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Biodiversity of Cyanophycean Members from Paddy Fields of Khazan Lands

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Abstract:

Survey of paddy fields situated in the areas with constant influx of salt water, commonly termed as khazan lands recorded 84 species of cyanobacteria belonging to 16 different genera. The species recorded were unicellular, heterocystous and non-heterocystous. Among the non-heterocystous forms genus Oscillatoria was maximum as compared to others. This is followed by heterocystous forms like Anabaena, Calothrix, Nostoc, Lyngbya, phormidium, Chroococcus, Aphanothece, Scytonema and other unicellular genera like Microcystis, Gleocapsa, Spirulina and Cylindrospermum one each.

Keywords: *Cyanophyceae, Cyanobacteria, heterocystous, khazan lands*

INTRODUCTION:

Many tropical paddy fields receive neither chemical fertilizer nor natural manure, yet they remain productive and capable of supporting large population with basic food. Here the fertility of paddy soil is maintained by the activities of blue green algae which grow spontaneously and often luxuriantly in the water-logged field. They provide fixed nitrogen to paddy plants through both secretion of nitrogenous substances and on their decay and subsequent mineralization of organic substances in the soil.

In the present study survey of the BGA from the khazan paddy fields of Goa, was carried out. This would enable to know the indigenous cyanobacterial flora of the region and help to understand and document the same from the paddy fields in Goa. Besides, it would assist in identifying the dominant species and heterocystous nitrogen fixers which in turn would help in the production of area specific inocula of indigenous cyanobacterial nitrogen fixers.

MATERIAL AND METHODS:

The study constituted mainly the collection of soil samples containing blue green algae from the paddy fields of different selected areas of khazan lands. Collection of the soil samples containing blue greens was initiated during the study period, at regular intervals from the growing, till the harvesting of the paddy. Care was taken to collect algal samples from the surface of the soil, from the surface of submerged parts of the paddy plants and from the water surface. The identification of the blue green algae isolated from various sites was carried out by using standard keys (Desikachary, 1959; Anand, 1989; Prasad and Srivastava, 1992; Santra, 1993).

RESULTS:

The study was carried out for three consecutive years during kharif and rabi seasons of paddy cultivation. The distribution of BGA during the study period is depicted in the **Table 1**. The three-year study revealed that in all the selected khazan paddy fields, variations in the distribution of genera and species for the two growing seasons of paddy

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i.e. kharif and rabi were observed. The kharif season of the first year recorded 43 species belonging to 13 genera in khazans. The rabi season of the first year, recorded 33 species belonging to 13 genera. The kharif season of the second year recorded 44 species belonging to 15 genera. The rabi season of the second year, recorded 34 species belonging to 11genera. The kharif season of the third year recorded 44 species belonging to 15 genera. The rabi season of the same year, recorded 36 species belonging to 13 genera in khazans **(Table 1)**.

The study also revealed that the BGA documented belonged to three different groups *viz.*, unicellular, heterocystous and non-heterocystous forms. All the 13 species of unicellular forms belonging to 5 genera were members of family Chroococcaceae of order Chroococcales. *Microcystis* is represented by two species viz., *M. aeruginosa* and *M. elabens, Chroococcus* is represented by *C. turgidus, C. minutes, C. pallidus* and *C. cohaerens, Gloecapsa* is represented by *G. punctata*, *G. aeruginosa* and *G. kuetzingiana, Aphanocapsa* is represented *A. banaresensis*; while *Aphanothece* is represented by *A. stagnina, A. saxicola* and *A. castegnei.*

The non-heterocystous BGA belonged to family Oscillatoriaceae of order Nostocales. The study recorded 30 species belonging to 4 genera of non-heterocystous forms. *Lyngbya* is represented by *L. spiralis*, *L. bergei, L. dendrobia, L. confervoides* and *L. martensiana*; *Oscillatoria* is represented by 19 species *viz., O. ornata, O. limosa, O. subbrevis, O. curviceps, O. princeps, O. anguina, O. proboscidea, O. chlorina, O. martini, O. chalybea, O. tenuis, O. simplissima, O. limnetica, O. psudogeminata, O. claricentrosa, O. formosa, O. salina, O. accuminata, O. brevis*; *Spirulina* is represented by *S. meneghiniana, S. princeps*; while *Phormidium is* represented by *P. jadinianum, P. microtomum, P. purpurascens* and *P. mucosum.*

