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ORIGINAL ARTICLE

Taxonomic Diversity and Economic Importance of Cynaobacterial Taxa from the Chours of Supaul District, Bihar

Sneha Kumari*
Department of Botany, Manohar Lal Tekriwal College, Saharsa, Bihar- 852201, India.
***Corresponding Author**: **Email**: sneha09mallik@gmail.com,
Phone: +91 9717688273

ABSTRACT
Cyanobacteria, also known as blue-green algae, play a crucial role in the ecology and economy of wetland ecosystems. This study investigates the economic importance of cyanobacteria commonly found in the wetlands of Supaul district, Bihar, India. Cyanobacteria play crucial roles in aquatic ecosystems and have significant potential for various applications. Through extensive field sampling, taxonomic identification, and analysis of their properties, this research aims to elucidate the economic value and potential uses of cyanobacterial species in this region. The findings reveal several economically important genera including Microcystis, Anabaena, Nostoc, Lyngbya, Phormidium Oscillatoria, and Spirulina. Their applications range from biofertilizers and soil conditioners to sources of bioactive compounds and potential biofuels. Cyanobacteria in the wetlands of Supaul District, Bihar, demonstrate considerable economic importance, particularly in agriculture and ecosystem services. Their role in sustainable farming practices and potential for biotechnological applications underscore the need for conservation and further study of these valuable microorganisms.

Keywords: *Carbon Sequestration, Biofertilizers, Cyanobacteria, North Bihar, Wetlands*

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INTRODUCTION

Cyanobacteria, also known as blue-green algae, are ancient photosynthetic prokaryotes that have played a crucial role in shaping Earth's biosphere for over 3.5 billion years [1]. These microscopic organisms are ubiquitous in aquatic ecosystems, particularly in wetlands, where they form the foundation of complex ecological networks and contribute significantly to primary production. In recent years, the economic potential of cyanobacteria has garnered increasing attention from researchers, policymakers, and industry stakeholders, particularly in regions where wetland ecosystems are prevalent. Cyanobacteria are key players in wetland ecosystems, contributing significantly to primary production, nitrogen fixation, and soil stabilization [2]. Their ability to thrive in diverse aquatic environments, including nutrient-poor and extreme conditions, makes them ubiquitous in wetlands worldwide. The economic potential of cyanobacteria extends beyond their ecological roles. In recent years, there has been growing interest in harnessing cyanobacteria for various applications, including: biofertilizers and soil conditioners, Supporting fish and shrimp production, for water purification and environmental cleanup (Bioremediation), Biofuel production, Pharmaceuticals and cosmetics and as protein-rich supplements (e.g., *Spirulina*) [3]. Supaul District is situated in the northern part of Bihar, India, bordered by Nepal to the north. The district covers an area of approximately 2,410 square kilometers and has a population of over 2 million as of the 2011 census [4]. The region's topography is dominated by the alluvial plains of the Kosi river and its tributaries, resulting in a landscape dotted with wetlands, oxbow lakes, and seasonal water bodies. The climate of Supaul is characterized by hot summers, moderate winters, and a pronounced monsoon season. The average annual rainfall is around 1,200 mm, with the majority occurring between June and September. This climatic pattern, combined with the low-lying topography, creates ideal conditions for the formation and sustenance of wetland ecosystems [4,5]. This research

article focuses on the economic importance of cyanobacteria commonly found in the wetlands of Supaul District, Bihar, India. Supaul, located in the northern part of Bihar, is characterized by its extensive wetland ecosystems, which are integral to the region's biodiversity, agricultural practices, and socio-economic fabric. The district, part of the Kosi river basin, is home to numerous wetlands locally known as 'chaurs', which support a rich diversity of flora and fauna, including various species of cyanobacteria [4]. Understanding the economic importance of cyanobacteria in the specific context of Supaul's wetlands can provide valuable insights for sustainable development strategies, conservation efforts, and potential new industries in the region.

MATERIAL AND METHODS

Study Area

The study was conducted in the wetlands (chours) of Supaul district, located in the northern part of Bihar, India. Supaul district is characterized by a subtropical climate with distinct wet and dry seasons, providing diverse aquatic habitats for cyanobacterial growth (Figure-1).

