



Ecotaxonomic studies of some filamentous members of Cyanophycota in four Districts of Punjab, Pakistan

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Abstract

Fifty nine species of blue-green algae belonging to nine genera and two families were collected from four different districts of Punjab, Pakistan. These districts are Gujranwala, Gujrat, Sialkot and Narowal. The collected species were taxonomically identified. Most of the species were collected in the start of summer season at variable temperature. pH and EC was also measured and it was observed that *Spirulina*, *Oscillatoria* and *Lyngbya* were widely distributed genera. It was found that maximum pH was of *O. annae* i.e. 10.8 and minimum was of two species i.e. *O. prolifca* and *O. anguina* i.e. 7.1. Minimum Electrical conductivity (EC) was of *O. prolifca* and *O. anguina* i.e. 53 and the maximum EC was of *Lyngbya truncicola* which is 205.

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Introduction

There is world-wide distribution of blue-green algae. These are thought to be the pioneers of bare areas and are principal producers in the aquatic environment. These release oxygen in the environment for itself and also for other aerobic organisms. Ecologically algae play a significant role in the nitrogen fixation and these are the initiators of food chains. These are one of the most important indicators of water quality because of their rapid reaction to environmental changes related to larger animals and plants (Ali *et al.*, 2010, 2011).

Different environmental factors effect on the distribution of different algal species. Light, temperature, salinity, pH, hardness, solubility of gases, electrical conductivity, density and concentration of different nutrients are the important factors for growth of algae. Therefore, this study was carried out to explore some unidentified as well as reported and unreported freshwater algal species and also to explore the relation between algal growths and different ecological factors especially pH and EC (Odum, 1971; Maher *et al.*, 2000; Janjua *et al.*, 2009; Maher *et al.*, 2009).

By studying various reviews by the different researchers in this field particularly in sub-continent, give an idea that they put more emphasis on morphological features of algal species. Although, the importance of ecological factors like pH and EC cannot be ruled out for their distribution in various places. So, by keeping in mind the necessity of the eco-taxonomic studies of algal species now a day, this research work was carried out at large extent. This study could be helpful at various stages in applied fields of phycology like the designing of algal cultures and biofuel production by identifying the algae at their optimum environmental conditions.

Materials and methods

Study area

This research was carried out in north-eastern areas of Punjab, Pakistan. Four districts were selected i.e. Gujranwala, Gujrat, Sialkot and Narowal. This area is

located between two main rivers of Punjab i.e. River and Chenab. But apart from these, there are several irrigation canals, water channels, ponds, small lakes, rain pools and fish farms. These all act as the natural habitats for algae.

Collection and preservation of samples

Sampling was carried out in different seasons during 2011 to 2015. Samples were collected either by hand picking, forceps or nets in plastic bottles. Then, the collected samples were preserved according to standard method (APHA, 1985) i.e., in 3 to 4% formaline (aqueous solution of formaldehyde). Voucher specimens were kept in Phycology lab, Department of Botany, GC University, Lahore. Different ecological parameters e.g. pH, TDS and EC were also measured.

Laboratory study

The samples were slightly stained with 1% iodine solution to make wall and other structures clearly visible. The stained material was examined under inverted microscope and sketches were drawn with the help of camera Lucida and the required measurements were obtained by means of a calibrated ocular microscope. The specimens were taxonomically identified with the help of literature e.g. Prescott (1962) and Desikachary (1959). The algal species were systematically arranged according to the Shameelian classification system (Shameel, 2012).

Results and discussion

Collected samples were investigated under microscope and identified up to species level. On the basis of morphological and cytological characteristics fifty nine species belonging to Kingdom Monera were identified. All species belong to Phylum Cyanophycota, class Nostocophyceae, order Nostocales. These species belong to two families i.e. Microchaetaceae and Oscillatoriaceae. Family Microchaetaceae having only genus which further contains only species i.e. *Microchaete aqualis*, while on the other hand family Oscillatoriaceae contains nine genera i.e. Arthrospira, Lyngbya, Oscillatoria, Spirulina, Schizothrix, Microcoleus, Phormidium,