The heterocystous BGA identified belonged to three families viz., Nostocaceae, Scytonemataceae and Rivulariaceae. A total of 41 species belonging to 7 genera of heterocystous forms were recorded during the study period. Family Nostocaceae was represented by genera *Cylindrospermum, Nostoc* and *Anabaena. Cylindrospermum* is represented by *C. stagnale* and *C. Musicola*; *Nostoc* is represented by 14 species *viz., N. punctiforme, N. entophytum, N. paludosum, N. linkia, N. rivulare, N. carneum, N. ellipsosporum, N. calcicola, N. passerinianum, N. muscorum, N. commune, N. microscopium, N. hatei* and *N. sphaericum*; *Anabaena* is represented by 6 species *viz., A. sphaerica, A. oryzae, A. fertilissima, A. naviculoides, A. variabilis* and *A. torulosa.* Family Scyto*nemataceae* is represented by two genera *viz., Scytonema* and *Tolypothrix. Scytonema* is represented by five species, *viz., S. simplex, S. coactile, S. bohneri, S. schmidtii* and *S. fremyii* while *Tolypothrix* is represented by five species *viz., T. nodosa, T. tenuis, T. fragilis, T. byssoidea* and *T. conglutinata.* Family Rivulariaceae recorded 9 species belonging to 2 genera. *Calothrix* is represented by *C. castellii, C. elenkinii, C. braunii, C. parietina, C. weberi, C. membranacea* and *C. marchica. Rivularia* is represented by only two species *viz., R. aquatica* and *R. globiceps.* The forms showed variations in their occurrence during both kharif and rabi seasons.

Table 1: Distribution of BGA from different rice field habitats for the year 2006 -2007

	Seasons &Study sites →	**Khazan fields (kharif year 1)**	**Khazan fields (rabi year 1)**	**Khazan fields (kharif year 2)**	**Khazan fields (rabi year 2)**	**Khazan fields (kharif year 3)**	**Khazan fields (rabi year 3)**
	species↓						
1	***Microcystis aeruginosa***	+	+	+	+	+	+
2	***M. elabens***	-	-	-	-	-	-
3	***Chroococcus turgidus***	+	+	+	+	+	+
4	***C. minutus***	-	-	-	-	-	-
5	***C. pallidus***	+	+	+	+	+	+
6	***C. cohaerens***	-	-	-	-	-	-
7	***Gleocapsa***	+	+	+	+	+	+

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	punctate						
8	***G. aeruginosa***	+	+	+	+	+	+
9	***G. kuetzingiana***	-	-	-	-	-	-
10	***Aphanocapsa banaresensis***	-	+	-	+	-	-
11	***A. stagnina***	+	+	+	+	+	+
12	***A. saxicola***	-	-	-	-	-	-
13	***A. castagnei***	+	+	+	+	+	+
14	***Lyngbya spiralis***	+	+	+	+	+	+
15	***L. bergei***	-	-	-	-	-	-
16	***L. dendrobia***	+	+	+	+	+	+
17	***L. confervoides***	+	+	+	+	+	+
18	***L. martensiana***	+	+	+	+	+	+
19	***Oscillatoria ornata***	-	-	-	-	-	-
20	***O. limosa***	+	+	+	+	+	+
21	***O. subbrevis***	+	+	+	+	+	+
22	***O. curviceps***	-	-	-	-	-	-
23	***O. princeps***	+	+	+	+	+	+
24	***O. proboscidea***	+	+	+	+	+	+