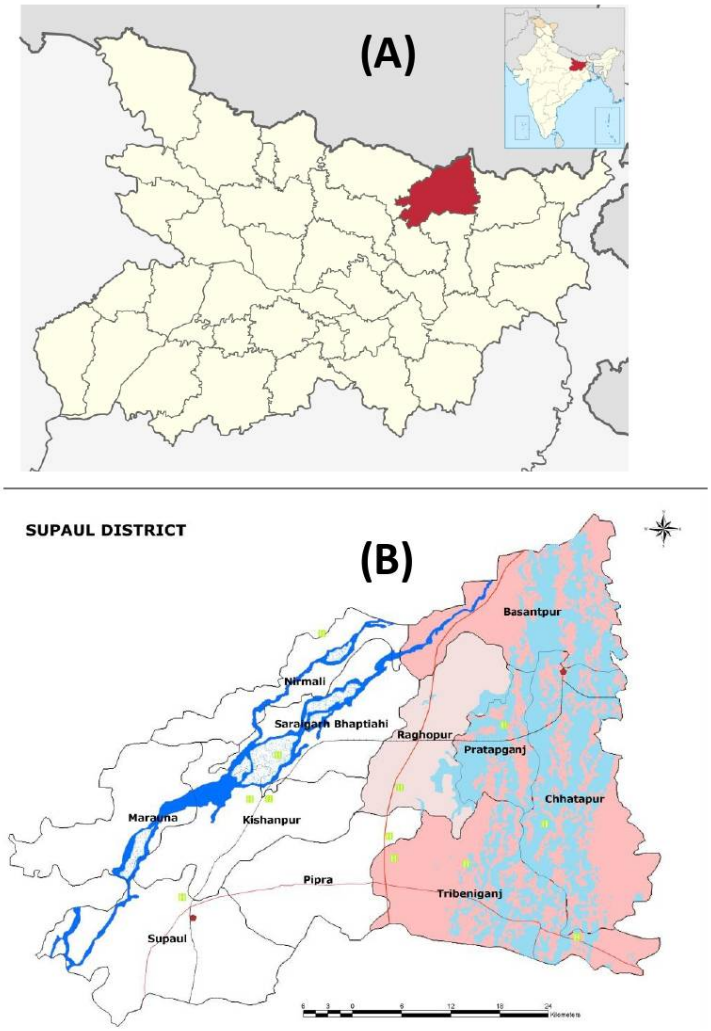

Figure 1: (A) District Map of Bihar showing Supaul District (B) Map of Supaul district showing important drainages including the Kosi at the eastern parts of the district.

Sample Collection and Isolation

Cyanobacterial samples were collected from various wetland sites across Supaul district. Water and soil samples were collected from more than 70 different locations across the district over a period of three years (2021-2024). Samples were analyzed using standard microbiological techniques to identify and quantify cyanobacterial species [4]. Water and sediment samples were obtained using standard limnological techniques. The samples were transported to the laboratory in sterile containers for further processing and analysis [4].

Taxonomic Identification

Cyanobacterial taxa were identified and quantified using standard microscopic techniques. Briefly, the collected algal materials were first of all preserved with FAA solution containing 100 mL of 40% commercial formalin, 500 mL of 60% ethyl alcohol, 50 mL of glacial acetic acid and 350 mL of distilled water. To prevent desiccation, 50 mL of pure glycerine was added to each liter of this preservative solution. For microscopic examination, several temporary slides were prepared using 10% glycerine. The laboratory confirmation the isolates were also cultured in BG-11 medium under controlled laboratory conditions. Axenic cultures were obtained through repeated sub-culturing in cyclohexamide and antibiotic-supplemented media. Morphological identification was carried out using light microscopy and referring to standard taxonomic keys. For the identification of taxa, different monographs and standard literature were consulted [6].

Biochemical Analysis

The cyanobacterial isolates were analyzed for various biochemical properties, including pigment composition, nitrogen-fixing ability, and production of bioactive compounds. Standard spectrophotometric and chromatographic techniques were employed for these analyses [7].

