

## **SURVEY OF FRESHWATER ALGAE FROM KARACHI, PAKISTAN**

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### **Abstract**

Altogether 214 species of algae belonging to 86 genera of 33 families, 15 orders, 10 classes and 6 phyla were collected from various freshwater habitats in three towns of Karachi City during May 2004 and September 2005. Among various phyla, Cyanophycota was represented by 82 species (38.32%), Volvophycota by 78 species (36.45%), Euglenophycota by 4 species (1.87%), Chrysophycota by 2 species (0.93%), Bacillarophycota by 38 species (17.76%) and Chlorophycota by 10 species (4.67%). Members of the phyla Cyanophycota and Volvophycota were most prevalent (74.8%) and those of Euglenophycota and Chrysophycota poorly represented (2.8%).

### **Introduction**

Karachi, the largest city of Pakistan is spread over a vast area of 3,530 km<sup>2</sup> and includes a variety of ponds, streams, water falls, artificial and natural water reservoirs and two small ephemeral rivers with their branchlets, which inhabit several groups of freshwater algae. Only a few studies have been carried out in the past on different groups of these algae, either from a point of view of their habitats and general occurrence (Parvaiz & Ahmed, 1981; Shameel & Butt, 1984; Aisha & Hasni, 1991; Aisha & Zahid, 1991; Leghari *et al.*, 2002) or from taxonomic viewpoint (Salim, 1954; Aizaz & Farooqui, 1972; Farzana & Nizamuddin, 1979; Ahmed *et al.*, 1983). Recently, a study was made on the occurrence of algae within Karachi University Campus (Mehwish & Aliya, 2005). Thus the available information about the algal flora of this city was not sufficient. Therefore, a large survey was initiated in May 2004 to collect and identify the freshwater algae from different areas of Karachi.

### **Materials and Methods**

Specimens were collected from various freshwater habitats in three towns (Saddar, Jamshaid and Gulshan-e-Iqbal) of Karachi City during May 2004 and September 2005. They were brought to the laboratory and preserved in 3% formaline solution. The specimens were mounted on glycerin and semi-permanent slides were prepared by sealing the cover-slip with nail polish. They were examined under binocular light microscope and taxonomically determined with the help of authentic literature (Desikachary, 1959; Krieger & Gerloff, 1962, 1965, 1969; Prescott, 1962; Starmach, 1964, 1966; Taft & Taft, 1971; Tiwari, 1975; John *et al.*, 2002; Wehr & Sheath, 2003).

## Results and Discussion

The collected specimens of freshwater algae were investigated under microscope and identified up to species level. On the basis of their morphological and cytological characteristics 214 species belonging to 86 genera of 33 families, 15 orders, 10 classes and 6 phyla were observed in three towns of Karachi City (Table 1). They have been systematically arranged according to the recently proposed classification (Shameel, 2001, 2008), therefore the new taxonomic nomenclature has been used here. The phylum Cyanophycota was found to be represented by 82 species (38.32%), Volvophycota by 78 species (36.45%), Euglenophycota by 4 species (1.87%), Chrysophycota by 2 species (0.93%), Bacillariophycota by 38 species (17.76%) and Chlorophycota by 10 species (4.67%). Members of the phyla Cyanophycota and Volvophycota were most prevalent (74.8%) and those of Euglenophycota and Chrysophycota poorly represented (2.8%). No member of the phyla Charophycota and Vaucherophycota was found to occur. These results are nearly similar with the observations made by Leghari *et al.*, (1999) at the water reservoir of Chotiari (Sanghar District, near Karachi), where 157 species of freshwater algae were recorded. Among them, 65.36% species belonged to the phyla Cyanophycota and Volvophycota. Members of the phylum Bacillariophycota were 17.5%, which is almost equal to our observation.

The phylum Cyanophycota exhibited largest diversity with 82 species. Our results are also comparable with the observations made by Leghari *et al.*, (2003) at the water reservoirs of Wah Garden (district Attock), where species of the phyla Cyanophycota and Volvophycota were dominant during summer seasons because physico-chemical factors such as high temperature, alkaline pH, high light intensity and stagnant water conditions were suitable for their excessive growth.