Sr. No.	**Seasons & Study sites →**	**Khazan fields (kharif year 1)**	**Khazan fields (rabi year 1)**	**Khazan fields** (kharif year 2)	**Khazan fields** (rabi year2)	**Khazan fields** (kharif year 3)	**Khazan fields** (rabi year 3)
	Name of Algae↓						
25	***Oscillatoria anguina***	+	+	-	-	-	-
26	***O. formosa***	+	+	+	+	+	+
27	***O. chlorina***	-	-	-	-	-	+
28	***O. martini***	+	+	-	-	-	-
29	***O. chalybea***	+	+	-	-	-	+
30	***O. tenuis***	+	+	+	+	+	+
31	***O. simplissima***	+	+	+	+	+	+
32	***O. limnetica***	-	-	+	-	-	-
33	***O. pseudogeminata***	-	-	+	-	-	-
34	***O. claricentrosa***	-	-	-	-	-	+
35	***O. salina***	+	+	+	+	+	+
36	***O. acuminata***	+	+	+	+	+	+
37	***O. brevis***	+	+	+	+	+	+
38	***Spirulina meneghiniana***	-	-	+	+	+	+

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39	***S. princeps***	+	+	-	-	-	+
40	***Phormidium jadinianum***	-	-	+	-	-	-
41	***P. microtomum***	-	-	-	+	-	-
42	***P. purpurascens***	-	+	-	-	-	-
43	***P. mucosum***	-	-	-	-	+	+
44	***Cylindrospermum stagnale***	-	-	+	+	+	-
45	***C. muscicola***	+	+	-	-	-	-
46	***Nostoc punctiforme***	+	+	+	+	+	-
47	***N. entophytum***	-	-	+	+	+	-
48	***N. paludosum***	+	+	-	-	-	+
49	***Nostoc linckia***	+	+	+	+	+	+
50	***N. rivulare***	+	+	+	+	+	+
51	***N. carneum***	-	-	+	-	-	-
52	***N. ellipsosporum***	-	-	+	-	-	-
53	***N. calcicola***	+	-	-	-	+	-
54	***N. passerinianum***	-	-	+	-	-	-
55	***N. muscorum***	+	+	+	+	+	+
56	***N. commune***	+	+	+	+	+	+
57	***N. microscopium***	+	+	+	+	+	+
58	***N. hatei***	-	+	+	+	+	+
59	***N. sphaericum***	+	+	+	+	+	+
60	***Anabaena sphaerica***	+	+	+	+	+	+
61	***A. oryzae***	+	+	+	+	+	+
62	***A.fertilissima***	+	+	+	+	+	+
63	***A. naviculoides***	+	+	+	+	+	+
64	***A. variabilis***	-	+	-	-	-	-
65	***A. torulosa***	+	-	-	-	-	-
66	***Scytonema simplex***	+	-	-	-	-	-
67	***S. coactile***	-	+	-	-	-	-
68	***S. bohneri***	-	-	-	+	-	-
69	***S. schmidtii***	-	+	-	-	-	-
70	***S. fremyii***	+	-	-	-	+	-
71	***Tolypothrix nodosa***	-	-	-	-	-	+
72	***T. tenuis***	+	-	-	-	+	-
73	***Tolypothrix fragilis***	-	-	+	-	-	+
74	***T. byssoidea***	-	-	-	+	-	-
75	***T. conglutinata***	-	+	-	-	-	-
76	***Calothrix castellii***	-	-	+	-	-	-
77	***C. elenkinii***	-	-	-	+	-	-
78	***C. braunii***	-	+	-	-	-	+
79	***C. parietina***	+	-	-	+	-	-
80	***C. weberi***	-	-	+	-	-	-

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81	***C. membranacea***	+	+	+	+	+	+
82	***C. marchica***	-	+	-	-	-	-
83	***Rivularia aquatica***	-	-	-	+	-	-
84	***R. globiceps***	-	-	+	-	-	+

Table 2: Physico-chemical parameters of water and soil samples from khazan paddy fields for kharif and rabi seasons during study period of three consecutive years.

