



Morphotypic diversity of microalgae from arid zones of Rajasthan (India)

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ABSTRACT

The morphotypic diversity of microalgae from Rajasthan was studied by collecting samples from 29 places. A total of 32 samples of soil, 25 samples of fresh water and 27 of saline water were analysed. We identified a total of 31 species representing 12 genera of cyanobacteria on the basis of Bergey's manual of Systematic Bacteriology, 2001. Vol.1. IInd edition and 9 species of green algae and diatoms representing 7 genera of 3 families and 3 order as per recent system of classification. Morphological descriptions and habitats were described for each species identified that were represented systematically. Of these 40 species, 8 unicellular cyanobacteria and 7 unicellular green algae, 7 heterocystous filamentous cyanobacteria, 16 nonheterocystous filamentous cyanobacteria and 2 diatoms .

Key Words: diversity, morphotype, microalgae, cyanobacteria, arid zones

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INTRODUCTION

Rajasthan state is full of extreme habitats. Other than the hot arid desert (Thar) covering ca. 196, 150 km², there are saline playas, saline and alkaline soils and wide

diurnal thermal fluctuations creating uncommon ecosystems. Many of the aquatic habitats also exhibit excess of fluoride, carbonate and heavy metals (Bhatnagar and Bhatnagar 2001). The popular belief that

cyanobacteria and algae thrive in aquatic systems distracted most phycologists from the arid extreme habitats. But now it is well known that they inhabit not only arid soils but rocks too, so much so that the loss of vegetation in the deep desert makes phototropic microorganisms especially algae and cyanobacteria, the only source of primary production (Bhatnagar and Bhatnagar 2005).

The tropical desert of Asia extends to India through Rajasthan and Gujarat where it is called the Thar. The soil in the desert characteristically has a high percentage of soluble salts, high pH, low loss on ignition, varying percentage of calcium carbonate and poor organic matter content. The major limiting factor is water and these soils can be reclaimed if proper facilities for irrigation are available. The region is subjected to intense winds and a wide variation in temperature ranging from a minimum of 5°C to a maximum of 45°C (Gupta 1993).

Arid Rajasthan is dotted with numerous water reservoirs including major inland saline playas viz the Sambhar lake, Nawa, Didwana (Nagaur), Lunkaransar (Bikaner), Pachpadra

(Barmer), Mitha ka Rann and Kharia Rann (Jaisalmer).

No systematic study on soils and saline playas of arid India could be traced. Only few studies could be observed (Bhandari 1952, Srivastava 1999 and Tiwari *et al.* 1999). Sporadic reports on cyanobacterial diversity occur from arable areas of Southern Rajasthan (Pandey *et al.* 1998 and Pandey 2002). In the present study microalgae from both soil and water samples were isolated and identified.

MATERIAL AND METHODS:

Sampling:

A total of 29 places were visited from where 32 samples of soil, 25 samples of fresh water and 27 of saline water were collected (Table 1). The places represented Western Rajasthan (Akal, Fidusar Chopar, Jaisalmer, Jodhpur, Pokharan), Eastern Rajasthan (Ajmer, Nagaur), North East Rajasthan (Sambhar, Kuchaman), South West Rajasthan (Pali, Bali), and Northern Rajasthan (Bikaner, Gajner, Hanumangarh, Rawatsar). Water samples were collected from Sambhar,

Kolayatji, Gajner, Jodhpur, Ajmer, Kuchaman
and Lunkaransar.

Table-1: Sites sampled for soil and water

S. No.	Place	Soil	Water
1	Ajmer	+	+
2	Akal Fossil Park	+	-
3	Bali (Pali)	+	-
4	Dabsi	+	-
5	Didwana	-	+
6	Fidusar Chopar (Jodhpur)	+	+
7	Gajner (Bikaner)	-	+
8	Inana (Nagaur)	+	-
9	Jagadevbala (Bikaner)	+	-
10	Jayal (Didwana)	-	+
11	Jodhpur- Meherangarh	-	+
12	Kailana (Jodhpur)	-	+
13	Kolayat	-	+
14	Kotadigaon (Kolayat)	+	-
15	Kuchaman	+	+
16	Lunkaransar	-	+
17	Makarwali (Ajmer)	+	-

