International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Diversity and Distribution of Cyanobacterial Strains in Paddy Field Ecosystems of Kaushambi District, Uttar Pradesh, India

Sweety Sahu[1], Kirti Raje Singh[2]

[1]Department of Botany, C.M.P. Degree College, Prayagraj, Uttar Pradesh, India
Email: *sweetysahu326[at]gmail.com*

[2]Department of Botany, C.M.P. Degree College, Prayagraj, Uttar Pradesh, India
Email: *dr.kirtiraje[at]gmail.com*

Abstract: ***Cyanobacteria are the essential part of rice field ecosystems because they have the capability of nitrogen fixation, though they play a major role in soil fertility. The present study showed the survey of different rice fields of the Kaushambi district of U.P. and discussed the different strains of blue-green algae that were found in these rice fields. In this study algal samples were collected from eight different sites of rice fields. These samples were isolated in the laboratory and identified as 12 different forms of Cyanobacteria that include both heterocystous and non-heterocystous forms. There was no dominant genus. Quantitative analysis showed an almost perfect evenness (Pielou's J = 0.987) and high community diversity (Shannon–Wiener H' = 2.45). The most common genera were Nostoc, Gloeotrichia and Nodularia (87.5% of sites) and the most restricted Gloeocapsa (37.5%). Chi-square goodness-of-fit tests showed no statistically significant heterogeneity of species occurrence ($\chi^2 = 4.12$, df = 11, $P > 0.05$) and site richness ($\chi^2 = 1.30$, df = 7, $P > 0.05$) across sites, indicating the cyanobacterial flora of the surveyed paddy field agroecosystem was basically homogenous and well adapted. Jaccard similarity analysis also identified an ecological cluster between Koodapur, Nizampur Puraini and Jankipur. The dominance of nitrogen-fixing, heterocystous species is indicative of the ecological suitability of rice-field habitats for cyanobacterial growth and their potential use as environmentally friendly biofertilizer's in sustainable agriculture.***

Keywords: Biofertilizer, Cyanobacteria; Diversity indices, Kaushambi district; Rice fields

1. Introduction

According to Researchers rice fields aquatic-terrestrial habitat is very importance because cyanobacteria are found in this ecosystem that has the capability to fix atmospheric nitrogen [(3)], accumulating organic matter, and secreting growth-promoting compounds, Cyanobacteria which is also called as blue-green algae play a significant part in preserving soil fertility [(10)]

In Indian rice fields Cyanobacteria such as *Nostoc, Anabaena* are frequently found that greatly increase agricultural production. [(18).] Cyanobacteria have a specialised cell called as heterocyst which is the site of nitrogen fixation therefore heterocystous forms are of especially significant [(16).] These organisms enhance soil texture, and boost nutrient availability. [(5)]

The cyanobacterial diversity has been documented from Indian paddy fields such as Prayagraj, Varanasi, Bihar, and Tamil Nadu [(6).] Thus, the current study was conducted to examine the variety and distribution of cyanobacterial strains in the soils of rice fields in the Kaushambi district.

2. Materials and Methods

Study Area

The present investigation was carried out using cyanobacterial samples collected from rice fields of Kaushambi district, Uttar Pradesh, India.

Collection of Samples

Cyanobacterial samples were collected from rice fields using sterile spatulas and forceps. The visible algal mats along with moist soil were transferred into sterile polyethylene bags and properly labeled with date, site number, and locality name. Samples were brought to the laboratory in an ice box and processed immediately for isolation and purification. Environmental parameters such as temperature, pH, moisture, and waterlogged conditions of the sampling sites were noted during collection.

Isolation and Culture

Isolation and purification of cyanobacterial strains were carried out by the serial dilution method and microscopic examination. The purpose of isolation was to obtain pure, uncontaminated, and unialgal cultures of cyanobacteria from rice field samples collected from Kaushambi district.

The isolates samples were cultivated in BG- 11 [(16)] growth media. For the purpose of morphological observations, individual Cyanobacterial colonies were separated and kept as mother cultures.