Water Sample									
Parameters	**pH**	**EC mmhos/cm**	**Temp ^{0}C**	**DO mg/l**	**Ca mg/l**	**Mg mg/l**	**P mg/l**	**Cl mg/l**	**pH**
Months									
June	**6.50**	**8.15**	**29.50**	**8.20**	**1.80**	**1.20**	**0.03**	**8.60**	**6.30**
July	**6.20**	**10.30**	**29.00**	**8.30**	**2.70**	**1.30**	**0.03**	**7.80**	**6.40**
Aug	**6.30**	**9.35**	**27.20**	**7.50**	**2.80**	**0.90**	**0.04**	**5.80**	**6.30**
Sept	**6.30**	**7.25**	**26.50**	**7.70**	**1.70**	**0.80**	**0.01**	**4.60**	**6.50**
Oct	**6.40**	**6.83**	**26.00**	**6.80**	**2.60**	**1.10**	**0.02**	**5.20**	**6.80**
Dec	**6.20**	**9.20**	**26.00**	**7.30**	**2.80**	**1.80**	**0.02**	**4.50**	**6.50**
Jan	**6.30**	**8.70**	**26.00**	**7.60**	**3.20**	**1.10**	**0.12**	**7.20**	**6.60**
Feb	**6.50**	**7.20**	**26.50**	**7.90**	**3.30**	**1.00**	**0.15**	**7.30**	**6.60**
March	**6.40**	**7.90**	**27.00**	**7.80**	**3.10**	**1.20**	**0.08**	**4.90**	**6.70**
April	**6.10**	**7.40**	**27.50**	**7.20**	**3.00**	**1.80**	**0.09**	**4.80**	**6.70**
Average	**6.32**	**8.23**	**27.12**	**7.63**	**2.70**	**1.22**	**0.06**	**6.07**	**6.54**
SD ±	**0.13**	**1.13**	**1.24**	**0.46**	**0.55**	**0.34**	**0.05**	**1.51**	**0.17**

Continue **Table 2: Physico-chemical parameters…….**

Soil Sample											
E.C mmhos/cm	**N kg/ha**	**P kg/ha**	**K kg/ha**	**Ca mg/l**	**Mg mg/l**	**Cl mg/l**	**Zn ppm**	**Fe ppm**	**Mn ppm**	**Cu ppm**	**B ppm**
10.85	**0.98**	**6.10**	**918.00**	**8.30**	**1.60**	**7.80**	**2.65**	**57.80**	**0.19**	**2.86**	**0.89**
10.25	**0.45**	**6.01**	**910.20**	**6.70**	**1.20**	**7.50**	**3.52**	**61.30**	**0.18**	**1.98**	**0.81**
11.82	**1.34**	**6.00**	**909.00**	**6.80**	**1.20**	**7.40**	**2.28**	**62.50**	**0.17**	**1.87**	**0.51**
12.60	**1.09**	**5.96**	**893.00**	**7.30**	**2.20**	**9.20**	**3.83**	**60.90**	**0.12**	**1.92**	**0.42**
8.90	**1.28**	**5.95**	**894.00**	**2.10**	**1.80**	**9.30**	**2.92**	**58.32**	**0.11**	**1.85**	**0.81**
11.53	**1.42**	**5.95**	**716.00**	**1.80**	**1.50**	**9.00**	**2.78**	**56.52**	**1.20**	**2.20**	**0.82**
10.28	**1.45**	**3.02**	**772.00**	**1.70**	**1.50**	**9.10**	**1.12**	**62.33**	**1.28**	**2.60**	**0.72**
9.83	**0.56**	**2.88**	**767.00**	**1.70**	**1.50**	**9.30**	**1.13**	**64.35**	**1.30**	**2.70**	**0.65**
10.13	**0.31**	**3.25**	**758.00**	**1.70**	**0.28**	**5.20**	**2.10**	**56.28**	**0.17**	**2.50**	**0.49**
10.56	**0.58**	**3.30**	**812.00**	**0.30**	**0.28**	**4.60**	**2.00**	**52.38**	**0.18**	**2.30**	**0.79**
10.68	**0.95**	**4.84**	**834.92**	**3.84**	**1.31**	**7.84**	**2.43**	**59.27**	**0.49**	**2.28**	**0.69**
1.07	**0.43**	**1.49**	**77.51**	**3.02**	**0.61**	**1.73**	**0.90**	**3.64**	**0.53**	**0.37**	**0.16**

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DISCUSSION:

In the present investigation, the three-year study revealed overall number of 84 species belonging to 16 genera from khazan paddy fields of Goa. The paddy fields of Goa are rich in indigenous cyanobacterial population consisting of unicellular, non-heterocystous and heterocystons forms. Occurrence of all forms of BGA was recorded in both kharif and rabi cultivation seasons at different times.

