Pak. J. Bot., 35(5): 731-741, 2003.

SURVEY OF FRESHWATER CYANOPHYTA FROM CERTAIN AREAS OF NORTHERN REGION OF PAKISTAN AND AZAD KASHMIR

SABEEN NAZ[1], MUSTAFA SHAMEEL[1], MASUD-UL-HASAN[2] AND SHAFIQUE-UR-REHMAN[3]

[1]*Department of Botany, University of Karachi, Karachi-75270*
[2]*Department of Botany, Government College University, Lahore*
[3]*Department of Botany, AJK University, Muzaffarabad*

Abstract

One hundred sixty-nine species of planktonic, epipelic, epipsammic, epiphytic, aerophytic and epilithic blue-green algae belonging to 2 classes, 4 orders, 9 families and 33 genera have been collected from various freshwater habitats in the districts of Jhang, Jhelum, Gujranwala, Sialkot, Lahore, Kasur, Sheikhupura, Sargodha, Khushab and Jauharabad in the province of the Punjab, as well as from N.W.F.P., Pakistan and Azad Kashmir. Members of the Nostocophyceae with 125 species were found to be more prevalent than those of the Chroocophyceae with 44 species. *Oscillatoria* with 45 species was the most commonly occurring genus. Greatest species diversity was exhibited by the collections made in Lahore and neighbouring areas. Heterotrichous species were only scarcely observed. Their growth was most abundant in the aquatic environment especially in planktonic state than in the terrestrial environment in benthic condition.

Introduction

The blue green algae have been an interesting object of investigation because of their very primitive nature and a world-wide distribution, which is due to their capability to exit under most varied environmental conditions. They are the pioneers of the bare areas and play an important role in nitrogen fixation from the atmosphere. They are amphibious in character *i.e.* they live on land as well as in fresh and seawater both (Shameel, 2000). A few studies have been conducted on freshwater cyanophytes of Karachi (Farzana & Nizamuddin, 1979; Shameel & Butt, 1984), other areas of Sindh (Leghari & Arbani, 1983, 1984; Leghari *et al.*, 2000, 2001) and N.W.F.P. (Faridi, 1964, 1971, 1975, 1978). But little attention has been paid on the study of blue-green algae of the Punjab and Azad Kashmir. Ghose (1919, 1924) was the first phycologist to start the systematic study of blue-green algae from this area and reported fifty-nine species including nine new species and three new varieties. Randhawa (1930) mainly worked on Chlorophyta but added twenty-three species of blue-green algae to the list of this region. Twenty-five species of blue-green algae growing in the culture of rice field soils of Kashmir were isolated by Khan (1957). About ninety-five species were reported by Ali & Sandhu (1972) of which seventy-eight were recorded for the first time from this area. Later on Masud-ul-Hasan (1978a,b) has reported some freshwater green algae including Cyanophyta which were collected from ponds around Lahore.

Materials and Methods

Several surveys were made and algae were collected from various freshwater habitats *e.g.* rain pools, temporary ponds, permanent water reservoirs, rivers, rivulets,

brooks, brooklets, rice fields, canals, irrigation channels, lakes and tanks from the districts of Jhang, Jhelum, Gujranwala, Sialkot, Kasur, Sheikhupura, Sargodha, Khushab and Jauharabad in the province of the Punjab, from Attock and Swat in N.W.F.P., Pakistan and from Muzaffarabad, Chenari and Neelam Valley in Azad Kashmir at different seasons of the year. Temeperature and pH of water at the place of collection were noted. The material collected in the field was brought to the laboratory and preserved in 3-5 percent formalin solution to which a little of glycerine was added. For studying the material under microscope, semi-permanent preparations in glycerine were made and sealed with nail polish. Various blue green species were taxonomically determined with the help of standard literature (*e.g.* Geitler 1932; Rao 1937; Desikachary, 1959; Prescott, 1969; Anagnostidis & Komarek, 1985, 1988; Komarek & Anagnostidis, 1986, 1989 etc.).

Result and Discussion

On the basis of their morphological and cytological characteristics an attempt was made to identify the collected blue green algae up to species level. The following 169 species have been identified, they are systematically arranged according to the recently proposed classification (Shameel, 2001).