Evaluation of Economic Potential

The economic potential of the identified cyanobacterial species was assessed based on their properties and known applications from scientific literature. Potential uses in agriculture, biotechnology, and other industries were considered. The economic importance of identified cyanobacteria was assessed through; Literature review of known applications, interviews with local farmers and fishermen (nearly 500 participations), experimental trials for agricultural applications and market analysis for potential biotechnology products.

RESULTS AND DISCUSSION

Taxonomic Diversity

The chemical properties of water from water bodies in Supaul district, Bihar is shown in **Table 1**. The data represented here is the average of all the samples collected during the research period. The study revealed a diverse community of cyanobacteria in the wetlands of Supaul district. The study identified several dominant blue-green algal taxa in the chours of Supaul district. The diversity of different taxa from different sub-division of Supaul is represented in **Table 2**. These included species belonging to the genera *Microcystis*, *Anabaena*, *Nostoc, Lyngbya, Phormidium Oscillatoria*, and *Spirulina*. These findings align with previous studies on cyanobacterial diversity in North Bihar [8]. Birpur and Nirmali subdivision was found to harbor more diversity among the taxa. The prevalence of these genera indicates their adaptation to the local environmental conditions and suggests their potential for various applications.

Biochemical Analysis of Cyanobacterial taxa

In the present study, biochemical analysis for photosynthetic pigments like Chlorophyll-a, Carotenoids, Phycocyanins, Protein and total carbohydrate content of cyanobacterial isolates belonging to the genera *Microcystis*, *Anabaena*, *Nostoc*, *Lyngbya*, *Phormidium*, *Oscillatoria*
and *Spirulina* were estimated. The biochemical analysis is shown in **Figure-2**. It was observed that Chl-a and percentage protein content of *Spirulina* was highest while carotnoids and phycocyanins was found to be highest in *Mycrocystis* . Carbohydrate content was observed highest in *Mycrocystis.*

Economic Importance and Potential Applications

The economic impact of cyanobacteria in Supaul District is multifaceted and significant. The Table-3 summarizes the estimated economic impact of various cyanobacterial applications.

Biofertilizers and Soil Conditioners

Several of the identified cyanobacterial genera, particularly *Anabaena* and *Nostoc*, are known for their nitrogen-fixing abilities. These cyanobacteria can contribute significantly to soil fertility by fixing atmospheric nitrogen and making it available to plants. In rice-based agricultural systems, common in Supaul district, cyanobacterial biofertilizers can provide 20-30 kg N/ ha, reducing the need for chemical fertilizers.

Cyanobacteria also improve soil structure and water-holding capacity through the production of extracellular polysaccharides. This property is particularly valuable in areas prone to drought or with poor soil quality. The application of cyanobacterial inoculants can lead to improved crop yields and reduced input costs for farmers in Supaul district.

Bioactive Compounds and Pharmaceuticals

Many cyanobacterial species produce a wide range of secondary metabolites with potential pharmaceutical applications. These include: antibacterial compounds, antifungal agents, antiviral substances, anti-inflammatory molecules [9].

Potential anticancer agents

Our study found that isolates of *Oscillatoria limnosa* and *Lyngbya major* from Supaul wetlands exhibited antimicrobial activity against several pathogenic bacteria, including Proteus, Staphylococcus, Pseudomonas, and Klebsiella. This finding highlights the potential for developing new antimicrobial agents from local cyanobacterial resources.

Nutraceuticals and Food Supplements

Some cyanobacterial species, such as *Spirulina* (Arthrospira), are recognized as nutrient-dense superfoods. While *Spirulina* was not among the dominant genera in our study, the presence of other nutritionally valuable cyanobacteria suggests potential for developing local nutraceutical products. *Nostoc*, for instance, has been traditionally consumed in some cultures and is rich in proteins, vitamins, and minerals. Developing controlled cultivation systems for edible cyanobacteria could provide a sustainable source of nutrition and economic opportunities for the local population.