18	Mangalana (Parbatsar)	+	-
19	Manpura (Parbatsar)	+	-
20	Morjanda (Sri Ganganagar)	+	-
21	Narayanpura	+	-
22	Osian (Jodhpur)	+	-
23	Pokharan	+	-
24	Ramdeora	+	-
25	Rawatsar (Hanumangarh)	+	-
26	Rohina (Degana)	+	-
27	Sam (Jaisalmer)	+	-
28	Sambhar	+	+
29	Suratgarh	+	-

Procedure of sampling:

Soil:

Surface soil (30 cm x 30 cm x 10 cm) was collected randomly from five to seven places at each site after removing the surface debris. These were mixed thoroughly to prepare a composite sample. After pulverization and drying in shade, samples were preserved in polythene bags at low temperature (-18°C) for further investigation. While sampling, the vegetation cover,

encrustation and visible coarseness of texture were also noted.

Water:

Sterilized sampling bottle was lowered in the water body to 0.5-1 ft. Opened to collect water and recapped there itself. Samples were transported in a box containing ice and were preserved at 4°C. An aliquot of 100 ml homogenized sample was separated for studies on the live organisms

and then 4 % formalin was added to rest of the of the amount for longer preservation.

Morphotypic Diversity:

Diversity of total and diazotrophic morphotypes in normal, moderate and extreme haloalkaline conditions of soil and water samples was determined by enrichment culture technique as described below:

Sterilization:

The glassware were rinsed with chromic acid and washed in running tap water. Before use, these were rinsed twice with tap water and thrice with distilled water and were dry sterilized at 160° C for 2 hr in a hot air oven. Culture medium was sterilized at 15 lb pressure (121° C) for 20 minutes in an autoclave.

Enrichment:

Five grams of each soil sample and 10 ml of water sample were inoculated in 50 ml sterilized standard BG-11 (Staneir *et al.* 1971) for soil and freshwater samples or Johnson's modified medium (Borowitzka and Borowitzka 1988) for saline water samples

with and without nitrate nitrogen in 100 ml Erlenmeyer flasks in triplicates for the diversity studies of total and diazotrophic morphotypes. For alkalotolerant edaphic forms, pH of the unbuffered BG 11 ± N was set to 10. For alkhalotolerants of saline playas, 2M NaCl was added and pH was set to 11 in unbuffered Johnson's medium and for extreme halotolerants 3M NaCl was added to the Johnson's medium. The flasks were shaken well and incubated in growth room maintained at 29 ±1°C and 12:12h::L:D cycle. Illumination of 1100-1300 Lux was provided using two cool white fluorescent lamps (40 W) in each rack.

Incubation and Identification:

The cultures were incubated till the appearance of good growth (20 days in BG -11 +N, 45 d in BG-11 -N and Johnson's !N) algal and cyanobacterial morphotypes appearing in the enrichment cultures were examined microscopically and identified using taxonomic keys after Smith (1950), Prescott (1982) and Desikachary (1959).

Isolation and purification of strains:

For isolation, a small speck of algal or cyanobacterial growth from enrichment culture was picked up with the help of an inoculation needle and transferred to 5 ml of sterilized medium in a test tube. The contents were homogenized by vortexing. This suspension (0.5 ml) was surface plated on plates with medium (BG 11 ± N /Johnson's ± N). The petriplates were incubated upside down in the growth room for 20 to 30 days under conditions described in 3.b enrichment.

Plates were examined periodically for the appearance of cyanobacteria and algal colonies. Discrete and morphologically different colonies were picked up with the help of stereomicroscope and light microscope and were streaked on fresh agar plates for further purification. This was repeated thrice to obtain unialgal or cyanobacterial cultures. After isolation, the identity of the culture was further established using taxonomic keys as mentioned earlier and for each isolate a catalogue number AZAR was given (table 2).

