



# Taxonomic Studies of Freshwater Algae from Taxila, Pakistan

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**Abstract:** A taxonomic study of algal flora on the basis of their morphological and cytological features was conducted for identification up to species level. In the present study we collected a total number of 25 species of fresh water algae, 2 species belonged to class Ulvophyceae, 2 Zygnemophyceae, 7 Chlorophyceae and remaining 14 belonged to class Cyanophyceae from the different freshwater habitats of Taxila zone. It is a first comprehensive taxonomical study from Taxila and its surrounding areas.

**Keywords:** Algae, freshwater, Chlorophyceae, zygnemophyceae, cyanophyceae

## 1. INTRODUCTION

Algae are unicellular or multicellular, photosynthetic but lack true leaves, stems and roots. Their habitat is fresh water and moist areas. Algae have a great value to life on earth. As they are primary producers and play an important role in food chains mostly in aquatic environment & ecosystem [1]. Algae also use in the water cleaning and determination of pollution [2]. Taxila is an important archaeological place in the Rawalpindi District of the Punjab province in Pakistan. It is located about 33 km northwest of Islamabad and Rawalpindi and lies about 550 meters above the sea level. The weather of Taxila is moist subtropical with average rainfall of 990 mm. Most of the rainfall in study areas occurs in monsoon season. The algal samples were collected from Taxila and its surroundings for identification and classification on the basis of their taxonomical characteristics and properties.

## 2. MATERIALS AND METHODS

Twenty five samples of freshwater algae were collected from different freshwater habitats of Taxila, Pakistan and its surrounding areas during winter,

spring and summer seasons from the streams, slow running water, ponds and sides of stagnant ponds. The samples were washed carefully to remove dust particles and then were preserved in 3 % formalin solution in small glass bottles, numbered and labeled according to their habitat. Then these samples were brought in the laboratory of Botany Department, Government College University, Faisalabad. Algal samples were placed on glass slides, teased into pieces, using fine needles, and then covered with cover slips. The slides were placed under the electron-microscope. We determined the taxonomy of samples to the level of species by comparison with published information on taxonomy of taxonomic identification of algae [3–8].

## 3. RESULTS

A taxonomic study of algal species was conducted on the basis of their morphological and cytological features for identification identified up to species level. On the basis of their morphological and cytological features the following 25 species of fresh water algae in which 9 species belong to genus *Oscillatoria*, 4 species belonged to

genus *Stigeoclonium*, 3 species belonged to genus *Microspora*, 3 species belonged to genus *Phormidium*, 2 species belonged to genus *Closterium*, 2 species belonged to genus *Rhizoclonium*, 1 species belonged to genus *Chroococcus* and 1 species of genus *Nostoc* was identified and their classification arranged according to recently proposed pattern. Their taxonomical characters are given below:

**1: *Chroococcus dispersus*** (Keissler) Lemmermann 1904: 102

**General characters:**

There colonies were small with a mucous cover of 3 to 15 cells. The cells were spherical; pale blue green, 4.1 to 4.7  $\mu\text{m}$  in diameter.

**2: *Closterium praelongum*** Brébisson 1856: 152

**General characters:**

The filaments of this species are colorless and lightly striated almost 10 to 14 striate in 10.5  $\mu\text{m}$ . The both ends are suddenly tapered, apex is 2-3  $\mu\text{m}$  wide and there are 5 pyrenoids, 2-8 granules on terminal. The cell walls are smooth & colorless; the filaments are 251  $\mu\text{m}$  long and 13.5  $\mu\text{m}$  in diameter.

**3: *Closterium strigosum*** Brébisson 1856: 153

**General characters:**

The cell wall of the filaments of this species also smooth, colorless and apexes are fairly incurved & 4-5.5  $\mu\text{m}$  broad. There are 2 to 4 pyrenoids, the cells are freely move within the filaments and the length of filament is 168  $\mu\text{m}$  & 8-10  $\mu\text{m}$  in diameter.

**4: *Microspora floccosa*** (Vaucher) Thuret 1850: 222

**General characters:**

The cells are cylindrical in shape and rarely contracted at cross walls. The filaments were unbranched, the length is 22 to 23  $\mu\text{m}$  & diameter is 13 to 14  $\mu\text{m}$ . The color of it is light blue and the filaments are disassociating into H-pieces on fragmentation. The cell wall divided into two sections and show overlapping in the center regions where segment of deadly cell protrudes as indicated by broken ends of filament.

