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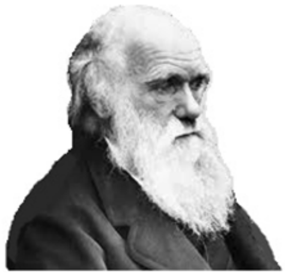

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Cyanobacterial species Biodiversity in Mahasamund district of Chhattisgarh region, India

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ABSTRACT

Rice is the principal crop of the Chhattisgarh State. It covers 66% of all cultivable land and is mostly grown within the kharif cropping season. To increase sustained productivity without decreasing soil quality, algal bio-fertilizers are widely used in the State. Hence, the culture of cyanobacterial bio-fertilizers has been started on a regional basis. This includes survey, isolation and screening of stress-tolerant cyanobacteria. Thus, this study concerns the characterization of physical and chemical properties of soil collected from Mahasamund districts of Chhattisgarh state with respect to the bio-diversity of cyanobacteria.

***Keywords*:** Cyanobacterial screening, Physicochemical properties of soil, Rice fields

1. INTRODUCTION

Cyanobacteria (Blue-green algae) are large group of phototrophic microorganisms with highly variable morphological futures. For long time, mainly morphological characteristics were taken into account for a taxonomical classification of cyanobacteria (Rippka *et al*., 1979, Schopf, 2000). Cyanobacteria comprise one of the major eubacterial lineages. The diversity within a lineage, including both that of morphology (single cells, branching filaments, akinets, etc.) and physiology (nitrogen fixation, heterotrophy, motility, etc.) has fascinated microbiologists (Bryant, 1994). They are one of the dominant genera in various ecological habitats, especially in rice fields, where they are found as both free-living and symbiotic with the water fern, *Azolla*.

Morphology, developmental and biochemical parameters may vary with environmental or culture conditions. They can be classified on the basis of morphology, cellular differentiation, and biochemical, physiological and genetic criteria.

The role of cyanobacteria as biological inputs in agriculture has been well documented and substantiated, has been reported that cyanobacterial inoculation was equally effective for the high yielding dwarf rice (*Oriza sativa* L.) varieties under high fertility. Cyanobacteria also occupy a variety of terrestrial environments. Soil is one of the most potential habitats for cyanobacterial growth, particularly in moist or waterlogged conditions. They play a significant role in maintaining soil fertility and in soil reclamation (Singh, 1961, Watanabe, 1962, Venkataraman, 1975, 1981, Venkataraman *et al*., 1974 and Watanabe, and Yamamoto, 1970).

2. MATERIAL AND METHOD

All investigations in the soils of paddy fields were performed in the five sites of Mahasamund district. Soil samples of paddy fields were collected randomly from Basana, Bagbahra, Mahasamund, and Saraipali region of Chhattisgarh state. Soil samples from paddy fields were collected in kharif cropping season. The soils were contained fertilizers which were used by the farmers. The paddy fields of Mahasamund district were divided into 5 different sites:

Site Number	Name of site
1	Basana
2	Bagbahra
3	Mahasamund
4	Pithora
5	Saraipali

Identification of Cyanobacteria

The samplings were done randomly from soil of the paddy fields. Temporary slides were prepared for each sample for identification. The strains were identified based on their morphological features and cell structure following the monograph of Desikachary (1959) and Anand (1989). The collected samples were maintained by culturing in freshly prepared modified Chu-10 medium (Gerloff *et al*., 1950).

Physico-Chemical Analysis of Soil

The soil is a porous mixture of inorganic particles, organic matter, air and water. This mixture contains a large variety of living organisms. The soil environment is influenced by several factors including geological, physico-chemical and biological properties of the soil, climate and human activities prevailing in that area. Soil analysis includes soil type and analysis for different physico-chemical properties of the soil. A number of physico-chemical properties such as pH and electrical conductivity were analyzed from different sites of paddy fields.

a. Determination of pH: pH of the soil samples were determined by pH meter. The above study has been done using the procedure as follows: 10 g of soil was dissolved in 25 ml of distilled water. Suspension was shaken for 30 minutes, pH meter was calibrated by using buffer solutions of pH 4.0 and 7.0. The electrode was dipped in soil-water suspension. The reading was measured in triplicate.

b. Determination of Electrical Conductivity: Electrical conductivity was measured by conductivity meter. The electrical conductivity has been calculated by using the procedure 1:2 soil water/ soil water suspension was prepared by dissolving 10 g of soil in 20 ml distilled water. Suspension was shaken for 30 minutes. The conductivity cell was dipped in soil water suspension. The galvanometer of conductivity meter was balanced and the conductance of soil solution was measured.