It was seen during study period that the pH in khazan lands was neither highly acidic nor alkaline (6.5 to 7.9) and the P content of the soil was high (Table 2). Begum *et al*., (2008) reported significant variation in cyanobacterial population from the paddy field soils of 11 districts of Bangladesh, where the highest number of indigenous cyanobacterial population was reported from paddy field soils with pH range of 6.8 to 7.5 and available P (12.42 to 28.50µg/g soil) which is in conformity with the results obtained in the present study.

Our study reports the presence of BGA belonging to two orders *viz.,* Chroococcales and Nostocales and families Chroococcaceae, Oscillatoriaceae, Nostocaceae, Scytonemataceae and Rivulariaceae. Singh (1978) conducted a survey in the farms of the Central Rice Research Institute, Cuttack, India and reported the dominance *Aphanothece, Anabaena, Aulosira, Cylindrospermum, Gloetrichia* and *Nostoc*. Similarly, Ghadai *et al*., (2010) reported seven major groups that include Chroococcaceae, Pleurocapsaceae, Oscillatoriaceae, Nostocaceae, Rivulariaceae, Scytonemataceae and Stigonemataceae from paddy fields of Gunpur, Orissa.

In the present study, the khazan fields recorded appreciable number of BGA which showed variations in the two cultivation seasons. Such variations in cyanobacterial population were recorded earlier in paddy field soils of India (Roger *et al*., 1993). However, Aiyer, (1965) and Amma *et al*., 1966 reported rich cyanobacterial flora from the coastal and saline paddy fields of Kerala. The growth of nitrogen fixing cyanobacteria is known to be affected by acidic pH, low content of P and Ca (Roger and Reynaud, 1976; Healey, 1973).

Both cultivation seasons showed dominance of heterocystous forms like *Nostoc, Anabaena* and *Calothrix*. Among the non-heterocystous forms, *Oscillatoria* showed maximum (19) species with species number given in parenthesis. Dominance of Oscillatoriaceae and Nostocaceae in paddy fields have been reported earlier (Ghadai *et al*., 2010).

Unicellular genera like *Microcystis* (2), *Chroococcus* (4), *Gloecapsa* (3), *Aphanocapsa* (1) and *Aphanothece* (3) were also recorded with species number given in parenthesis.

The non-heterocystous genera recoded in the present study include *Lyngbya* (5), *Spirulina* (2), *Oscillatoria* (19) and *Phormidium* (4) while the heterocystous genera include *Cylindrospermum* (2), *Nostoc* (14), *Anabaena* (6), Scytonema (5), *Tolypothrix* (5), *Calothrix* (7) and *Rivularia* (2) with species number in parenthesis. The most dominant heterocystous species in all the habitats include *Nostoc rivulare* kiitzing, ex Born. et Flah, *Anabeana oryzae* Fritisch and *Calothrix membranacea* Schmidle. The nitrogen fixing heterocystous BGA were dominant in all the study sites. In an all India survey, Venkataraman, (1975) observed that out of 2213 soil samples from paddy fields, 33% harboured nitrogen fixing cyanobacteria. Similar observations have been recorded in the present study.

CONCLUSION:

The information generated on the dominant indigenous cyanobacterial population in khazan paddy fields could be applied for sustainable agricultural practices by reducing the application of chemical fertilizers and also reclamation of khazan lands which are most productive paddy fields. The information could also be used to avoid the appearance of non-nitrogen fixers in soil that might compete with nitrogen fixers for nutrients. Finally, it may be concluded that the documentation on cyanobacteria may enhance the understanding of the nutrient status of the field and also enhance knowledge about the indigenous nitrogen fixers. The nitrogen fixing indigenous bacteria could be used to produce a biofertilizer inoculum for the fields to be distributed to the local farmers. It will take care of the cost and also the natural soil conditions which otherwise degrade due to heavy use of chemical fertilizers.

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