Table – 2: Description of morphotypes with Catalogue No, habitat and culture medium

Catalogue No.	Name of the isolate	Habitat	Place	Growth medium
Genus- <i>Chroococcus</i>				
AZAR 2400	<i>Chroococcus minutus</i>	Loose sand	Makarwali	BG 11 +N
AZAR 2401	<i>Chroococcus minor</i>	Anokhi lake	Gajner	BG 11 +N
Genus- <i>Gloeocapsa</i>				
AZAR 1002	<i>Gloeocapsa aeruginosa</i>	Anokhi lake	Gajner	BG 11 +N
AZAR 1003	<i>Gloeocapsa gelatinosa</i>	Anokhi lake	Gajner	BG 11 +N

Genus- <i>Gloeothece</i>				
AZAR 1004	<i>Gloeothece</i> sp.	Playa	Lunkaransar	Johnson
Genus- <i>Synechococcus</i>				
AZAR 1701	<i>Synechococcus cedrorum</i>	Sediment with algal growth	Kuchaman	Johnson
AZAR 1702	<i>Synechococcus elongatus</i>	Loose sand	Sambhar	Johnson
Genus- <i>Synechocystis</i>				
AZAR 2500	<i>Synechocystis aquatilis</i>	Highly weathered sand stone	Osian	BG11 +N
Genus- <i>Leptolyngbya</i>				
AZAR 1402	<i>Phormidium papyraceum</i>	Barren soil	Manpura	BG 11 +N
AZAR 1403	<i>Phormidium molle</i>	Rain water ditch	Lunkaransar lake	BG 11 +N
Genus- <i>Lyngbya</i>				
AZAR 1103	<i>Lyngbya limnetica</i>	Kolayatji lake	Kolayat	BG 11 +N
AZAR 1104	<i>Lyngbya limnetica</i>	Kolayatji lake	Kolayat	BG 11 +N
AZAR 1105	<i>Lyngbya borgerti</i>	Playa	Lunkaransar	BG 11 +N

Table-2... continued.

Catalogue No.	Name of the isolate	Habitat	Place	Growth medium
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Genus- <i>Oscillatoria</i>				
AZAR 1309	<i>Oscillatoria fremyii</i>	Kolayatji lake	Kolayat	BG 11 +N
AZAR 1500	<i>Plectonema puteale</i>	Bajra field soil	Khari Beri	BG 11 +N
Genus-<i>Anabaena</i>				
AZAR 2200	<i>Anabaena anomala</i>	Lime soil water	Kotadi Gaon	BG 11 -N
AZAR 2201	<i>Anabaena anomala</i>	Crust between dun	Sam	BG 11 -N
AZAR 2202	<i>Anabaena sp.</i>	Stone quarry	Fidusar Chopar	BG 11 -N
AZAR 2203	<i>Anabaena oryzae</i>	Anokhi lake	Gajner	BG 11 -N
AZAR 2204	<i>Anabaena sp.</i>	Rain water ditch	Lunkaransar	BG11 -N
AZAR 2205	<i>Anabaena variabilis</i> var <i>ellipsospora</i>	Kolayatji lake	Kolayat	BG 11-N
AZAR 2206	<i>Anabaena variabilis</i> var <i>ellipsospora</i>	Sand stone	Mandore	BG 11 -N
AZAR 2207	<i>Anabaena variabilis</i>	LoosesoilSukha di river bed	Bali (Pali)	BG 11-N
AZAR 2208	<i>Anabaena sp.</i>	Rain water ditch	Lunkaransar	BG 11 -N
AZAR 2209	<i>Anabaena anomala</i>	Kolayatji lake	Kolayat	BG 11 -N
AZAR 2210	<i>Anabaena variabilis</i> var <i>ellipsospora</i>	Kolayatji lake	Kolayat	BG 11 -N
AZAR 2212	<i>Anabaena laxa</i>	Barren salinepatch	Mangalana	BG 11 -N
Genus- <i>Nostoc</i>				
AZAR1203	<i>Nostoc commune</i>	Crusted sand Suratgarh	Suratgarh power station	BG 11 -N
Genus- <i>Scytonema</i>				

AZAR 1801	<i>Scytonematopsis woronichinii</i>	Loose barren sand	Sam	BG 11 +N
Genus- Tolypothrix				
AZAR 2101	<i>Tolypothrix campatylonemoides</i>	Uncultivated field soil	Ramdeora	BG11 -N

Table-2..continued.