KINGDOM MONERA
PHYLUM CYANOPHYTA
CLASS CHROOCOPHYCEAE
Order Chroococcales
Family Chroococcaceae
Aphanocapsa Nägeli
A. crassa Ghose
A. pulchra (Kützing) Rabenhorst
A. roeseana de Bary
A. virescens (Hass) Rabenhorst
Aphanothece Nägeli
A. castagnei (Brébisson) Rabenhorst
A. saxicola Nägeli
Chroococcus Nägeli
C. cohaerens (Brébisson) Nägeli
C. gomontii (Kützing) Nygaard
C. hansgirgii Schmidle
C. minor (Kützing) Nägeli
C. minutus (Kützing) Nägeli
C. tenax (Kirchner) Hieron
C. turgidus (Kützing) Nägeli
C. varius A. Braun
Gloeocapsa Kützing
G. aeruginosa (Carm) Nägeli
G. calcarea Tilden
G. gelatinosa Kützing
G. kuetzingiana Nägeli
G. livida (Carm) Kützing
G. magma (Brébisson) Kützing
G. montana Kützing
G. pleurocapsoides Novacek
G. polydermatica Kützing
G. varius Hollerback
Gloeothece Nägeli
G. samoensis Wille
Merismopedia Meyen
M. aeruginea Brébisson
M. convoluta Brébisson
M. glauca (Eherenberg) Nägeli
M. marssonii Lemmermann
M. minima Beck
M. punctata Meyen
M. tenuissima Lemmermann
Microcystis Kützing
M. aeruginosa Kützing
M. flos-aquae (Witt) Kirchner
M. pseudofilamentosa Crow
M. pulverea (Wood) Forte
M. robusta (Clark) Nygaard
M. viridis (A. Braun) Lemmermann
Synechococcus Nägeli
S. aeruginosus Nägeli
S. elongatus Nägeli

Synechocystis Sauvageau
S. aquatilis Sauvageau
S. pevelekii Ercegovic
Family Entophysalidaceae
Johannesbaptistia J. de Toni
J. pellucida Dickie Taylor *et* Drouet
Order Chamaesiphonales
Family Dermocarpaceae
Stichosiphon Geitler
S.sansibaricus (Hieron) Drouet *et* Daily
CLASS NOSTOCOPHYCEAE
Order Nostocales
Family Microchaetaceae
Microchaete Thuret
M. aequalis Frémy
Family Nostocaceae
Anabaina Bory
A. ambigua C. B. Rao
A. anomala Fritsch
A. ballyganglii Banerji
A. spiroides var *contracta* Klebahn
A. fertilissima C. B. Rao
A. inaequalis (Kützing) Bornet *et* Flahault
A. iyengarii var *tenuis* C. B. Rao
A. laxa (Rabenhorst)
A. naviculoides Fritsch
A. oryzae Fritsch
A. oscillarioides Bory *ex* Bornet *et* Flahault
A. sphaerica Bornet *et* Flahault
A. vaginicola Fritsch *et* Rich
A. variabilis Kützing *ex* Born *et* Flahault
A. variabilis var *Kashiensis* (Bharadwaja) Fritsch
Anabaenopsis (Wolosz) Miller
A. circularis (G. S. West) Wolosz *et* Miller
Cylindrospermum Kützing
C. doryphorum Bruhl *et* Biswas
C. majus Kützing *ex* Bornet *et* Flahault
C. michailovskoense Elenkin
Nodularia Martens
N. spumigena Martens *ex* Bornet *et* Flahault
Nostoc Vaucher
N. calcicola Brébisson *ex* Bornet *et* Flahault
N. carneum Agardh *ex* Bornet *et* Flahault
N. passerinianum (De Not) Bornet *ex* Born *et* Flahault
Raphidiopsis Fritsch *et* Rich
R. indica R. N. Singh
Family Oscillatoriaceae
Arthrospira Stizenberger
A. khannae Drouet *et* Strickland
A. platensis (Nordst) Gomont
Lyngbya Agardh
L. birgei G. M. Smith
L. ceylanica Wille
L. confervoides C. A. Agardh *ex* Gomont
L. connectens Bruhl *et* Biswas
L. dendrobia Bruhl *et* Biswas
L. hieronmusii Lemmermann
L. lachneri (Zimmermann) Geilter
L. martensiana Meneghini *ex* Gomont
L. majuscula Harvey *ex* Gomont
L. polysiphoniae Frémy
L. rubida Frémy
L. scotti Fritsch
L. stagnina Kützing
L. toylorii Drouet *et* Strickland
L. truncicola Ghose
Microcoleus Desmazieres
M. paludosus (Kützing) Gomont
M. sociatus West *et* West
M. vaginatus (Vaucher) Gomont
Oscillatoria Vaucher
O. acuta Bruhl *et* Biswas orth mut Geitler
O. amoena (Kützing) Gomont
O. amphibia Agardh *ex* Gomont
O. amphigranulata Van Goor
O. anguina (Bory) Gomont
O. angusta Koppe
O. boryana Bory *ex* Gomont