Planktothrix and Porphyrosiphon. *Arthrospira* contains only two species *A. platensis* and *A. Jenneri*. *Lyngbya* contains 13 species which are *L. allorgei*, *L. martensiana*, *L. hieronymusii*, *L. spirulinoides*, *L. birgei*, *L. connectens*, *L. major*, *L. majuscula*, *L. confervoides*, *L. dendrobia*, *L. rubida*, *L. truncicola* and *L. stagnina*. Genus *Oscillatoria* contains 27 species which are *O. acuta*, *O. acutissima*, *O. amoena*, *O. anguina*, *O. angusta*, *O. annae*, *O. boryana*, *O. chalybea*, *O. chilkinsis*, *O. chlorine*, *O. curviceps*, *O. fremyii*, *O. hamelii*, *O. limnetica*, *O. limosa*, *O. martini*, *O. nigra*, *O. obscura*, *O. okenii*, *O. peronata*, *O. proteus*, *O. sancta*, *O. subbrevis*, *O. tenuis* and *O. vizagapatensis*. Genus *Spirulina* contains only six species which are *S. gigantea*, *S. laxissima*, *S. major*, *S. princeps*, *S. subsalsa* and *S. subtilissima*. Genus *Schizothrix* contains only one species i.e. *S. friesii* while genus *Microcoleus* contains three species which are *M. paludosum*, *M. acutissima* and *M. vaginatus*. Genus *Phormidium* contains five species which are *P. chalybeum*, *P. chlorinum*, *P. limosum*, *P. martini* and *P. okeni*. Genus *Planktothrix* and genus *Porphyrosiphon*, each contains one species *P. rubescens* and *P. martensianus* respectively. Some morphological characters were observed and compared in the table 1.

Most diverse genus was *Oscillatoria* having 27 species as it is an identification of polluted water and is found in sewage waste, ponds and other polluted water. Similarly, *Lyngbya* is also a diverse genus having 13 species. It was observed that *Spirulina*, *Oscillatoria* and *Lyngbya* were widely present throughout the study area. While, other genera like *Arthrospira*, *Phormidium* etc were not so common and diverse. These genera have few members and on few localities, they were abundant.

In this table five morphological characters were compared within 59 species of 2 families. These characters are trichome shape, trichome width, spiral width, spiral distance, and characters of vegetative cells. It was observed that spiral trichomes are present only in *Spirulina* and *Arthrospira* while rest all species lack this character. *Arthrospira* has loose

spirals ranging 13-57 μ spiral distance while on the other hand *Spirulina* is regularly spirally coiled having spiral distance in the range of 1.25-16 μ . Both genera are not covered with a protective sheath. Sometimes, coiled trichomes may be present in *Oscillatoria*.

Other genera like *Lyngbya*, *Microcoleus*, *Phormidium*, *Schizothrix* and *Porphyrosiphon* were sheathed. Their sheath may be colourless or of different colours due to the deposition of different pigments while genera like *Oscillatoria* and *Planktothrix* lack an evident sheath. One important character of *Schizothrix* was unique from rest of the sheathed genera that its sheath was dichotomously branch.

Oscillatoria annae was found at maximum pH i.e. 10.8 and *O. prolifica* and *O. anguina* was at minimum pH i.e. 7.1. It was observed from this study that all the species were found at basic pH and no species was found in acidic pH. Only two species were observed at very slight basic pH i.e. 7.1 and these species are *O. prolifica* and *O. anguina*.

It was estimated that at alkaline pH, dissolved inorganic and organic matter increased in water which favours the growth of algae. Those algae which were collected at pH range 8.0-9.0 show abundant growth.

Similarly Electrical Conductivity (EC) is another important ecological factor which controls the growth of algae in aquatic medium. Minimum Electrical conductivity (EC) was of *O. prolifica* and *O. anguina* i.e. 47 and the maximum EC was of *Lyngbya truncicola* which is 205. Most of the algae show growth above than 100 μ s.

Those algae which were collected below 100 μ s show restricted growth. It was also observed that algae showing maximum EC also have pH i.e. 9.0, which favours maximum growth on the other hand algae growing in minimum EC also have minimum value of pH which clearly depicts that minimum growth of algae.

Table 1. Some ecotaxonomic characters of different algal species of four Districts of Punjab, Pakistan.