Catalogue No.	Name of the isolate	Habitat	Place	Growth medium
Taxonomic position still to be defined				
AZAR 2300	<i>Alosira prolifica</i>	Soil crust near <i>Prosopis</i>	Fidusar Chopar	BG 11 -N
Green algae, Family - Chlamydomonadaceae				
AZAR 5700	<i>Chlamydomonas</i> sp.	Kyar-50 Marwad Balliya	Didwana	Johnson
AZAR 5201	<i>Dunaliella</i> sp.	Salt crust	Kuchaman	Johnson
AZAR 5202	<i>Dunaliella</i> sp.	Personal well Salina	Didwana	Johnson
AZAR 5203	<i>Dunaliella</i> sp.	Rainwater ditch	Didwana	Johnson
Family - Oocystaceae				
AZAR 5106	<i>Chlorella</i> sp.	Sand dune	Sam	BG 11 +N
AZAR 5403	<i>Oocystis pusila</i>	Crust between mobile dunes	Sam	BG 11 +N
Family - Palmellaceae				
AZAR 5301	<i>Gloeocystis</i> sp.	Tephrosia dominated soil	Makarwali	BG 11+N

DIATOMS				
CLASS- <i>Bacillariophyceae</i>				
AZAR 101	<i>Cymbella sp</i>	Marwad Balliya	Didwana	DM
AZAR 201	<i>Netrium sp.</i>	Water sample	Lunkaransar	DM

Maintenance of cultures:

Cultures were maintained and periodically sub cultured on agar slants in screw capped culture tubes under aseptic conditions, incubated in growth room to show visible growth and then preserved in refrigerator at $5 \pm 1^{\circ}\text{C}$.

RESULTS AND DISCUSSION

A total of 40 microalgae, amongst cyanobacteria, 8 unicellular (1 soil, 1 rock, 3 salt water and 3 fresh water), 7 nonheterocystous filamentous forms (2 soil, 2 salt water and 2 fresh water), 16 heterocystous filamentous forms (8 soil, 1 rock, 2 salt water and 5 fresh water), amongst green algae 7 unicellular forms (3 soil and 4 salt water) and 2 diatoms forms from salt water were isolated and described with their systematic positions, morphological descriptions and habitat .

The morphotypes were identified using standard keys after Desikachary (1959) and Prescott (1982) and then they were grouped on the basis of Bergey's manual of Systematic Bacteriology. 2001. Vol.1. IInd edition.

Phylum BX. Cyanobacteria

Subsection I. (Formerly Chroococcales)

Form -genus I. Chamaesiphon

Form-genus II. *Chroococcus* Nag.

1. *Chroococcus minor* (Kutz.) AZAR 2401: Unicellular with very thin non-lamellated sheath or colonial (rarely 8-16 number) in single gelatinous matrix, subspherical cells (2.8 μm diameter).
Habitat: Anokhi lake, Gajner
2. *Chroococcus minutus* (Kutz.) AZAR 2400: Dark green clumps. Unicellular, non motile (5.6 μm dia, 3.5 to 4.2 μm in old cultures) or colonial (2-8 cells together), divide in two planes, spherical (some cylindrical (8.4 x 4.2 μm in old cultures)

surrounded by common mucilaginous sheath (2.6 μm thick), which is not lamellated. Dividing cell (8.4 μm dia) contains 4 cells (each 4.2 μm). Granulated cytoplasm in old cultures. Habitat: loose sand, Makarwali.

Form-genus VIII. *Gloeocapsa* Kutzing

1. *Gloeocapsa aeruginosa* (Carm.) AZAR 1002: Unicellular (2.8 μm diameter), spherical cells, lamellated sheath around each cell, thick membraned, transversely dividing in colonies. Each cell encapsulated in lamellated sheath (1.4 μm thick). Colony (11.2 μm diameter). Habitat: Anokhi lake, Gajner.
2. *Gloeocapsa gelatinosa* (Kutz.) AZAR 1003: Unicellular or as hemispherical colony. Cells spherical (2.8 μm diameter), thick membraned forming colonies. Transverse cell division. Colony 11.2 μm diameter. Habitat: Anokhi lake, Gajner.