O. brevis (Kützing) Gomont
O. chalybea (Martens) Gomont
O. chalybea var. *insularis* Gardner
O. chilkensis Biswas
O. chlorina Kützing *ex* Gomont
O. claricentrosa Gardner
O. curviceps Agardh *ex* Gomont
O. earlei Gardner
O. fracta
O. fremyii J. de Toni
O. foreauin Frémy
O. formosa Bory *ex* Gomont
O. geitleriana Elenkin
O. hamelii Frémy
O. jasorvensis Youk
O. lacustris (Klebahn) Geitler
O. laetevirens (Crouan) Gomont
O. limosa Agardh *ex* Gomont
O. limnetica Lemmermann
O. martini Frémy
O. obscura Bruhl *et* Biswas
O. okeni Agardh *ex* Gomont
O. ornata Kützing *ex* Gomont
O. ornata var. *crassa* C. B. Rao
O. perornata Skuja
O. princeps Vaucher *ex* Gomont
O. proteus Skuja
O. pseudogeminata G. Schmid
O. quadripunctulata Bruhl *et* Biswas
O. raoi J. de Toni
O. saucta (Kützing) Gomont
O. subbrevis Schmidle
O. subtilissima Kützing
O. tanganyikae G. S. West
O. terebriformis Agardh *ex* Gomont
O. tenuis Agardh *ex* Gomont
O. vizagapatensis C. B. Rao
O. willei Gardner *em.* Drouet

Phormidium Kützing
P. abronema Skuja
P. bohneri Schmidle
P. ceylanicum Wille
P. fragile (Meneghini) Gomont
P. foveolarum (Mont.) Gomont
P. jenkelianum G. Schmid
P. molle (Kützing) Gomont
P. mucosum Gardner
P. papyraceum (Agardh) Gomont
P. retzii (Agardh) Gomont
P. subfuscum Kützing *ex* Gomont
P. subincrustatun Fritsch *et* Rich
P. tenue (Meneghini) Gomont
P. usterii Schmidle

Polyclamydum West *et* West
P. insigne West *et* West

Spirulina Turpin *et* Gardner
S. gigantea Schmidle
S. laxissima G. S. West
S. major Kützing *ex* Gomont
S. princeps W. *et* G. S. West
S. subtilissima Kützing *ex* Gomont

Symploca Kützing
S. muscorum Agardh Gomont

Family Rivulariaceae

Calothrix Agardh
C. brevissima G. S. West
C. castellii (Massal) Bornet *et* Flahault
C. clavata G. S. West
D. contarenii (Zanard) Bornet *et* Flahault
C. crustacea Thuret
C. membranacea Schmidle
C. minima Frémy

Gloeotrichia Agardh
G. natans Rabenhorst *ex* Bornet *et* Flahault
G. pisum Thuret *ex* Born *et* Flahault

Rivularia (Roth) Agardh
R. hansgirgi Schmidle

Family Scytonemataceae

Plectonema Thuret
P. terebrans Bornet *ex* Gomont

Scytonema Agardh
S. simplex Bharadwaja

Scytonematopsis Kisselewa
S. kashyapi (Bharadwaja) Geitler

Order Stigonematales

Family Stigonemataceae

Stigonema Agardh
S. dendroideum Frém

Table 1. Occurrence of blue-green algae in different areas of northern region of Pakistan and Azad Kashmir.