**5: *Microspora tenerrima*** (Kützinger) Gay 1886: lvi

**General characters:**

The cells are cylindrical but short and thallus have unbranched filaments. It dissociate into H-pieces on fragmentation, filaments are 12-14  $\mu\text{m}$  long and 6-8  $\mu\text{m}$  wide. The structures of chloroplast varies, it may be folded, in an asymmetrical plates or a network of strands and parietal in appearance. The cell wall divided into two sections and show overlapping in the center regions where segment of deadly cell protrudes as indicated by broken ends of filament.

**6: *Microspora wittrockii*** (Wille) Lagerheim 1887

**General characters:**

This alga has unbranched filaments, the length of filaments is 33-36  $\mu\text{m}$  and 22-25  $\mu\text{m}$  in diameter. The cells are cylindrical, long and not contracted at cross walls. The color of filaments is yellowish green. The chloroplast appears in the shape of a thin sheet with perforations. The cell wall is smooth and colorless.

**7: *Nostoc sphaericum*** Vaucher ex Bornet & Flahault 1888: 208

**General characters:**

The colonies of *Nostoc sphaericum* are spherical in shape and yellowish brown in color. The cell walls are rough due to trichomes which are freely entangled. There is no individual sheath of each cell, the cells are 6  $\mu\text{m}$  wide and some heterocyst appears which are spherical in shape.

**8: *Oscillatoria acuminata*** Gomont 1892: 227

**General characters:**

The thallus of *oscillatoria acuminata* is reddish brown in color, adhesive, gristly, smooth and 2 cm in diameter. The filaments are 5-6  $\mu\text{m}$  in length, rarely contracted at joints and disperse the granules all over the filament. Thallus has straight, weak & unbranched trichomes, the diameter of it is 3-6  $\mu\text{m}$ . The apices are lightly tapering and many apices have extremely long, thin, spike like points which are 2  $\mu\text{m}$  broad & 31  $\mu\text{m}$  long, instantly and curved. The cross wall is visible, apical cells are sharply pointed. Sheaths are slim, fragile, colorless and internally dissolved into amorphous mucus, so

complicated to see. Heterocysts are absent.

**9: *Oscillatoriaagardlii*** var. *Isothrix* Skuja 1948: 49

**General characters:**

The apical cells are appears in this species which are shorten and pointed in shape, with or without a calyptras. It also have pseudo vacuoles and the length of the filaments is 3-5  $\mu\text{m}$  & 5- 7  $\mu\text{m}$  in diameter. The trichomes appear around their entire length which are straight, capitate and some are granular. Trichomes are briefly tapering at the anterior end and do not contracted at the cross wall. Trichomes are interwoven to form a blue green plant mass.

**10: *Oscillatoriaamoena*** (Kützing) Gomont 1892: 225

**General characters:**

The color of its thallus is blue green; the filaments are 2.0-4.8  $\mu\text{m}$  in length and 3-13  $\mu\text{m}$  in diameter. Trichomes cover the filaments which are straight, briefly curved and it contracted at the plane septa. The end of filaments is steadily attenuated; cells have dull blue green color, the end cell capitate with calyptra and generally conical.

**11: *Oscillatoriaamphibia*** C. Agardh 1827: 632

**General characters:**

The thallus of this species is deep bluish green, trichomes are instantly and some are twisted. The cross walls are not contracted, cells are pale blue green, the diameter of cells is 2-3  $\mu\text{m}$  but it three time much longer then broad, its length is 4-8  $\mu\text{m}$ . There is tow granules at the septa, apices are not thinned, not globose, end cells are rounded but not capitates and calyptras is not present.

**12: *Oscillatoriaanguina*** Bory ex Gomont 1892: 214

**General characters:**

The thallus of *oscillatoriaanguina* is dark green in color, trichomes are thinned, straight and having a u-shaped calyptras at the end. The cell walls occasionally granulated 6-9 $\mu$  wide and uncontracted at cross wall. The length of cells is 2.8-4  $\mu\text{m}$  and diameter is 5.8-8  $\mu\text{m}$ . The end cells are globose and covered by a slightly thickened membrane, cell contents are grainy.

**13: *Oscillatoriaangusta*** Koppe 1924: 641

**General characters:**

The thallus of this species is yellowish green but its trichomes are colorless and straight. The width of cells is 1.2-1.8  $\mu\text{m}$  and length is 3.6-4.5  $\mu\text{m}$ . The cell wall is granulated and not contracted at cross walls. The end cells are rounded and gas vacuoles are not present.

**14: *Oscillatoriacalcuttensis*** Biswas 1925: 5

**General characters:**

The thallus of this species is brownish green and has a fibrous structure. Trichomes are direct, equivalent; the end of trichomes is temporarily thinned and bent. Uncontracted at cross walls, cells are 1.2-2.8  $\mu\text{m}$  wide and 6-9  $\mu\text{m}$  long, three times much longer then broad. There are three granules present on cross wall and the color of it is green. The shape of end cells is pointed, narrow and not globose.