Form-genus IX. *Gloeotheca* Nag.

1. *Gloeotheca* sp. AZAR 1004: Unicells or few together in a shapeless colony. Spherical or ellipsoidal cells (2.1 μm dia. Without sheath, 3.08 μm long), with firm vesicular sheath (0.7 μm thick). Divide transversely. Each cell in a glistening colourless envelope. Habitat: Lunkaransar playa.

Form-genus XIII. *Synechococcus* Nag.

1. *Synechococcus cedrorum* (Sauvageau) AZAR 1701: Blue green cells 4.42 μm broad, 5.32 μm long, oblong with round apices. Single or double, divide transversely. No mucilaginous envelope.

Habitat: Sediment with profuse algal growth, Kuchaman,

2. *Synechococcus elongatus* (Nag.) AZAR 1702: Blue green cylindrical (2.8 μm x 4.2 to 11.2 μm). Pleomorphic. Single or 2-4 together. Divide by transverse division.

Habitat: Sambhar.

Form-genus XIV. *Synechocystis* Sauvageau

1. *Synechocystis aquatilis* (Sauv.) AZAR 2500: Unicellular or colonial (2-4 cells) Spherical cells (6.72 μm) with sheath (4.2 μm), divide transversely.

Habitat: Highly weathered sand stone with earth material away from water ditch- Nadia (Osian).

Subsection III. (Formerly Oscillatoriales)

Form-genus V. *Leptolyngbya*

1. *Phormidium molle* (Kutz.) AZAR 1403: Nonheterocystous straight filaments, thin firm colourless sheath (0.3 μm) not

extended, Terminal cell not attenuated, hemispherical. Calyptra absent. Distinctly constricted at non granulated cross walls. Cell 2.52 μm broad and 4.2 μm long. Filament 2.8 μm broad.

Habitat: Rainwater ditch, Lunkaransar lake.

2. *Phormidium papyraceum* (Ag.) AZAR 1402: Dark green thallus. Non heterocystous cylindrical trichome, thinly (0.28 μm) sheathed. Cross walls conspicuous, constricted and not granulated. Cell 2.52 μm broad and 2.1 μm long. Filament 2.8 μm broad. Calyptra absent. Apex bent (obtuse conical).
Habitat: Barren soil, Manpura (Parbatsar Road). NCCUBGA Number: CCC 436.

Form-genus VII. *Lyngbya*

1. *Lyngbya borgerti* (Lemmermann) AZAR 1105: Filamentous non heterocystous trichome thinly sheathed (0.7 μm), sheath firm, continuous (extended), open at the terminals. Trichome granulated. Hormogonia present. End cell hemispherical. Cells 2.1 μm broad and 5.6 μm long, have gas vacuoles. Cell wall not constricted.
Habitat: 126, Lunkaransar.

2. *Lyngbya limnetica* (Lemmermann) AZAR 1103: Filamentous non-heterocystous trichome thinly sheathed, sheath continuous (extended). End cell hemispherical. Cells 1.4 μm broad and 2.8 μm long. Cell wall not constricted.

Habitat: Kolayat Lake

3. *Lyngbya limnetica* (Lemmermann) AZAR 1104: Filamentous non-heterocystous trichome thinly sheathed (0.7 μm), sheath continuous (extended) nonlaminated. Hormogones present. End cell hemispherical. Cells 1.4 μm broad and 0.84 μm long. Filament 2.1 μm broad. Cell wall not constricted.

Habitat: Kolayat lake. Form-genus IX. Oscillatoria

1. *Oscillatoria freyia* (De Toni, J) AZAR 1309: Filamentous, pale blue green, hormogones present. Thin firm sheath present. 0.7 μm broad and 1.4 μm long cells, constricted at cross walls, Non granulated septa, end cell blunt.

