT CANTT
As6	*Calothrix*	BANK ROAD, MEERUT CANTT
As7	*Plectonema*	BANK ROAD, MEERUT CANTT
As8	*Aulosira*	BANK ROAD, MEERUT CANTT
As9	*Anabaena*	BANK ROAD, MEERUT CANTT
As10	*Oscillatoria*	GANGA NAGAR MEERUT
As11	*Calothrix*	GANGA NAGAR MEERUT
As12	*Anabaena*	GANGA NAGAR MEERUT
As13	*Westielopsis*	GANGA NAGAR MEERUT
As14	*Chrococcus*	GANGA NAGAR MEERUT

ESTIMATION OF PIGMENTS

CHLOROPHYLL

Chlorophyll estimation was done, and centrifugation was done for a homogenized suspension for 5 mins at 4000 g. At 60 °C for 30 minutes chlorophyll was extracted from the pellet with 95% methanol. Subsequently, the last volume was prepared and the amount of chlorophyll was determined by measuring the optical density at wavelengths of 650 and 665 nm. In 1941, McKinney calculated the total amount of chlorophyll.

CAROTENOIDS

At 4000 g for about 10 minutes, the algal suspension was centrifuged. The adhering salt traces were removed by washing them off with distilled water. Subsequently, 2-3 ml of 85% acetone was introduced and exposed to a series of freezing and thawing cycles. Until acetone became colorless continuous extraction was performed. A pooled acetone fraction was obtained and total volume was recorded. The total carotenoid concentration was determined by measuring the maximum absorbance at 450 nm using 85% acetone as a blank, according to Jensen (1978).

PHYCOBILLIPROTEINS

The amount of phycobilins (Phycocyanin, Phycoerythrin, Allophycocyanin) was extracted by following the process of repeated freezing and thawing at a pH of 7.5 until the particle lost its color as the pigments seeped out into a supernatant.

RESULT AND DISCUSSION

Cyanobacterial strains from different locations of Meerut were isolated and grown in BG11 medium for estimation of pigments (dry weight). The strains were observed on the 14th day of the incubation period. Chlorophyll is the main photosynthetic pigment found in cyanobacteria. The various aspects of physiological parameters in cyanobacteria has been studied by the members of IARI. Little attention has been given to the physiological parameters as compared to the nitrogen fixation (Tabassum R, Kumar R, Yadav R, Dhar DW, Bhatnagar SK. 2012). Total chlorophyll content was recorded highest of 0.96 $\mu g/mg^{-1}$ dry weight in (As5) *Nostoc sp.* followed by Anabaena sp. and Calothrix sp. ranging between 0.06 to 0.77$\mu g/mg^{-1}$. Cyanobacteria include carotenoids, a distinct pigment category (Kumar R, Bhowmick A, Chakdar H, Elumalai S and Pabbi S. 2015). The highest among all carotenoids was recorded in *Anabaena sp.* (As1) at 0.79 $\mu g/mg^{-1}$ dry weight and lowest in (As7) *Plectonema sp.* 0.08 $\mu g/mg^{-1}$. In addition to chlorophyll, Nitrogen-fixing heterocystous species of filamentous cyanobacteria are highly valued for their ability to produce phycobiliproteins and carotenoids, and other significant compounds that act as accessory pigments in photosynthesis (Deepika C, Wolf J, Roles J, Ross I, Hankamer B. 2022). Carotenoids safeguard cyanobacterial cells from photooxidative harm and are commonly linked with proteins (Kirilovsky D, Kerfeld CA. 2016). Phycocyanin varied from the highest of 4.5$\mu g/mg^{-1}$ in *Nostoc sp.* (As2) to the lowest of 0.94 $\mu g/mg^{-1}$ dry weight in (As7) *Phormidium sp*. Phycoerythrin was highest at

3.34µg/mg^{-1} dry weight in *Westielopsis sp.* (As13) and minimum in *Phormidium sp.* (As3) 0.63µg/mg^{-1} dry weight. Allophycocyanin was highest in (As5) *Nostoc sp.* 20.05µg/mg^{-1} followed by *Nostoc sp.* 15.02µg/mg^{-1} dry weight and lowest in *Phormidium* sp. and *Aulosira sp.* Phycobiliproteins play a major role in the photosynthetic process of cyanobacteria by facilitating the effective absorption and utilization of light energy (Li W, Su HN, Pu Y, Chen J, Liu LN, Liu Q, Qin S. 2019). The continuous research emphasizes the significance of these organisms not only in ecological settings but also in biotechnological advancements. Due to their distinct characteristics, they possess significant value in a diverse array of applications, spanning from scientific investigations to commercial merchandise (Bryant, D. A. 1982) examines the evolutionary importance of several phycobiliproteins, specifically phycoerythrocyanin, in cyanobacteria. An extensive examination of the chemical characteristics of phycobiliproteins and their many uses in biotechnology, including their utilization as organic pigments and in photodynamic therapy by (Pagels, F., Guedes, A. C., Amaro, H. M., & Malcata, F. X. 2019).

CONCLUSION

The present study concludes that the Porsche areas of Meerut, U.P are rich in useful blue-green algae and further investigation and advancement in these crucial domains will not only unleash the complete capabilities of cyanobacteria in transforming agriculture but also guarantee their secure and sustainable application, which can be harnessed for commercial purposes.

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