**15: *Oscillatoriachalybea*** Mertens 1822

**General characters:**

*Oscillatoriachalybea* has a light blue green thallus, living trichomes which are straight throughout their length but tapering toward the apex and uncontracted at cross walls. On cross wall granules are absent, the movement of trichomes is rotate and forward. Cells 2-13  $\mu\text{m}$  indiameter, 2-7  $\mu\text{m}$  long, cells are 1/3 times much wider as compared to length. The end cells are thickened and uncapitate, calyptras is absent & gas vacuoles are present.

**16: *Oscillatoria chlorine*** Harvey 1846

**General characters:**

The thallus of this species is yellowish green and thin. Trichomes are somewhat straight or bent, 3-9  $\mu\text{m}$  wide, slightly contracted at the cross walls. There are no granules on cross walls, gas vacuoles are not present, calyptra is absent, and cells are smaller than broad, 5-9  $\mu\text{m}$  broad and 2-8  $\mu\text{m}$  long.

**17: *Phormidiumantarcticum*** West & G.S. West 1911: 292

**General characters:**

The thallus is filamentous, dark green and attached

through the lower side. The filaments are septate, pointed at the ends and forming a gelatinous stratum. It has thorn like margins which help floating in water. Sheath is present which is thin, colorless and partly diffuent. Trichomes are twisted, narrow in width and uncontracted at joints. Cells are 0.7  $\mu\text{m}$  in diameter and 1.6  $\mu\text{m}$  in length. The apices are straight, coiled, frequently thin and may be capitate or non capitate. The apical cells have a calyptra.

**18: *Phormidiumbohneri*** Schmidle 1902: 59

**General characters:**

The thallus is filamentous, bluish green in color, the filaments are septate, slightly pointed at the ends, cylindrical and forming a leathery stratum. Sheath is present which is thin, colorless and partially diffuent. Trichomes are rounded, narrow in width and uncontracted at joints, non-granulated. Cells are 1.0-2.0  $\mu\text{m}$  in diameter and 1.6-1.9  $\mu\text{m}$  in length. The apices are straight, frequently thin and non-capitate. The apical cells are without a calyptra.

**19: *Phormidium fragile*** Gomont 1893: 163

**General characters:**

Its thallus is filamentous, light green in color, the filaments are septate, not pointed at the ends, cylindrical and forming a sticky stratum. Sheath is present which is thick and colorless. Trichomes are straight, wide and contracted at joints, thinned at the end, granulated. Cells are 1.8  $\mu\text{m}$  in diameter and 1.6-3.0  $\mu\text{m}$  in length, cross walls are granulated. The apices are straight, frequently thin and non-capitate.

**20: *Rhizocloniumfontanum*** Kützing 1843: 261

**General characters:**

Its filaments are slim and attached through the basal body. Cross wall present at some space from it and cells are cylindrical but the side walls are unevenly arranged. Cells are many times longer than broad, 62  $\mu\text{m}$  broad and 230-400  $\mu\text{m}$  long. Numerous nuclei are present; chloroplast is parietal.

**21: *Rhizoclonium implexum*** (Dillwyn) Kützing 1845: 206

**General characters:**

Its filaments are slim, branched and branches arise

from the adjacent cells of the parent filament. Cross wall present at some space from it and cells are cylindrical but the side walls are unevenly arranged. Cells are many times longer than broad, 45-48  $\mu\text{m}$  broad and 130-389  $\mu\text{m}$  long. Numerous nuclei are present; chloroplast is reticulate.

**22: *Stigeoclonium elongatum*** (Hassall) Kützing 1849: 355

**General characters:**

Its thallus is green and branched with long filaments; the branches become slowly tapered toward the end. Filaments are delicate, yellowish green, have a mucilaginous layer and attached through the rhizoids, width of filaments is 6.0-8.0  $\mu\text{m}$ . The terminal cells modified into setae.

**23: *Stigeocloniumlubricum*** (Dillwyn) Kützing 1845: 198

**General characters:**

The thallus is dark green, plane, erect and having branched filaments. Filaments are also dark green, smooth, oily and forming a hairy tufts, 2-6 cm long and attached through rhizoids with main axes. Cells of main axes are 13-22  $\mu\text{m}$  broad. The cell wall is thick, diameter of vegetative cells is 9-14  $\mu\text{m}$  and length is 14-20  $\mu\text{m}$ . The terminal cells are modified into setae.