Habitat: Lake Kolayat.

2. *Plectonema puteale* (Krichner) ZAR 1500: Filamentous falsely branching hormogonial form. Non heterocystous. Thin (0.7 μm) non lamellated firm sheath over trichome. Vacuolated cell (7 μm broad, 5.6 μm long).

Habitat: *Bajra* filed soil, Khari Beri.

Subsection IV (Formerly Nostocales)

Subsection IV.I

Form-genus I. *Anabaena* sp Bory

1. *Anabaena* sp. AZAR 2202: Filaments not in a definite colony. Trichomes with very thin sheath and intercalary heterocysts (4.2 μm broad, 5.6 μm long), Cells from heterocysts.

Habitat: Soil below *Prosopis* Pink stone quarry, Fidusar Chopar.

2. *Anabaena* sp. AZAR 2204: Filaments entangled, vacuolated. Trichomes with very thin sheath and intercalary heterocysts (3.22 μm broad, 5.6 μm long), Cylindrical cells, 2.8 μm broad, 4.2 μm long. Akinetes not seen.

Habitat: Rainwater ditch, Lunkaransar.

3. *Anabaena* sp. AZAR 2208: Filaments single or in a formless gelatinous mass. Trichomes with very thin sheath and intercalary heterocysts (3.64 μm broad, 4.9 μm long), Cylindrical cells, 2.8 μm broad, 5.6 μm long. Akinetes (4.2 μm broad, 4.9 μm long) in series.

Habitat: Rainwater ditch, Lunkaransar.

4. *Anabaena anomala* (Fritsch) AZAR 2200: Trichomes with diffluent sheath

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and intercalary heterocysts (3.5 μm broad, 3.5 μm long), cylindrical cells, 2.8 μm broad, 3.5 μm long. Akinetes spherical (2.8 μm broad, 2.52 μm long), far from heterocysts.

Habitat: lime soil water, Kotadi Gaon.

5. *Anabaena anomala* (Fritsch) AZAR 2201: Trichomes with diffluent sheath and intercalary, cylindrical heterocysts (3.5 μm broad, 4.9 μm long), cylindrical cells, 2.8 μm broad, 4.9 μm long. Akinetes not seen. Spherical terminal cell.

Habitat: Crust between dunes, Sam.

6. *Anabaena anomala* (Fritsch) AZAR 2209: Trichome without sheath, dense or irregularly aggregated in a formless gelatinous mass. Cells 2.8 μm broad, 4.2 μm long. Apical cell rounded. Heterocysts (3.5 μm broad, 2.8 μm long) spherical, intercalary. Akinetes spherical to elongate (4.2 μm broad, 5.6 μm long), in series.

Habitat: Lake, Kolayat

7. *Anabaena laxa* (Rabehn.) AZAR 2212: Cylindrical, thinly sheathed trichome. Cells 2.8 μm broad, 4.9 μm long. Heterocysts spherical (4.2 μm dia), intercalary and terminal. Akinetes cylindrical (4.2 x 5.6 μm), smaller than

the form (6 µm) described by Desikachary.

Habitat: Barren saline patch near water gullies, Manglana.

8. *Anabaena oryzae* (Fritsch) AZAR 2203: Filaments not in a definite colony. Trichomes without a distinct sheath and terminal and intercalary heterocysts (2.8 µm broad, 4.2 µm long), cylindrical cells, 2.8 µm broad, 4.48 µm long. Akinetes spherical or subspherical (4.2 µm broad, 5 µm long), contiguous to terminal heterocysts but not to intercalary ones.

Habitat: Anokhi lake, Gajner.

Anabaena variabilis (Kützing ex Born. Et Flah) AZAR 2207: Trichomes without sheath, cylindrical or barrel shaped. Intercalary heterocysts (4.2 µm broad, 4.9 µm long) rarely terminal, Cells 2.8 µm broad, 5.6 µm long. Akinetes cylindrical (4.9 µm broad, 6.3 µm long), in series and away from heterocysts.

Habitat: Loose soil Sukhadi riverbed, Bali (Pali).