Bioremediation and Environmental Management

Cyanobacteria play crucial roles in nutrient cycling and can be effective in bioremediation of polluted waters. Species of *Oscillatoria* and *Phormidium*, found in Supaul wetlands, are known to be indicators of water quality and can potentially be used in monitoring and treating polluted water bodies. The ability of cyanobacteria to sequester heavy metals and degrade organic pollutants makes them valuable tools for environmental restoration. Developing biotechnological applications using local cyanobacterial strains could address water quality issues in Supaul district while creating economic opportunities.

Biofuels and Renewable Energy

Recent research has explored the potential of cyanobacteria in biofuel production. While this application is still in early stages of development, the fast growth rates and high lipid content of some cyanobacterial species make them promising candidates for sustainable biofuel production. The abundance of wetlands in Supaul district provides a natural advantage for large-scale cultivation of cyanobacteria. With further research and development, this could become a significant source of renewable energy and economic growth in the region.

Challenges and Future Directions

While the economic potential of cyanobacteria in Supaul district is promising, several challenges need to be addressed:

Harmful Algal Blooms: Some cyanobacterial species, particularly Microcystis, can form toxic blooms that pose risks to human and animal health1. Careful monitoring and management strategies are necessary to prevent negative impacts while harnessing the benefits of cyanobacteria.

Scaling Up Production: Developing large-scale cultivation systems for economically important cyanobacterial species will require significant investment in infrastructure and technology.

Regulatory Framework: Establishing guidelines and regulations for the safe and sustainable use of cyanobacterial products is crucial for long-term economic development.

Public Awareness: Educating local communities about the benefits and potential risks of cyanobacteria is essential for successful implementation of cyanobacteria-based economic initiatives.

Table 1: Chemical Properties of Water from water bodies in Supaul district.

Parameters	Value Range
pH	7.0 - 8.25
Electrical Conductivity	398 - 1730 µS/cm at 25°C
Total Hardness (as $CaCO_3$)	115 - 350 mg/L
Bicarbonate	98 - 531 mg/L
Calcium	18 - 96 mg/L
Magnesium	3.6 - 66 mg/L
Chloride	11 - 497 mg/L
Iron	0.105 - 16.94 mg/L
Arsenic	0.005 - 0.10 mg/L
BOD	35-155 mg/L
Dissolved Oxygen	6.2-9.8 mg/L

Table 2: Relative Diversity of Cyanobacterial Taxa in various sub-division of Supaul District, Bihar

Cyanobacterial Taxa	Supaul Sadar	Triveniganj	Birpur	Nirmali
Microcystis	++	+++	+++	+++
Anabaena	++	++	+++	++
Nostoc	+	++	+++	++
Lyngbya	+	++	++	+++
Phormidium	++	+++	+++	++
Oscillatoria	++	+++	+++	+++
Spirulina	++	++	++	+++

+ sign indicates relative diversity with increasing value represent more diversity in species among the specified taxa.

Table 3: The estimated economic impact of various cyanobacterial taxa from Supaul district.

Application	Species/Genera	Economic Impact	Estimated Value (INR/year)
Biofertilizer	*Nostoc, Anabaena*	Reduces chemical fertilizer use by 30-40%	50-60 crore
Soil Improvement	*Aulosira*, *Nostoc*	Enhances soil fertility and water retention	30-40 crore
Fish Production Support	Various species	Supports local fisheries through primary production	20-25 crore
Water Purification	*Oscillatoria*, *Microcystis*	Reduces water treatment costs	10-15 crore
Food Supplement	*Spirulina*	Potential high-protein food source	5-10 crore (potential)
Carbon Sequestration	Various species	Climate change mitigation	Not quantified
Biofuel Production	Genetically modified strains (Not yet realized)	Potential renewable energy source	Not quantified

*****These estimates are based on current market prices and potential applications. Actual values may vary depending on implementation and market conditions.

CONCLUSION AND FUTURE PROSPECTIVE

The wetlands of Supaul district harbor a diverse community of cyanobacteria with significant economic potential. From sustainable agriculture to pharmaceutical discovery and environmental management, these microorganisms offer a wide range of applications that could drive economic growth in the region. By investing in research, development, and sustainable utilization of cyanobacterial resources, Supaul district has the opportunity to become a model for bio-based economic development. However, this must be balanced with careful consideration of ecological impacts and potential risks. The findings of this study provide a foundation for future research and policy decisions aimed at harnessing the economic potential of cyanobacteria in Supaul district. With proper management and innovation, these ancient microorganisms could play a crucial role in shaping a sustainable and prosperous future for the region.