Identification of Samples

Identification was done based on morphological and microscopic traits such trichome structure, heterocyst development, akinete presence, branching pattern, and colony morphology [(2),(4), (7)]

Results (Statistical analysis)

In the present study total eleven Cyanobacterial strains were identified which were collected from various rice field locations in the Kaushambi district (U.P.). There were both heterocystous and non-heterocystous types are mention in table -1

Table 1: List of Algal strains found in the different sites of Rice fields of Kaushambi district, Uttar Pradesh, India

Serial No.	Strain	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
1.	*Nostoc*	+	+	+	+	+	+	-	+
2.	*Anabaena*	+	+	-	+	+	-	+	
3.	*Cylindropsermum*	-	-	+	-	+	+	+	+
4.	*Aulosira*	-	+	+	-	+	+	+	+
6.	*Gleocapsa*	+	-	-	-	+	+		-
6.	*Gloeotrichia*	+	+	+	+	+	-	+	+
7.	*Tolypothrix*	+	-	-	+		+		+
8.	*Microcoleus*	+	-	+	-	+	-	+	+
9.	*Rivularia*	-	+	-	+		+		+
10.	*Nodularia*	+	-	+	+	+	+	+	+
11.	*Scytonema*	+	-	-	+	+	-	-	+

(S1 = Manauri, S2 = Sayyed Sarawan, S3 = Jankipur, S4 = Chilla Shahbazi, S5 = Koodapur, S6 = Ratgahan Mohiddinpur, S7 = Janke, S8 = Nizampur Puraini.)

Table 2: Frequency of occurrence and Raunkiaer's frequency class of cyanobacterial taxa

S. No.	Strains	Sites Present	Frequency	Class
1.	*Nostoc*	7/8	87.5	E
2.	*Gloeotrichia*	7/8	87.5	E
3.	*Nodularia*	7/8	87.5	E
4.	*Aulosira*	6/8	75.0	D
5.	*Anabaena*	5/8	62.5	D
6.	*Cylindropermum*	5/8	62.5	D
7.	*Microcoleus*	5/8	62.5	D
8.	*Tolypothrix*	4/8	50.0	C
9.	*Rivularia*	4/8	50.0	C
10.	*Scytonema*	4/8	50.0	C
11.	*Gleocapsa*	3/8	37.5	B

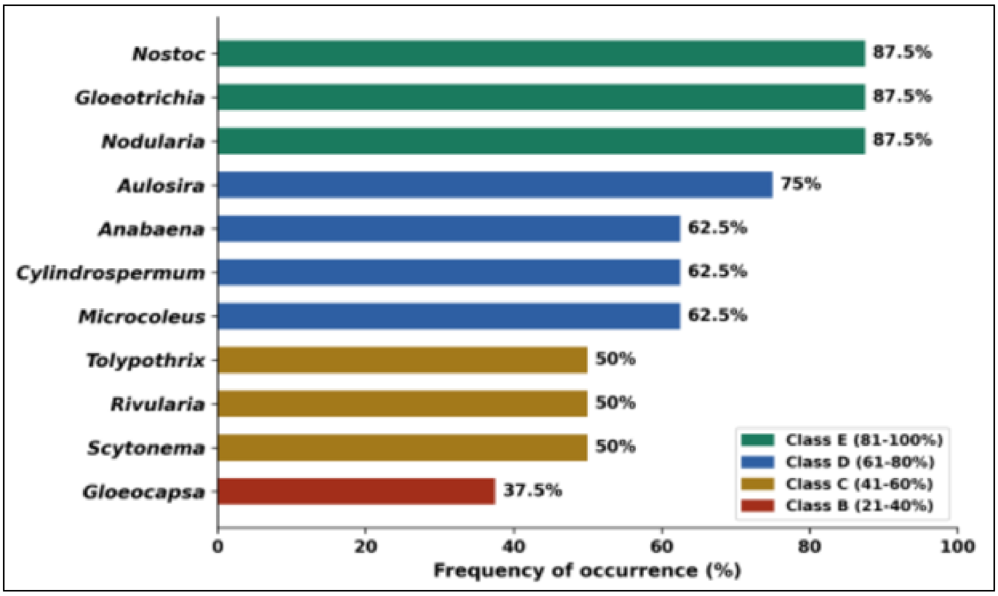

Figure 1: Frequency of occurrence (%) of cyanobacterial taxa across the eight study sites, shaded by Raunkiaer frequency class (B–E)

Table 3: Cyanobacterial species richness recorded at each study site

S. No.	Site	Location	Richness (no. of taxa)
1.	S1	Manauri	8
2.	S2	Sayyed Sarawan	6
3.	S3	Jankipur	6
4.	S4	Chilla Shahbazi	8
5.	S5	Koodapur	9
6.	S6	Ratgahan Mohiddinpur	8
7.	S7	Janke	7
8.	S8	Nizampur Puraini	9

Mean richness = 7.63 ± 1.19 (SD); range = 6–9 taxa per site.