**24: *Stigeocloniumnanum*** (Dillwyn) Kützing 1849: 354

**General characters:**

The thallus is yellowish green and having smaller filaments with erect branches arising from each cell alternately and become pointed toward the end. The diameter of cells of main axis is 10-12  $\mu\text{m}$  which is larger than the cell of branches 5-10  $\mu\text{m}$ , the length of cells is 10-20  $\mu\text{m}$  similar throughout the branching system. Cells are colorless, globose, chloroplast is reticulate and later portion broadly filamentous or pseudoparenchymatous.

**25: *Stigeocloniumtenue*** (C. Agardh) Kützing 1843: 253

**General characters:**

The thallus is green to yellowish green, forming a fragile mat and having filaments with contrary branching & tapering ends. Branches are arising

irregularly from the main axis; filaments have erect and slender rhizoids. Cells are 10-13  $\mu\text{m}$  wide, 3 to 6 times much longer than wide, 23-45  $\mu\text{m}$  in length and cells are cylindrical, thin walled. The apices are hair like.

#### 4. DISCUSSION

In the present study we identified a total number of 25 species and 8 genera of fresh water algae, 2 species were belonged to class Ulvophyceae, 2 Zygnemophyceae, 7 Chlorophyceae and remaining 14 were belonged to class Cyanophyceae from the Taxila zone. In which 9 species belonged to genus *Oscillatoria* which is related to the phylum *Cyanobacteria*, class *Cyanophyceae*, order *Oscillatoriales* and family *Oscillatoriaceae*. Previously this genus was reported from Gujranwala, Jauharabad, Jhang, Kasure, Sargodha & the province of N.W.F.P. and Muzaffarabad, Azad Kashmir [10], Lahore, Sheikhpura and Sialkot Districts of the Punjab Province [11], from Golapara district, Assam, India [12]. From the remaining 16 species 4 belonged to genus *Stigeoclonium* which is related to phylum *Chlorophyta*, class *Chlorophyceae*, order *Chaetophorales*, family *Chaetophoraceae*. Previously this genus was studied from Gujranwala Districts and Lahore District during April 2004 and May 2005 [13] and 3 species belonged to genus *Microspora* which is related to phylum *Chlorophyta*, class *Chlorophyceae*, order *Microsporales*, family *Microsporaceae*. This genus was previously described from Switzerland and Lahore District. The remaining 9 species 3 belonged to genus *Phormidium* which is related to phylum *Cyanobacteria*, class *Cyanophyceae*, order *Oscillatoriales*, family *Phormidiaceae*, this genus previously identified from India [14] and from Ongul Island, Vicinity and Antarctica [15] and 2 species belonged to genus *Rhizoclonium* which related to phylum *Chlorophyta*, class *Ulvophyceae*, order *Cladophorales*, family *Cladophoraceae*. This genus was previously reported from Sialkot and Kasure District [16] and 2 species belonged to genus *Closterium* which related to phylum *Charophyta*, class *Zygnemophyceae*, order *Desmidiales*, and family *Closteriaceae*, this genus previously studied from Attock and Swat of NWFP and Lahore, Sialkot Districts of the Punjab province of Pakistan and

Neelum Valley of Azad Kashmir [17] and 1 species belonged to genus *Chroococcus* which related to phylum *Cyanobacteria*, class *Cyanophyceae*, order *Chroococcales*, family *Chroococcaceae* & remaining 1 species were belonged to genus *Nostoc* which related to phylum *Cyanobacteria*, class *Cyanophyceae*, order *Nostocales*, family *Nostocaceae* and these two species previously reported from Ongul Island, Vicinity and Antarctica [18]. Both were the rarest genus in the study areas among the one species but the genus *Oscillatoria* was very common due to its large numbers of species. During the present study the species were found observed in Unicellular, unbranched filamentous, colonial, branched filamentous, pseudo filamentous and mesh like thallus & irregular forms. Seasonal variation of fresh water algae was also noticed, generally green & blue green algae were studied which breed in summer and spring season, but in summer they also survive. Water temperature is important, as the temperature increases the dissolved oxygen content decrease in water due to increase metabolism and respiration. High temperature has a direct effect on growth of algal species. In summer, the temperature was high up to 45  $^{\circ}\text{C}$  with monsoon rainfall, tremendous Sunlight and sluggish water with pH 7.3; this was the most favorable environment for growth of algae. The rate of reproduction is very rapid of those species that reproduced in summer and rainy season and created a heavy mass on the surface of water. Their growth was most frequent in the aquatic medium especially in planktonic state as compared to the terrestrial environment. This is a first comprehensive taxonomical study from Taxila and its surrounding areas. These findings will be of great use to scientists in future who want to discover more and more about fresh water algae of Taxila.

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