S. No.	Algal Species	Trichome shape	Vegetative cells	*TW (µm)	*SW (µm)	*SD (µm)	pH	*EC (µs)
01	1. <i>Arthrospira platensis</i> var. <i>tenuis</i>	More or less spirally coiled in regular fashion	2-6 long	6-8	26-36	13-57	8.7	155.5
	2. <i>A. Jenneri</i>	More or less spirally coiled in regular fashion	4-5 long	5-8	9-15	21-31	8.9	85.5
02	1. <i>Lyngbya allorgei</i>	Twisted	Up to 1.5 times as long as broad	3.5-4	-	-	9.35	87.5
	2. <i>L. martensiana</i>	Elongate and flexible	1/2-1/4 times as long as broad	6-10	-	-	7.45	53
	3. <i>L. spirulinoides</i>	Regularly spirally coiled	Cells 1/2-1/5 as long as broad	14-16	-	73-108	9.05	112
	4. <i>L. birgei</i>	Straight	Cells much shorter than broad	18-23	-	-	8.75	145.5
	5. <i>L. connectens</i>	Filaments may or may not be straight	Cells 1/6 as long as broad	12-17	-	-	9.4	122.5
	6. <i>L. hieronymusii</i>	Straight or straightly bent	Cells 4-5 times broad than long	12-14	-	-	9.95	163
	7. <i>L. major</i>	Straight	Cells 1/4-1/8 as long as broad	11-16	-	-	8.25	129
	8. <i>L. majuscula</i>	Curved or rarely slightly coiled	Cells 1/6-1/5 times as long as broad	16-60	-	-	8.55	92.5
	9. <i>L. confervoides</i>	Straight	Cells 1/3-1/8 times as long as broad	9-25	-	-	8.4	179
	10. <i>L. dendrobia</i>	Long and flexible closely interwoven	Cells 1.7-2.5 times as long as broad	9-10	-	-	8.6	117
	11. <i>L. rubida</i>	Straight and stiff	Cells 1 ^{1/2} -3 times as long as broad	6-8	-	-	9.2	125
	12. <i>L. stagnina</i>	Flexuous	Length greater than width	9.5-12	-	-	8.5	158.5
	13. <i>L. truncicola</i>	Straight more or less parallel	Length is much greater than width	12-14	-	-	9.0	205
03	1. <i>Oscillatoria acuta</i>	Quite straight	1.8-6 long and 1.6-8 broad	4-6	-	-	8.25	139.5
	2. <i>O. amoena</i>	Straight	2.5-4.2 long and 5-14 broad	2.5-5	-	-	8.2	141.5
	3. <i>O. angusta</i>	Straight	5-7 long	0.8-1.2	-	-	8.05	130.5
	4. <i>O. annae</i>	Straight	1.5-4 long and up to 7 broad	7.5-8	-	-	10.8	54.5
	5. <i>O. anguina</i>	Straight	1.5-2.5 long and 5.6-7.6 broad	6-8	-	-	7.1	47
	6. <i>O. acutissima</i>	Straight	3-7 long and 1.5-2 in diameter	1.5-2	-	-	8.75	95
	7. <i>O. boryana</i>	Screw liked coiled	4-6 long	6-8	-	-	8.4	95.5
	8. <i>O. chalybea</i>	Straight or irregularly spirally coiled	3.6-8 long and 4.5-5.5 broad	8-13	-	-	8.85	133.5
	9. <i>O. chilkensis</i>	Somewhat curved	2 long and 4-6 broad	Up to 4	-	-	7.75	74
	10. <i>O. chlorina</i>	Straight or curved	3.7-8 long	3.5-6	-	-	7.55	68
	11. <i>O. curviceps</i>	More or less straight or spirally coiled at the ends	2-5µ long	10-17	-	-	8.7	155.5
	12. <i>O. fremyii</i>	More or less straight	1-2 long	1-1.3	-	-	8.9	143.5
	13. <i>O. hamelii</i>	More or less bent or undulate	7.2-8 long	4.8-5	-	-	8.1	129
	14. <i>O. limnetica</i>	Straight or slightly bent	4-12 long	1.5	-	-	8.75	157