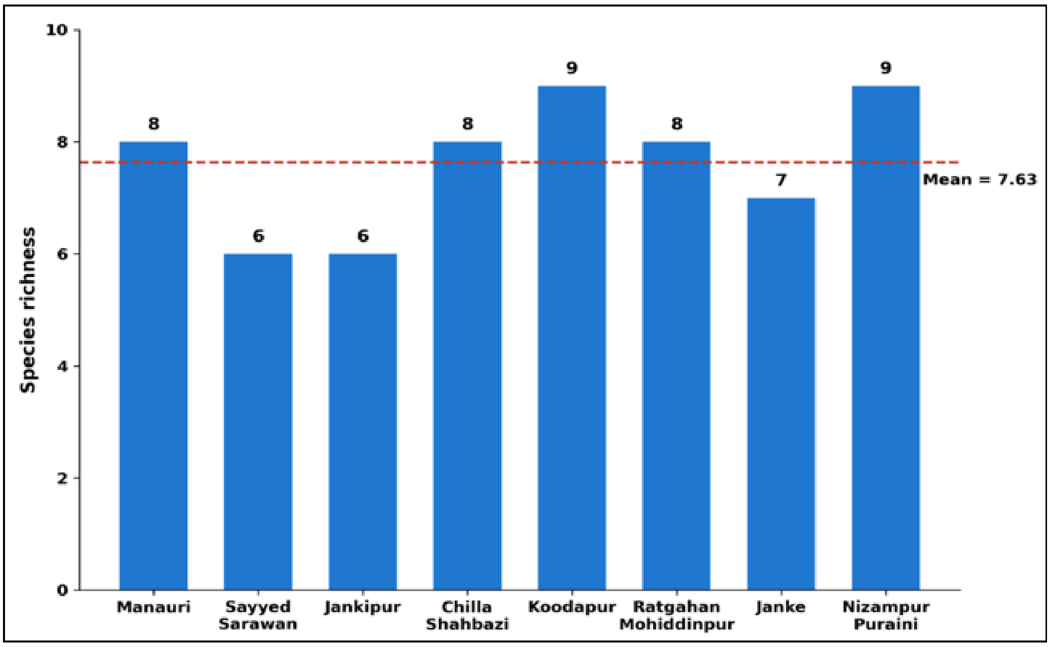

Figure 2: Cyanobacterial species richness at the eight rice-field sites of Kaushambi district. Dashed line indicates mean richness (7.63)

Table 4: Community diversity indices for cyanobacterial taxa in the rice fields of Kaushambi district

S. No.	Index	Value	Interpretation
1.	Shannon–Wiener (H′)	2.45	High diversity (H max = ln 12 = 2.48)
2.	Pielou's evenness (J)	0.987	Near-perfect evenness; no dominant taxon
3.	Simpson's index (D)	0.089	Low dominance
4.	Simpson's diversity (1−D)	0.911	High diversity
5.	Simpson's reciprocal (1/D)	11.2	≈ effective no. of equally common taxa

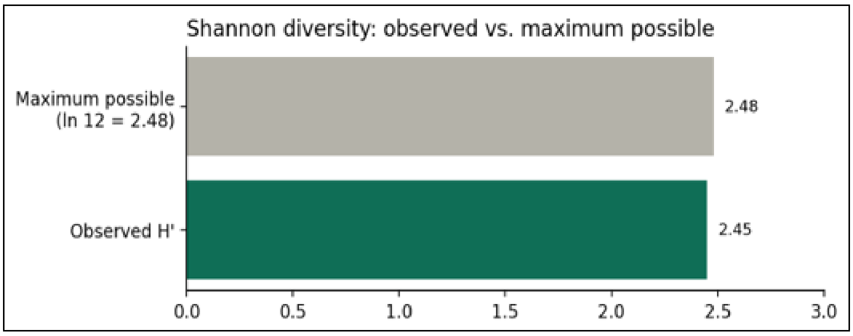

Figure 3: Observed Shannon–Wiener diversity (H′ = 2.45) compared with the theoretical maximum for twelve equally common taxa (ln 12 = 2.48)

Chi-square goodness-of-fit tests - Inter-site similarity (Jaccard index)