Algal species	Habitat	Localities											
		1	2	3	4	5	6	7	8	9	10	11	12
Aphanocapsa													
A. crassa	Planktonic									+			
A. pulchra	Planktonic	+					+		+			+	
A. roeseana	Planktonic										+		
A. virescens	Planktonic											+	
Aphanothece													
A. castagnei	Planktonic									+			
A. saxicola	Planktonic					+							
Chroococcus													
C. cohaerens	Planktonic						+					+	
C. gomontii	Planktonic		+										
C. hansgirgii	Planktonic											+	
C. minor	Planktonic						+				+		
C. minutus	Planktonic		+			+	+			+	+		+
C. tenax	Planktonic						+			+			
	Epilithic												+
C. turgidus	Planktonic		+			+	+						
C. varius	Planktonic						+						
Gloeocapsa													
G. aeruginosa	Planktonic						+						
G. calcarea	Planktonic						+						
G. gelatinosa	Planktonic						+						
G. kuetzingiana	Planktonic									+			
G. livida	Planktonic												+
G. magma	Planktonic						+						
G. montana	Planktonic						+						
G. pleurocapsoides	Epioikotic									+			
G. polydermatica	Epioikotic						+						
G. varius	Planktonic						+						
Gloeothece													
G. samoensis	Epioikotic									+			
Merismopedia													
M. aeruginea	Edaphic									+			
M. convoluta	Planktonic						+						
M. glauca	Planktonic						+					+	
M. marssonii	Planktonic												+
M. minima	Planktonic						+						
M. punctata	Planktonic		+					+		+		+	
M. tenuissima	Planktonic						+					+	
Microcystis													
M. aeruginosa	Planktonic						+						
M. flosaquae	Planktonic						+						

Table 1 (Cont'd.)

Algal species	Habitat	Localities											
		1	2	3	4	5	6	7	8	9	10	11	12
M.pseudofilamentosa	Planktonic						+						
M. pulverea	Planktonic										+		
M. robusta	Planktonic					+	+						
M. viridis	Planktonic									+			
Synechococcus													
S. aeruginosus	Edaphic						+						
S. elongatus	Planktonic									+			
Synechocystis													
S. aquatilis	Edaphic						+						
S. pevelekii	Edaphic					+	+						
Johannesbaptistia													
J. pellucida	Edaphic						+			+			
Stichosiphon													
S. sansibaricus	Planktonic									+			
Microchaete													
M. aequalis	Planktonic							+					
Anabaenopsis													
A. circularis	Planktonic										+		
Anabaina													
A. ambigua	Planktonic						+			+			
A. anomala	Planktonic			+			+						
A. ballyganglii	Planktonic						+						
A. spiroides	Planktonic			+			+						
A. fertilissima	Planktonic		+	+			+						+
A. inaequalis	Planktonic						+						
A. iyengarii	Planktonic		+	+			+			+			
A. laxa	Planktonic						+						
A. naviculoides	Planktonic						+						
A. oryzae	Planktonic						+						
A. oscillarioides	Planktonic		+			+	+			+			
A. sphaerica	Planktonic						+						
A. vaginicola	Planktonic						+						
A. variabilis	Edaphic						+						
Cylindrospermum													
C. doryphorum	Epilithic												+
C. majus	Epilithic											+	
C. michailovskoense	Planktonic						+						
Nodularia													
N. spumigena	Planktonic						+						
	Epipsammic										+		
Nostoc													
N. calcicola	Planktonic											+	
N. carneum	Planktonic											+	

Table 1 (Cont'd.)

Algal species	Habitat	Localities											
		1	2	3	4	5	6	7	8	9	10	11	12
N. passerinianum	Planktonic												+
Raphidiopsis													
R. indica	Planktonic									+			
Arthrospira													
A. khannae	Planktonic					+	+						
A. platensis	Planktonic						+			+			
Lyngbya													
L. birgei	Planktonic		+										
L. ceylanica	Planktonic						+						
L. confervoides	Planktonic		+		+								+
L. connectens	Planktonic										+		
L. dendrobia	Planktonic		+				+						
L. hieronmusii	Planktonic		+	+			+	+			+		+
L. lachneri	Edaphic						+						
L. martensiana	Planktonic						+				+		
L. majuscula	Planktonic						+						
	Epioikotic										+		
L. polysiphoniae	Planktonic									+			
L. rubida	Planktonic		+										
L. scotti	Edaphic						+						
L. stagnina	Planktonic											+	
L. taylorii	Edaphic						+						
L. truncicola	Edaphic									+			
	Planktonic			+									
Microcoleus													
M. paludosus	Planktonic						+						
M. sociatus	Planktonic						+						
M. vaginatus	Planktonic							+			+		
Oscillatoria													
O. acuta	Planktonic		+				+	+			+	+	
O. amoena	Edaphic										+		
	Planktonic						+						
O. amphibia	Edaphic						+						
O. amphigranulata	Planktonic					+							
O. anguina	Planktonic						+						
O. angusta	Planktonic										+		
O. boryana	Planktonic		+										
O. brevis	Edaphic		+				+						
O. chalybea	Planktonic						+						
O. chilkensis	Planktonic						+						
O. chlorina	Planktonic						+						
	Edaphic										+		
O. claricentrosa	Planktonic					+							

Table 1 (Cont'd.)