3. RESULTS AND DISCUSSION

Cyanobacteria, as natural biofertilizer, by maintaining the soil fertility, are increasing rice growth and the yield is well established fact (Rai 2006). In the present study, rich diversity of cyanobacteria were recorded from all the study sites. The occurrence of cyanobacteria in the rice fields may be attributable to favorable environment with respect to their requirement for light, water, high temperature and nutrient availability, which is in confirmation with the earlier finding (Konda and Yasuda 2003).

Several reports are available on the geographic regional distribution and the role of cyanobacteria in tropical rice fields (Singh 1961, Venkataraman 1981, Sharma and Naik 1996 and 1998, Devi, 1997, Anand and Hooper, 2005, Bhakta *et al*., 2006, Dey and Bastia 2008, Digambar *et al*., 2008, Prasanna *et al*., 2009, Shrivastava *et al*., 2009, and Bajpa 2013, but their abundance and diversity vis-à-vis diverse rice ecologies is a relatively less explored area.

The various forms recorded from different study sites are listed in **Tables 2**, **3**, **4**, **5**, and **6**. The present investigation showed the predominance of non-heterocystous forms at all the study sites (**Table 1**).

However, Nayak and Prasanna (2007) recorded more heterocystous forms while studying cyanobacterial abundance and diversity in rice field soils of India. Generally, cyanobacteria form heterocysts during unfavorable environment and nutrient deficiency. The abundance of non-heterocystous forms indicates suitable environmental conditions for their growth.

Soil pH

The pH determines the solubility of CO_2 and minerals in the medium and directly or indirectly influences the metabolism of cyanobacteria. Micronutrient availability is pH dependent. The pH of sites 1, 4, and 5 are almost same (Table 1), where as acidic to neutral pH range is 5.0-7.1. Site 2 and site 3 have been shown pH as an acidic to alkaline (5.7-7.5). Among different physico-chemical properties, pH is important in determining growth, establishment and diversity of cyanobacterial flora, which has generally been reported to prefer neutral to slightly alkaline (Roger and Kulasooriya, 1980).

In our study, a high positive correlation is observed between the soil pH (pH = 5.0-7.5) and cyanobacterial population, mostly non-heterocystous forms and contradicts that heterocystous forms were reported to be more abundant at alkaline pH (Nayak and Prasanna, 2007) (Table 1). In the present study, maximum heterocystous forms (total 8) were recorded from site 1, where the soil showed acidic pH, followed by site-2 and site-4 which showed acidic to alkaline (5.7-7.5) and acidic to almost neutral pH (5.0-7.1), respectively (Table 1).

Electrical Conductivity

The conductivity values for different soil samples from site 1-5 were in the range of 0.062-0.692 m mho/cm (Table 1). The value is within the permissible limits. The conductivity values helped to improve cyanobacterial growth, where electrical conductivity grows above 2 m mhos/cm; then soil became salty in nature due to the presence of ions, like metals, which allow the electric current to pass through them. A positive correlation has been observed between conductivity and cyanobacterial population (Table 1). Such finding indicates the ubiquitous distribution of cyanobacteria in natural environment.

Table 1. Distribution pattern of cyanobacterial species in rice field soils of Mahasamund district.

Name of site	**No. of soil sample studied**	**Soil pH**	**Soil conductivity**	**No. of cyanobacteria forms recorded**				
				Unicellular	**Non hetro filamentous**	**Hetro. filamentous**	**Total species**	**Hetrocystous sp.**
Basana	8	5.1-6.8	0.070-0.444	07	36	08	51	08
Bagbahra	8	5.7-7.5	0.166-0.692	04	32	07	43	07
Mahasamund	8	6.3-7.5	0.254-0.678	01	24	03	28	06
Pithaura	8	5.0-7.1	0.062-0.526	02	26	06	34	04
Saraipali	8	5.3-7.1	0.098-0.502	04	28	03	35	04

Table 2. Cyanobacterial species recorded from Basana (Site - 1).