Table 5: Jaccard similarity coefficients between pairs of study sites

	S2	S3	S4	S5	S6	S7	S8
S1	0.27	0.40	0.60	0.70	0.33	0.36	0.55
S2	—	0.33	0.56	0.36	0.40	0.44	0.36
S3		—	0.27	0.67	0.27	0.63	0.67
S4			—	0.42	0.45	0.36	0.55
S5				—	0.42	0.60	0.64
S6					—	0.36	0.55
S7						—	0.45

Paper ID: SR26909041706 DOI: https://dx.doi.org/10.21275/SR26909041706

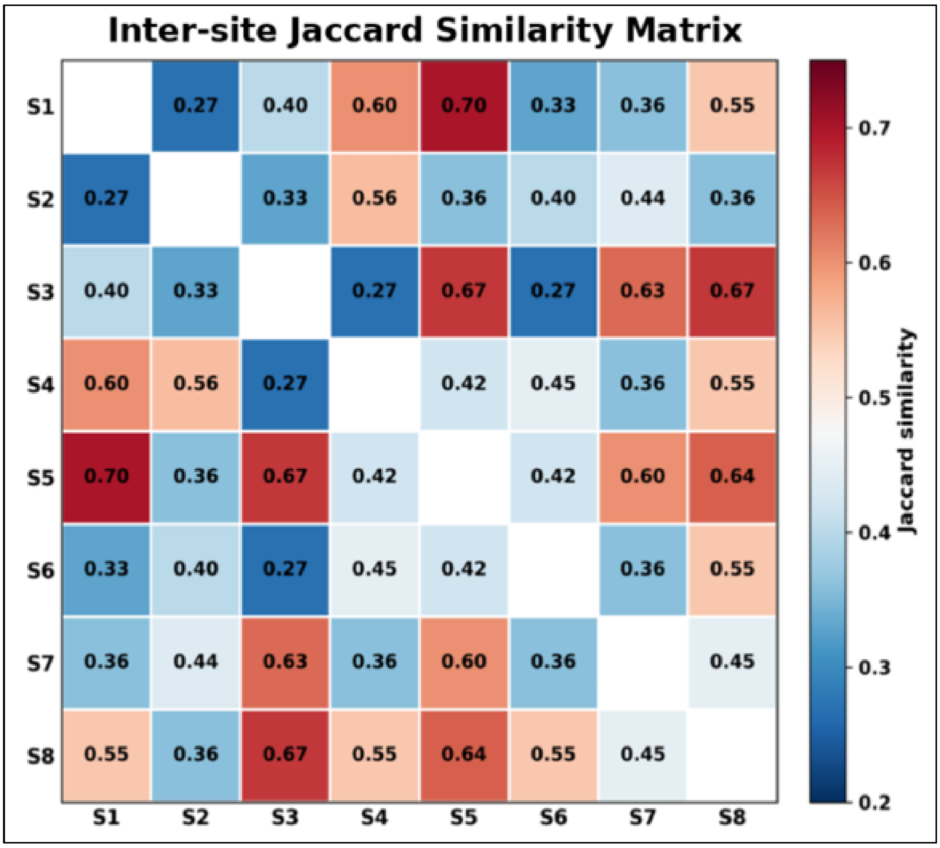

Figure 4: Heatmap of inter-site Jaccard similarity coefficients; darker shading indicates greater similarity in cyanobacterial species composition

3. Discussion

In the present study it was found that a wide variety of cyanobacterial strains was present in the rice fields of Kaushambi district of Uttar Pradesh. A total of twelve cyanobacterial strains were recorded from eight sampling sites, indicating that rice-field ecosystems provide ecologically favourable conditions for the growth and proliferation of cyanobacteria [11] The existence of heterocystous and non-heterocystous forms indicates the structural and functional diversity of paddy fields with high organic input, varying light and nutrient conditions and frequent flooding that are conducive to diverse cyanobacterial flora. [3].

Species in the highest frequency class (E) of Raunkiaer reported were *Nostoc, Gloeotrichia* and *Nodularia*. *Nostoc* was recorded in seven of the eight sites (87.5%) and had the widest distribution of all documented species. The broad distribution of *Nostoc* fits well with its well-documented physiological plasticity, which enables it to colonise a variety of microhabitats more successfully than less tolerant genera because of its ability to form akinetes, tolerate desiccation by means of mucilage, and adapt to a wide range of soil moisture, pH and nutrient regimes. [18]. Heterocystous taxa, like *Anabaena*, *Cylindrospermum*, *Aulosira*, and *Gloeotrichia*, are able to obtain atmospheric nitrogen via special heterocyst cells [16]. Besides, they had a wide distribution (classes D-E). The nitrogen-fixing activity in these rice fields is widely distributed in the cultivated landscape rather than concentrated in a few dominant species or isolated patches, as indicated by the consistent occurrence in most sites and the extremely low Simpson dominance value ($D = 0.089$) obtained in this study. This pattern, in turn, directly affects the potential for in situ biofertilisation of the district as opposed to only a few suitable sites.