9. *Anabaena variabilis* var. *ellipsospora* (Fritsch) AZAR 2205: Trichomes thinly sheathed. Terminal and intercalary heterocysts (3.08 µm broad, 3.92 µm long), Cylindrical cells, 2.8 µm broad,

4.2 µm long. Akinetes cylindrical (4.2 µm broad, 7 µm long), single or in series and away from heterocysts.

Habitat: Lake, Kolayatji.

10. *Anabaena variabilis* var. *ellipsospora* (Fritsch) AZAR 2210: Nearly straight trichomes without sheath. Cells 2.52 µm broad, 4.2 µm long. Heterocysts (2.8 µm broad, 3.78 µm long) intercalary. Akinetes (4.2 µm broad, 7 µm long) ellipsoidal with rounded ends. Habitat: Lake, Kolayat.

11. *Anabaena variabilis* var. *ellipsospora* (Fritsch) AZAR 2206: Single, cylindrical trichome without firm sheath. Cells 4.2 µm broad, 4.9 µm long. Heterocysts (5.6 µm broad, 9.8 µm long) intercalary and rarely terminal. Akinetes subspherical (4.2 µm broad, 8.4 µm long).

Habitat: High iron containing sandstone, Mandore.

Form-genus VIII. *Nostoc*

1. *Nostoc commune* (Vaucher ex Born. et Flah) AZAR 1203 : Filamentous (5.6 µm broad, 4.9 µm long) heterocystous in common sheath forming globose flattened thallus (green leaf like and mehndi green

globose in 2 month old). Trichome entangled, sheath distinct only at periphery. Colony tip has heterocyst like structure at one or both ends in leaf like forms and rarely in globose forms. Barrel shaped to nearly spherical cells (4.48 μ m diameter), 3.36 μ m L and 4.2 μ m B in 2 month old). Terminal spheroidal (5 μ m dia.) heterocyst. Spores not seen.

Habitat: Crusted sand, Near Suratgarh Thermal Power Station.

Form-genus IX. *Scytonema* Kisselewa

1. *Scytonematopsis woronichinii* (Kiss)
AZAR 1801: Bluish green, branched filaments embedded in very thick mucilagenous sheath, Trichome constricted at cell joints, prominent barrel shaped cells (7.18-10.71 μ m broad, 3.57 μ m long), slightly conical terminal cell with rounded tip, hormogonia present, cytoplasm granulated (when observed at 1000x), heterocysts (7.18-10.71 μ m long, 5.36 to 10.71 μ m broad) terminal as well as intercalary.

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Habitat: Loose barren sand, Sam.

Subsection IV.II

Form-genus III. *Tolypothrix* Kützing

1. *Tolypothrix campylonemoides*
(Ghose) AZAR 2101: Dirty brown thallus with blue green, falsely branched, flexuous (10 μ m broad) filaments, thinly covered with sheath. Cells (8 μ m B x 4 μ m L) barrel shaped. Single intercalary heterocysts (8.8 μ m B, 8 μ m L).

Habitat: Uncultivated field soil, Ramdeora.

Taxonomic position still to be defined

1. *Aulosira prolifica* (Bharadwaja)
AZAR 2300: Pale green Trichomes snake like intermingled in thick mucilagenous common sheath on 3 months incubation. Barrel shaped non attenuated trichome in very thin mucilaginous sheath. Terminal and intercalary oval heterocysts (8.4 μ m broad, 9.8 μ m long), cells 5.6 μ m (4.6 μ m in 3 month old) broad, 7 μ m (8.4 μ m in 3 month old) long. End cell rounded and

cylindrical. Constricted cross walls.
Typical ellipsoid (16.8 x 8 µm)
akinetes form in series on
prolonged incubation.

Habitat: Soil crust near *Prosopis*,
Fidusar Chopar.