Algal species	Habitat	Localities											
		1	2	3	4	5	6	7	8	9	10	11	12
O. curviceps	Planktonic					+	+					+	
O. earlei	Planktonic									+			
O. fracta	Edaphic						+						
O. fremyii	Planktonic						+				+		
O. foreauin	Edaphic						+						
O. formosa	Edaphic						+						
O. geitleriana	Planktonic					+							
O. hamelii	Planktonic										+		
O. jasorvensis	Edaphic						+						
O. lacustris	Edaphic						+						
O. laetevirens	Edaphic						+						
O. limosa	Planktonic			+	+							+	
O. limnetica	Planktonic											+	
O. martini	Planktonic										+	+	
O. obscura	Planktonic												
O. okeni	Planktonic										+	+	
O. ornata	Planktonic		+	+			+						
O. perornata	Planktonic			+			+						
O. princpes	Planktonic			+			+						
O. proteus	Planktonic		+									+	
O. pseudogeminata	Epioikotic						+			+			
O. quadripunctulata	Edaphic						+						
O. raoi	Planktonic						+					+	
O. sancta	Edaphic											+	
	Planktonic						+						
O. subbrevis	Edaphic							+				+	+
	Planktonic						+				+		
O. subtilissima	Edaphic						+						
O. tanganyikae	Edaphic						+						
O. terebriformis	Planktonic						+						
O. tenuis	Edaphic					+					+		+
	Planktonic						+						
O. vizagapatensis	Planktonic										+		
O. willei	Planktonic						+						
Phormidium													
P. abronema	Edaphic						+						
P. bohneri	Edaphic						+						
P. ceylanicum	Planktonic										+		
P. fragile	Edaphic						+						
P. foveolarum	Edaphic						+						
P. jenkelianum	Edaphic						+						
P. molle	Edaphic						+						
P. mucosum	Edaphic						+						

Table 1 (Cont'd.)

Algal species	Habitat	Localities											
		1	2	3	4	5	6	7	8	9	10	11	12
P. papyraceum	Edaphic						+						
P. retzii	Epioikotic						+						
P. subfuscum	Edaphic						+						
P. subincrustatum	Edaphic						+						
P. tenue	Edaphic						+						
P. usterii	Edaphic						+						
Polyclamydum													
P. insigne	Planktonic						+						
Spirulina													
S. gigantea	Planktonic											+	
S. laxissima	Planktonic						+				+		
S. major	Planktonic						+						
	Edaphic									+	+		+
S. princeps	Planktonic						+						
S. subtilissima	Planktonic						+						
Symploca													
S. muscorum	Planktonic						+						
Calothrix													
C. brevissima	Planktonic						+						
C. castellii	Planktonic						+						
C. clavata	Planktonic						+						
C. contarenii	Planktonic						+						
C. crustacea	Planktonic						+						
C. membranacea	Planktonic						+				+		
C. minima	Planktonic						+						
Gloeotrichia													
G. natans	Planktonic						+						
G. pisum	Planktonic					+							
Rivularia													
R. hansgirgi	Edaphic									+			
Plectonema													
P. terebrans	Planktonic									+			
Scytonema													
S. simplex	Planktonic									+			
Scytonematopsis													
S. kashyapi	Planktonic									+			
Stigonema													
S. dendroideum	Planktonic									+			

1 = Attock, **2** = Gujranwala, **3** = Jauharabad, **4** = Jhang, **5** = Kasur, **6** = Lahore, **7** = Pasroor, **8** = Sargodha, **9** = Sheikhupura, **10** = Sialkot, **11** = Swat, **12** = Azad Kashmir.