The most restricted taxon was the non-heterocystous coccoid form *Gloeocapsa* (Class B, 37.5%), while *Scytonema, Rivularia, Tolypothrix* and the morphologically different *Anabaena sp.* 2 were found in an intermediate frequency class (C, 50%). Compared to the widely tolerant *Nostoc–Anabaena* group, these taxa may be more vulnerable to finer-scale variations in soil texture, water retention, organic matter content, and light penetration among sites (Pandey and Tiwari, 2007). The co-occurrence of *Microcoleus* with *Gloeocapsa* suggests that other non-heterocystous, non-nitrogen fixing forms also maintain a constant, though more limited, presence in this ecosystem, where they probably contribute to the turnover of organic matter and soil surface stabilisation rather than to nitrogen input (Fogg *et al*., 1973).

This image of a non-skewed, diverse cyanobacterial assemblage is supported by community-level indicators. Pielou's evenness ($J = 0.987$) was close to 1 overall, indicating an assemblage with almost no dominant genus. The Shannon-Wiener diversity value ($H' = 2.45$) was close to the theoretical maximum for twelve equally abundant species ($H\ max = 2.48$). Statistical support for these findings was provided by non-significant chi-square goodness-of-fit results for species occurrence ($\chi^2 = 4.12$, $df = 11$, $P > 0.05$) and site richness ($\chi^2 = 1.30$, $df = 7$, $P > 0.05$), suggesting that neither specific taxa nor specific sites deviated significantly from a uniform pattern of distribution. Over all these results suggest a fairly homogenous cyanobacterial flora that is more influenced by general regional agroclimatic and irrigation conditions typical of smallholder paddy agriculture than by specific, site-specific environmental filtration.

Nevertheless, behind this general homogeneity, finer-scale structure was found using the Jaccard similarity analysis. A loosely defined cluster of sites that were similar to each other was formed by Koodapur, Nizampur Puraini, and Jankipur (J = 0.63–0.67). This suggests that these sites may share similar local soil or hydrological characteristics, such as water retention capacity, organic carbon content or cropping history that may favour a more closely matched cyanobacterial assemblage. In contrast, site pairs such as Manauri–Sayyed Sarawan and Jankipur–Chilla Shahbazi/Ratgahan Mohiddinpur were clearly less similar (J = 0.27), suggesting that localised edaphic or management differences could still result in compositional divergence that merits further investigation through targeted soil physico-chemical analysis.

These results are in line with previous reports on cyanobacterial diversity in Indian paddy fields, where heterocystous, nitrogen-fixing genera have been found to predominate due to their agronomic significance and close ecological coupling to the flooded-soil habitat [10] [15]. In addition to providing a quantitative ecological framework for the first time in this region – frequency classes, diversity indices, significance testing, and similarity clustering – the current study expands this body of work to a previously uncharacterised district and advances the assessment beyond simple presence/absence reporting towards a statistically supported characterisation of community structure.

4. Conclusion

The current study shows that the cyanobacterial diversity in the rice fields of Uttar Pradesh's Kaushambi district is abundant and statistically well-distributed. Across eight sampling sites, twelve cyanobacterial taxa were identified. The most common and ubiquitous members of the community were heterocystous, nitrogen-fixing genera of the order Nostocales, including *Nostoc, Gloeotrichia, Nodularia, Anabaena,* and *Cylindrospermum.* The conclusion that this community is a generally homogeneous, well-adapted cyanobacterial flora throughout the surveyed paddy-field agroecosystem rather than one driven by a few dominant species or isolated hotspots was supported by quantitative analysis, which confirmed high overall diversity (H′ = 2.45) and near-perfect evenness (J = 0.987). Chi-square tests also revealed no statistically significant heterogeneity in either taxon occurrence or site richness.