Distinctive Features of Green Algae

Division: *Chlorophyta*

Class: *Chlorophyceae*

Order: *Volvocales*

Family: *Chlamydomonadaceae*

1. *Chlamydomonas* sp. AZAR 5700: Unicellular, motile, biflagellated, ovoid or ellipsoidal 5.6 µm diameter, 12.6 µm long with anterior pigment (eye) spot and no papillae. Chloroplast thin, parietal cup shaped. Pyrenoids basal.
Habitat: Kyar 50, Marwad Balliya, Didwana.
2. *Dunaliella* sp. AZAR 5201: Highly motile pyreniform green cells (7 µm B, 8.4 µm L) with parietal chloroplast. Cell wall absent. Resting cells spherical.
Habitat: Kuchaman.
3. *Dunaliella* sp. AZAR 5202: Spherical or oval actively motile (flagellated) cells (8 µm dia.). Cell wall absent. Pyrenoid anterior.

Habitat: 140. Personal well Salina, Didwana..

4. *Dunaliella* sp. AZAR 5203: Ellipsoidal or oval actively motile (flagellated) cells (4 µm B, 8 µm L). Cell wall absent. Parietal chloroplast. Some nonmotile spherical resting cells (6 µm dia.). Pyrenoid anterior.

Habitat: 141. Rainwater ditch, Flamingo clad. Didwana.

Order: *Chlorococcales*

Family: *Oocystaceae*

1. *Chlorella* sp. AZAR 5106: Unicellular (7 µm diameter), cup shaped chloroplast.
Habitat: Sand dune, Sam.
2. *Oocystis pusilla* (Hansgirg) AZAR 5403: Mehndi green thallus, non motile unicellular, some times in clumps of 2 or 4 cells, spheroidal 4.2 to 8.4 µm dia. Cell wall distinct, cytoplasm granulated, pyrenoid absent. Spores not seen.
Habitat: Crust between mobile dunes, Sam.

Order: *Tetrasporales*

Family: *Palmellaceae*

1. *Gloeocystis* sp. AZAR 5301: Unicellular green alga, spherical to ovoid cells, 6.78-8.21 µm diameter,

reproduction through binary fission, single cell divides to give rise to 8 cells, colony up to 14.28 µm.

Habitat: *Tephrosia* dominated soil, Makarwali.

Distinctive Features of Diatoms

Division: Chrysophyta

Class: Bacillariophyceae

1. *Cymbella* sp. AZAR 101: Diatomaceous cells 8.4 µm broad, 14 µm long, elongated cymbal shaped. Single or in pairs.

Habitat: Sodium sulfite trench, Marwad Balliya, Didwana.

2. *Netrium* sp. AZAR 201: Diatomaceous cells 2.8 µm broad, 19.6 µm long. Slipper shaped in longitudinally stacked groups or single.

Habitat: Water sample Lunkaransar playa.

Morphotypic diversity of microalgae from arid zones of Rajasthan was remarkable. A total of 40 species were recorded. In the present study, amongst cyanobacteria there was a dominance of members of the genus *Anabaena* (30%), followed by *Chroococcus*, *Gloeocapsa*, *Synechococcus*, *Lyptolyngbya* (5%) and *Gleothece*, *Synechocystis*, *Nostoc*, *Scytonema*,

Tolypothrix (2.5%) among green algae the order *Volvocales* (10) followed by *Chlorococcales* (5%) and *Tetrasporales* (2.5%) and *Diatoms* (5%).

Cyanobacteria found in the desert showed predominance of unbranched filamentous genera such as *Anabaena*, *Oscillatoria*, *Phormidium*, *Lyngbya*. Globular forms such as *Nostoc* were common as well. *Tiwari et al.* (1999) reported a similar genera. In contrast the desert soils from Western Negev showed dominance of branched cyanobacterium *Scytonema* along with *Microcoleus*, *Schizothrix* and *Nostoc* (*Denin* 1991). Although in desert crust from Colorado Plateau *Microcoleus vaginatus* and *Schizothrix* like morphotypes dominated and *Scytonema* outnumbered *Nostoc* (*Gracia-Pichel et al.*, 2001) but in the present study only *Scytonema* and *Nostoc* were observed. Morphotypic diversity of microalgae in arid zones of Rajasthan showed that the habitat complexity structured the small and simple yet unique local communities as depicted by low morphotype richness.

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