S. No.	Unicellular form	S. No.	Non heterocystous filamentous form	S. No.	Heterocystous filamentous form
	Genus *Chrococcus*		**Genus *Oscillatoria***		**Genus *Nostoc***
		1.	*O. amoena*		
1.	*C. minutus*	2.	*O. anguina*	1.	*N. linekia*
2.	*C. turgidus*	3.	*O. animalis*	2.	*N. spongiformae var. tenue*
Genus *Aphanocapsa*		4.	*O. chilkensis*		**Genus *Aulosira***
		5.	*O. claricentrosa*		
3.	*A. montana*	6.	*O. earlei*	3.	*A. laxa*
4.	*A. roseana*	7.	*O. foreaui*		**Genus *Camptylonemopsis***
5.	*A. thermalis*	8.	*O. formosa*	4.	*C. lahorensis*
	Genus *Aphanthece*	9.	*O. fremyii*		**Genus *Tolypothrix***
6.	*A. naegelii*	10.	*O. grunowina*	5.	*T. byssoidea*
	Genus *Synechoccus*	11.	*O. jasorvensis*		**Genus *Microchaete***
7.	*S. cedrorum*	12.	*O. late-virens*	6.	*M. tenera*
		13.	*O. loktakensis*		**Genus *Calothrix***
		14.	*O. minnesotensis*	7.	*C. marchica var. bravifilamentosa*
		15.	*O. okeni*	8.	*C. marchica var. intermedia*
		16.	*O. proboscidea*		
		17.	*O. rubescens*		
			Genus *Phormidium*		
		18.	*P. ambiguum*		
		19.	*P. anomala*		
		20.	*P. fragile*		
		21.	*P. microtomum*		
		22.	*P. papyraceum*		
		23.	*P. rotheanum var. capitatum*		

		24.	*P. subfuscum*		
			Genus *Lyngbya*		
		25.	*L. aestuarii*		
		26.	*L. ceylanica*		
		27.	*L. digueti*		
		28.	*L. martensiana*		
		29.	*L. Taylorii*		
			Genus *Schizothrix*		
		30.	*S. arenaria*		
		31.	*S. tenuis*		
			Genus *Symploca*		
		32.	*S. cartalagianea*		
		33.	*S. elegans*		
		34	*S. muralis*		
		35.	*S. muscorum*		
			Genus *Microcoleus*		
		36.	*M. chthonoplastes*		

Table 3. Cyanobacterial species recorded from Bagbahara (Site - 2).

S. No.	Unicellular form	S. No.	Non heterocystous filamentous form	S. No.	Heterocystous filamentous form
	Genus *Chrococcus*		**Genus *Oscillatoria***		**Genus *Cylindrospermum***
1.	*C. minor*	1.	*O. anguina*	1.	C. doryphorum
2.	*C. minutus*	2.	*O. animalis*		**Genus *Nostoc***
3.	*C. pallidus*	3.	*O.cortiana*	2.	*N. amplissima*
	Genus *Aphanthece*	4.	*O. formosa*	3.	*N. puncutiformae*

4.	*A. microscopiai*	5.	*O. fremyii*		**Genus *Anabaena***
		6.	*O. jasorvensis*	4.	*A. anomala*
		7.	*O. quadripunctulata*	5.	*A. oryzae*
		8.	*O. rubescens*		**Genus *Calothrix***
		9.	*O. simplicissima*	6.	*C. marchica var. bravifilamentosa*
		10.	*O. subravis*	7.	*C. marchica var. intermedia*
			Genus *Phormidium*		
		11.	*P. arbonema*		
		12.	*P. ambiguum*		
		13.	*P. angustissimum*		
		14.	*P. favosum*		
		15.	*P. fragile*		
		16.	*P. microtomum*		
		17.	*P. stagnina*		
		18.	*P. subfuscum*		
			Genus *Lyngbya*		
		19.	*L. aestuarii*		
		20.	*L. ceylanica*		
		21.	*L. cinerescens*		
		22.	*L. contorta*		
		23.	*L. digueti*		
		24.	*L. erebi*		
		25.	*L. martensiana*		
		26.	*L. putealis*		

		27.	*L. scotti*		
		28.	*L.semiplena*		
		29.	*L. Taylorii*		
			Genus *Schizothrix*		
		27.	*S. arenaria*		
		28.	*S. friesii f. repens*		
		29.	*S. tenuis*		
			Genus *Symploca*		
		30.	*S. elegans*		
		31.	*S. hydnoides*		
			Genus *Hydrocoleum*		
		32.	*H. lyngbyaceum*		

Table 4. Cyanobacterial species recorded from Mahasamund (Site - 3).

S. No.	*Unicellular form*	*S. No.*	*Non heterocystous filamentous form*	*S. No.*	*Heterocystous filamentous form*
	Genus *Aphanocapsas*		**Genus *Oscillatoria***		**Genus *Nostoc***
1.	*A. roeseana*	1.	*O. chlorina*	1.	*N. puncutiformae*
		2.	*O. formosa*		**Genus *Anabaena***
		3.	*O. jasorvensis*	2	*A. anomala*
		4.	*O. minnesotensis*	3.	*A. orientalis*
			Genus *Phormidium*		**Genus *Aulosira***
		5.	*P. africanum*	4.	*A. aenigmatica*
		6.	*P. ambiguum*	5.	*A. fertilissima*