In this rice-growing district heterocystous cyanobacteria, which are nitrogen fixing, are consistently dominant in almost all sites indicating their important role in maintaining and possibly enhancing soil fertility and their suitability for low-cost, environment-friendly biofertilizer applications in Kaushambi district and similar rice-growing areas of Uttar Pradesh; future studies should include soil physicochemical parameters, seasonal sampling in multiple cropping cycles, and physiological or molecular characterisation of the dominant isolates, especially in relation to their applications. Future studies should include soil physicochemical parameters, seasonal sampling over more than one cropping cycle, physiological or molecular characterisation of the dominant isolates, especially in the context of their applications in the Kaushambi district and other similar rice-growing areas of the state of Uttar Pradesh. Additional research is needed to include soil physico-chemical parameters, seasonal sampling over several cropping cycles and physiological or molecular characterisation of candidates for sustainable agriculture [17]. Future research incorporating soil physicochemical parameters, seasonal sampling across multiple cropping cycles and physiological or molecular characterisation of the dominant isolates especially *Nostoc* and *Anabaena* strains are needed to transform these descriptive and statistical findings into useful recommendations for selection of effective locally adapted cyanobacterial strains for large scale biofertilizer applications in Kaushambi district and similar rice growing regions of Uttar Pradesh.

References

[1] APHA (1998). *Standard methods for the examination of water and wastewater* (20th ed.). American Public Health Association

[2] Desikachary, T. V. (1959). *Cyanophyta*. Indian Council of Agricultural Research.

[3] Fogg, G. E., Stewart, W. D. P., Fay, P., & Walsby, A. E. (1973). *The blue-green algae*. Academic Press.

[4] Geitler, L. 1932. *Cyanophyceae*. In: Rabenhorst's *Kryptogamen-Flora von Deutschland, Österreich und der Schweiz*, Vol. 14. Akademische Verlagsgesellschaft, Leipzig.

[5] Jaccard, P. (1908). Nouvelles recherches sur la distribution florale. *Bulletin de la Société Vaudoise des Sciences Naturelles, 44*, 223–270.

[6] Kaushik, B. D. (1994). Algalization of rice in salt-affected soils. *Annals of Agricultural Research, 15*, 105–108.

[7] Komárek, J. & Anagnostidis, K. 2005. *Cyanoprokaryota. 2. Teil: Oscillatoriales*. In: Büdel, B., Gärtner, G., Krienitz, L. & Schagerl, M. (eds), *Süßwasserflora von Mitteleuropa*, Vol. 19/2. Elsevier/Spektrum Akademischer Verlag, Munich.

[8] Pandey, U., & Tiwari, S. K. (2007). Diversity of blue-green algae in paddy fields of eastern Uttar Pradesh. *Journal of Phytological Research, 20*, 271–274.

[9] Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology, 13*, 131–144.

[10] Prescott, G. W. (1962). *Algae of the western Great Lakes area*. W.M.C. Brown Co.

[11] Raunkiaer, C. (1934). *The life forms of plants and statistical plant geography*. Clarendon Press.

[12] Roger, P. A., & Kulasooriya, S. A. (1980). *Blue-green algae and rice*. International Rice Research Institute.

[13] Roger, P. A., & Reynaud, P. A. (1982). Free-living blue-green algae in tropical soils. In Y. R. Dommergues & H. G. Diem (Eds.), *Microbiology of tropical soils and plant productivity* (pp. 147–168). Martinus Nijhoff Publishers.

[14] Shannon, C. E. (1948). A mathematical theory of

[15] -Bazire, G., (1971). Purification and properties of unicellular blue-green algae (Order communication. *The Bell System Technical Journal, 27*, 379–423.

[16] Simpson, E. H. (1949). Measurement of diversity. *Nature, 163*, 688.
[17] Singh, R. N. (1961). *Role of blue-green algae in nitrogen economy of Indian agriculture*. Indian Council of Agricultural Research.
[18] Singh, S. P., & Singh, J. S. (1989). Distribution of blue-green algae in rice fields of eastern Uttar Pradesh, India. *Phykos, 28*, 153–159.
[19] Stanier, R. Y., Kunisawa, R., Mandel, M., and Cohen Chroococcales). **Bact. Rev**., 35: 171-205.
[20] Venkataraman, G. S. (1972). *Algal biofertilizers and rice cultivation*. Today and Tomorrow's Printers and Publishers.
[21] Venkataraman, G. S. (1981). *Blue-green algae for rice production — A manual for its promotion* (FAO Soils Bulletin No. 46). FAO.