Members of the class Nostocophyceae with 125 species were found to be more prevalent than those of the class Chroocophyceae with 44 species. Similar observations were made on the diversity of intertidal marine cyanophytes in the shore waters of Karachi (Bano & Siddiqui, 2003). *Oscillatoria* with 45 species was the most commonly occurring genus, while *Anabaina*, *Lyngbya* and *Phormidium* with 14-15 species were the next; among unicellular genera *Gloeocapsa* was most common with 10 species. Poorly distributed genera were *Johannesbaptistia* and *Stichosiphon* among unicellular algae and *Anabaenopsis*. *Microchaete*, *Nodularia*, *Plectonema*, *Polyclamydum*, *Raphidiopsis*, *Rivularia*, *Scytonema*, *Scytonematopsis*, *Stigonema* and *Symploca* among filamentous algae, being represented by a single species each. Greatest species diversity was exhibited by the collections made in Lahore and neighbouring areas (Table 1), while poorest diversity was shown in the collections from the areas of Attock, Jhang and Sargodha. Other groups of freshwater algae were also found in abundance in Lahore (Masud-ul-Hasan, 1978a,b). Heterocystous blue-green algae were only scarcely observed. Absence of heterocystous algae has also been noted at Balochistan coast (Shameel, 2000) and in other marine environments (Thajuddin & Subramanian, 1992; Stall *et al.*, 1996). Reduction in the abundance in heterocystous species has been found out subsequent to anthropogenically elevated levels of nutrients in a freshwater ecosystem (Perona *et al.*, 1998)

Usually blue green algae were found to grow in summer season, but some of them also occurred in winter. High temperature (up to 48°C) with rainfall, intense sunlight and stagnant water with pH 7.5 appeared most suitable for their growth. Members of the same species growing in the summer and rainy season occurred in massive quantity and possessed larger cells than those growing in the winter season. Their growth was most abundant in the aquatic environment especially in planktonic state than in the terrestrial environment (Table 1). The edaphic and epilithic blue-green algae were found to be most diverse compared to their assemblages in rock pools and coastal water of Karachi (Bano & Siddqui. 2003). This is mainly due to the basic difference in the environmental adaptation of freshwater and marine Cyanophyta. The poor abundance of benthic species may be a consequence of their grazing by herbivorous organisms, as sugested by results of herbivore-exclusion experiments where the surfaces of experimental rocks showed dominated growth of blue-green algae (Brendelberger, 1997; Williams *et al.*, 2000). Species of gastropods have been shown to consume Cyanophyta.

A brief report of the occurrence of blue-green algae in the freshwater environment of the Punjab, N.W.F.P. and Azad Kashmir has been presented here. The detailed taxonomic description and habitat ecology of each species will soon follow.

References

Ali, S. and G. R. Sandhu. 1972. Blue green algae of the saline soil of the Punjab. *Oikos*, 23: 268-272.

Anagnostidis, K. and J. Komarek. 1985. Modern approach to the classification system of cyanophytes; 1-Introduction. Arch. Hydrobiol./Suppl. 171. *Algol. Stud.*, 38/39: 291-302.

Anagnostidis, K. and J. Komarek. 1988. Modern approach to the classification system of cyanophytes; 3-Oscillatoriales. Arch. Hydrobiol./Suppl. 80, 1-4 *Algol. Stud.*, 53: 327-472.

Bano, A. and P. J. A. Siddiqui. 2003. Intertidal cyanobacterial diversity on a rocky shore at Buleji near Karachi, Pakaistan. *Pak. J. Bot.*, 35: 27-36.

Brendelberger, H. 1997. Contrasting feeding stratigies of two freshwater gastropods, *Ridex peregra* (Lymnoidae) and *Bithynia tentaculata* (Bithyminiidae). *Arch. Hydrobiol.*, 140: 1-21.

Desikachary, T. V. 1959. *Cyanophyta*. ICAR Monographs, New Delhi, 686 pp.