	7.	*P. anomala*		**Genus *Microchaete***
	8.	*P. autumnale*	6.	*M. tenera*
	9.	*P. bohneri*		
	10.	*P. corium*		
	11.	*P. foveolarum*		
	12.	*P. fragile*		
	13.	*P. tenue*		
	14.	*P. uncinatum*		
		Genus *Lyngbya*		
	15.	*L. aestuarii*		
	16.	*L. limnetica*		
	17.	*L. lutea*		
	18.	*L. nigra*		
	19.	*L. putealis*		
	20.	*L. rubida*		
	21.	*L. spiralis*		
	22.	*L. Taylorii*		
		Genus *Schizothrix*		
	23.	*S. tenuis*		
		Genus *Symploca*		
	24.	*S. elegans*		

Table 5. Cyanobacterial species recorded from Pithaura (Site - 4).

S. No.	*Unicellular form*	S. No.	*Non heterocystous filamentous form*	S. No.	*Heterocystous filamentous form*
	Genus *Aphanocapsa*		**Genus *Oscillatoria***		**Genus *Nostoc***
1.	*A. koordersi*	1.	*O. animalis*	1.	*N. linckia*
	Genus *Mixosarcina*	2.	*O. foreaui*		**Genus *Aulosira***
1.	*M. spectabilis*	3.	*O. jasorvensis*	2.	*A. laxa*
		4.	*O. late-virens*		**Genus *Microchaete***
		5.	*O. minnesotensis*	3.	*M. uberrima*
		6.	*O. obscura*		**Genus *Mastigocladus***
		7.	*O. simplicissima*	4.	*M.laminosus*
		8.	*O. tenuis var. natans*		
		9.	*O. terebriformis*		
			Genus *Phormidium*		
		10.	*P. ambiguum*		
		11.	*P. calcicola*		
		12.	*P. favosum*		
		13.	*P.fragile*		
		14.	*P. mucosum*		
		15.	*P. stagnina*		
			Genus *Lyngbya*		
		16.	*L. aestuarii*		
		17.	*L. allorgi*		
		18.	*L. ceylanica*		

		19.	*L. circumcreta*		
		20.	*L. corbietei*		
		21.	*L. martensiana*		
		22.	*L. stagnina*		
			Genus *Schizothrix*		
		23.	*S. tenuis*		
			Genus *Symploca*		
		24.	*S. elegans*		
			Genus *Microcoleus*		
		25.	*M. chthonoplastes*		

Table 6. Cyanobacterial species recorded from Saraipali (Site - 5).

S. No.	*Unicellular form*	*S. No.*	*Non heterocystous filamentous form*	*S. No.*	*Heterocystous filamentous form*
	Genus *Chrococcus*		**Genus *Oscillatoria***		**Genus *Nostoc***
1.	*C. minutus*	*1.*	*O. accuminata*	*1.*	*puncutiformae*
	Genus *Aphanocapsa*	2.	*O. amoena var. non granulata*		**Genus *Anabaena***
2.	*A. koordersi*	3.	*O. anguina*	2.	*A. anomala*
3.	*A. montana*	4.	*O. chilkensis*	3.	*A. orizae*
4.	*A.roseana*	5.	*O. late-virens*		
		6.	*O. minnesotensis*		
		7.	*O. quadripunculata*		**Genus *Aulosira*** 4. *A. laxa*
			Genus *Phormidium*		
		8.	*P. ambiguum*		

	9.	*P. anomala*	
	10.	*P. molle*	
	11.	*P. stagnina*	
		Genus *Lyngbya*	
	12.	*L. arboricola*	
	13.	*L. ceylanica*	
	14.	*L. digueti*	
	15.	*L. major*	
	16.	*L. martensiana*	
	17.	*L. stagnina*	
	18.	*L. Taylorii*	
		Genus *Schizothrix*	
	19.	*S. arenaria*	
	20.	*S. fragilis*	
	21.	*S. tenuis*	
		Genus *Symploca*	
	22.	*S. elegans*	
	23.	*S. parietina*	
		Genus *Sirocoleus*	
	24.	*S. kurzii*	
		Genus *Microcoleus*	
	25.	*M. lacustris*	

4. CONCLUSION

The physico-chemical analysis of soils from five different selected sites of Mahasamund district of Chhattisgarh state has shown that pH of block no. 2 and 3 are acidic to alkaline while rest of them are acidic to neutral. It has been evidenced that the micronutrient availability is pH dependent. The electrical conductivity helped to improve cyanobacterial growth.

In the present scenario, the use of cyanobacterial biofertilizers has been much reduced mainly as a consequence of their poor establishment patterns in different soil types or ecologies. For a wider exploitation and success of these biofertilizer technologies in agriculture, coordinated strategic research efforts in the laboratory and at field level are highly essential.

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