	15. <i>O. limosa</i>	More or less straight	1.5-5.0 long and 2.5-13.0 broad	13-16	-	-	7.4	52
	16. <i>O. martini</i>	Loosely or spirally coiled	2-6 long and 5-7 broad	6	-	-	10.2	85.5
	17. <i>O. nigra</i>	Straight or more or less bent	3.7-4.5 long and 8-10 in diameter	8-10	-	-	8.6	119
	18. <i>O. obscura</i>	Slightly bent or nearly straight	4-5 broad	Up to 4	-	-	8.65	153.5
	19. <i>O. okenii</i>	Straight	2.7-4.5	5.5-9	-	-	8.35	148
	20. <i>O. proteus</i>	More or less straight or sometimes curved	2-3.7 long	6-7	-	-	8.6	163.5
	21. <i>O. princeps</i>	Straight	3.5-7 long and 27-29 broad	16-60	-	-	8.55	84
	22. <i>O. prolifica</i>	Straight or curved	4-6 long and 2-5 broad	2.2-5	-	-	7.1	47
	23. <i>O. peronata</i>	Erect and flexuous	2.5-6.5 long and 8-9 broad	13-15	-	-	7.6	112
	24. <i>O. sancta</i>	Straight or bent distinctly	2.5-6 long and 11-13 in diameter	2.5-6	-	-	9.15	171
25. <i>O. subbrevis</i>	Nearly straight	1.5-2.5 long and 4.9-6.8	5-6	-	-	7.4	52	
26. <i>O. tenuis</i>	Straight or slightly flexuous	1.5-6 long and 4-5 broad	3-11	-	-	9.0	102.5	
27. <i>O. vizagapatensis</i>	Straight or bent	1.6-2 long	8-10	-	-	7.8	113.5	
04	1. <i>Spirulina subtilissima</i>	Regularly spirally coiled	Isodiametric	0.6-0.9	1.5-2.5	1.25-2	8.5	165
	2. <i>S. major</i>	Regularly spirally coiled	Isodiametric	1.2-1.7	2.5-4	2.7-5	9.45	126
	3. <i>S. princeps</i>	Regularly spirally coiled	Isodiametric	4.5-5	11-12	9.5-11	8.7	139
	4. <i>S. laxissima</i>	Spirals very loose but regular	Isodiametric	0.7-0.8	4.5-5.3	17-22	8.9	137.5
	5. <i>S. subsalsa</i>	Irregularly densely spirally coiled	Isodiametric	1-2	3-5	5.35	9.05	60.5
	6. <i>S. gigantea</i>	Regularly spirally coiled	Isodiametric	3-4	11-16	3-12	9.05	132.5
	7. <i>Schizothrix friesii</i>	Erect tufts	3-6 in diameter and 4-12 long	-	-	-	8.35	96.5
05	1. <i>Microcoleus paludosus</i>	Straight, sometimes branched at ends	-	5-7	-	-	8.75	108.5
	2. <i>M. acutissimus</i>	Nearly straight	cells 2-4 times as long as broad, 3.5-8 long	1.7-2.3	-	-	8.3	138
06	3. <i>M. vaginatus</i>	Nearly straight	3.5-7 long	5-5.6	-	-	7.9	143
	1. <i>Phormidium chalybeum</i>	Almost straight	cells 10-12 broad, 4-6 long	1-12	-	-	8.3	100
	2. <i>P. chlorinum</i>	Slightly curved	cells 5-7 broad, 2-4 long	5-7	-	-	7.7	121.5
	3. <i>P. limosum</i>	Straight	cells 9-11 broad, 4-6 long	9-11	-	-	8.2	146
	4. <i>P. martini</i>	Spirally coiled	5-7 broad, 1-2 long	5-7	-	-	7.75	57
07	5. <i>P. okeni</i>	Straight	7-9 broad and 3-4 long	7-9	-	-	8.75	108.5
	1. <i>Planktothrix rubescens</i>	Straight	2.5-3.5 long	6-7	-	-	9.15	181.5
08	1. <i>Porphyrosiphon martensianus</i>	Long, erect	Isodiametric, 3.3-3.5 long	7-9	-	-	10.2	85.5

Key: TW= Trichome Width; SW= Spiral Width; SD= Spiral Distance; EC= Electrical Conductivity.

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