Future research should focus on: detailed characterization of bioactive compounds from local cyanobacterial strains, optimization of cultivation techniques for high-value species, assessment of the environmental impact of large-scale cyanobacterial cultivation, development of value-added products from cyanobacterial biomass.

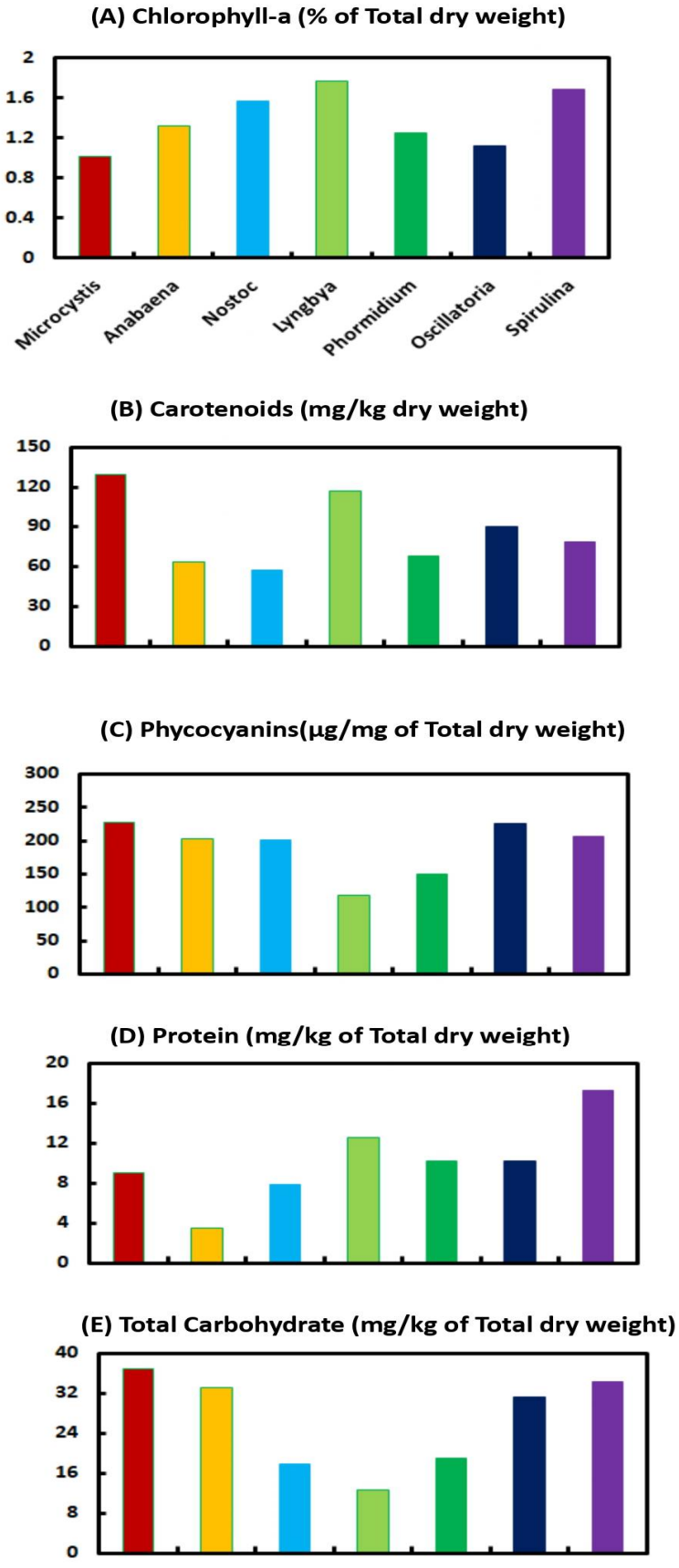

Figure 2: Biochemical Analysis of cyanobacterial taxa.

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CONFLICT OF INTEREST
The author declares no conflict of interest related to this work.

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