Faridi, M. A .F. 1964. The Chlorococcales of Peshawer Valley. *Biologia*, 10: 53-58.
Faridi, M. A .F. 1971. The genera of freshwater algae of Pakistan and Kashmir. *Biologia*, 17: 123-142.
Faridi, M. A .F. 1975. *Batrachospermum* in Pakistan. *Biologia*, 21: 107-109.
Faridi, M. A .F. 1978. The genus *Spirogyra* in Pakistan. *Biologia*, 24: 421-435.
Farzana, A. and M. Nizamuddin. 1979. Studies on some members of Cyanophyta from Karachi. *Nova Hedw.*, 31: 247-256.
Geitler, L. 1932. Cyanophyceae. *In*: Rabenhorst's Kryptogamenflora. *Leipzig*: 1-1196.
Ghose, S. L. 1919. The Myxophyceae of Lahore. *J. Ind. Bot. Soc.*, 1: 8-13.
Ghose, S. L. 1924. A systematic and ecological account of the collection of blue-green algae from Lahore and Simla. *J. Linn. Soc. Bot.*, 46: 333-346.
Khan, S. I. 1957. Cultures of algae of the rice field of Kashmir. *Biologia*, 3: 29-43.
Komarek, J. and K. Anagnostidis. 1986. Modern approach to the classification system of cyanophytes; 2-Chroococcales. Arch. Hydrobiol. Suppl. 73, *Algol. Stud.*, 43: 157-226.
Komarek, J. and Anagnostidis. 1989. Modern approach to the classification system of cyanophytes; 2-Nostocales. Arch. Hydrobiol. Suppl. 83, *Algol. Stud.*, 56: 247-345.
Leghari, S. M. and S. N. Arbani. 1983. Epizoic algae from the molluscs of Kinjhar Lake and adjoining areas of River Indus. *Sindh Univ. Res. J.*, Sci. Ser., 15: 140-142.
Leghari, S. M. and S. N. Arbani. 1984. Survey of freshwater algae (Cyanophyceae) from ponds and lakes of lower Sindh. *Sindhol. Stud.*, 2: 67-90.
Leghari, S. M., S.I.H. Jafri, M.A. Mahar, K.H. Lashari, S.S. Ali, T.M. Jahangir and M.Y. Khuhawar. 2000. Limnoligical study of Sonharo, Mehro Pateji and Cholari Lakes of District Badin, Sindh, Pakistan. *Pak. J. Biol. Sci.*, 3: 1904-1909.
Leghari, S. M., M.A. Sahito, Z.A. Nizamani and M.A. Baryar. 2001. Rare fossil algal, fungal and *Riccia* spores isolated from Sonda coal deposits, Thatta, Sindh, Pakistan. *Onl. J. Biol. Sci.*, 1: 173-174.
Masud-ul-Hasan. 1978a. A contribution to the freshwater algae of the Punjab-I. *Biologia*, 26: 71-79.
Masud-ul-Hasan. 1978b. A contribution to the freshwater algae of the Punjab-II. *Biologia*, 24: 81-96.
Perona, E., I. Bonilla and P. Mateo. 1998. Epilithic cyanobacterial communities and water quality: an alternative tool for monitoring eutrophication in the Alberche River (Spain). *J. Appl. Phycol.*, 10: 183-191.
Prescott, G. W. 1969. *The algae, A Review*. Nelson & Sons Ltd., New York, 416 pp.
Randhawa, M. S. 1959. *Zygnemaceae*. ICAR Monograph, New Delhi, 478 pp.
Rao, C. B. 1937. The Myxophyceae of the United Provinces, India-III. *Proc. Indian Acad. Sci.*, B6: 339-375.
Shameel, M. 2000. Biodiversity of the seaweeds growing along Balochistan coast of the northern Arabian Sea. In: *The Arabian Sea as a Source of Biological Diversity*. (Ed.): V.U. Ahmad. Proceed. National O.N.R. Symp., Kar. Univ., p. 45-64.
Shameel, M. 2001. An approach to the classification of algae in the new millennium. *Pak. J. Mar. Biol.*, 7: 233-250.
Shameel, M. and N. I. Butt. 1984. On the occurrence of Cyanophyta from Karachi, Pakistan. *Pak. J. Bot.*, 16: 75-79.
Stall, L. J., S. B. Behrens, M. Villbrandt, S. Van Bergeijk and F. Krinyning. 1996. Biochemsitry of two eutrophic lagoons and its effects on microphytobenthic community. *Hydrobiol.*, 329: 185-198.
Thajuddin, N. and G. Subramanian. 1992. Survey of Cyanobacterial flora of the southern east coast of India. *Bot. Mar.*, 35: 305-314.
Williams, G. A., M. S. Davis and S. Nagarkar. 2000. Primary succession on a seasonal tropical rocky shore: the relative roles of the special heterogeneity and herbivory. *Mar. Ecol. Prog. Ser.*, 203: 81-94.