Gulshan-e-Iqbal Town exhibited largest number of algal flora than other two towns, although these towns included the water reservoirs of Hill Park and Askari Park. The reason may be that the large area of Karachi University Campus is also included in Gulshan-e-Iqbal Town, where several water ponds, ditches and water channels are situated in educational departments showing a luxuriant growth of algae, as has been previously observed by Mehwish & Aliya (2005). The smallest number of algal species were observed in Saddar Town, where the collections were mainly obtained from Zoological Garden. The water at most of the pools and ditches in the garden is highly polluted due to waste thrown by children and visitors, which adversely affects the growth of algae.

It was observed that the growth of microscopic species was abundant, especially in the planktonic state. The differences in the percentage of species in various towns is due to different environmental conditions like temperature, pH and growth conditions as was observed in a variety of water pools at Rawal Dam (Leghari *et al.*, 2005). Species of the phylum Chrysophycota were found in smallest proportion (0.93%), as high water temperature (25-29°C) does not appear to be suitable for their growth. Similar observations were made in the previous studies at Karachi (Leghari *et al.*, 2002; Mehwish & Aliya, 2005).

Table 1. Freshwater algae of Karachi City during May 2004-September 2005.

| Algal Taxa                                                 | Sadar<br>Town | Jamshaid<br>Town | Gulshan-e-Iqbal<br>Town |
|------------------------------------------------------------|---------------|------------------|-------------------------|
| <b>KINGDOM MONERA:</b>                                     |               |                  |                         |
| <b>PHYLUM CYANOPHYCOTA</b>                                 |               |                  |                         |
| <b>CLASS CHROOCOPHYCEAE</b>                                |               |                  |                         |
| <b>Order Chroococcales</b>                                 |               |                  |                         |
| <b>Family Chroococcaceae</b>                               |               |                  |                         |
| <b><i>Aphanocapsa</i> Nägeli</b>                           |               |                  |                         |
| <i>A. elachista</i> W. West et G. S. West                  | -             | -                | +                       |
| <i>A. endophytica</i> G. M. Smith                          | -             | -                | +                       |
| <i>A. grevillei</i> (Hassall) Rabenhorst                   | -             | -                | +                       |
| <b><i>Aphanothece</i> Nägeli</b>                           |               |                  |                         |
| <i>A. castagnei</i> (de Brébisson) Rabenhorst              | -             | -                | +                       |
| <i>A. gelatinosa</i> (Henning) Lemmermann                  | -             | -                | +                       |
| <i>A. microscopica</i> Nägeli                              | -             | -                | +                       |
| <i>A. prasina</i> A. Braun                                 | -             | -                | +                       |
| <i>A. saxicola</i> Nägeli                                  | -             | -                | +                       |
| <b><i>Chroococcopsis</i> Geitler</b>                       |               |                  |                         |
| <i>C. chroococcoides</i> (Fritsch) Komárek et Anagnostidis | -             | -                |                         |
| <b><i>Chroococcus</i> Nägeli</b>                           |               |                  |                         |
| <i>C. aurantiacus</i> Bernard                              |               |                  | +                       |
| <i>C. disperses</i> (Keissler) Lemmermann                  | -             | -                | +                       |
| <i>C. gelatinosus</i> (Geitler)                            | -             | -                | +                       |
| <i>C. giganteus</i> W. West                                | -             | -                | +                       |
| <i>C. gomontii</i> Nygaard                                 | -             | -                | +                       |
| <i>C. limneticus</i> Lemmermann                            | -             | -                | +                       |
| <i>C. minutus</i> (Kützing) Nägeli                         | -             | -                | +                       |
| <i>C. minor</i> (Kützing) Nägeli                           | -             | -                | +++                     |
| <i>C. montanus</i> Hansgirg                                | -             | -                | ++                      |
| <i>C. pallidus</i> (Nägeli) Nägeli                         | -             | -                | ++                      |
| <i>C. turicensis</i> (Nägeli) Hansgirg                     | -             | -                | +                       |
| <i>C. turgidus</i> (Kützing) Nägeli                        | -             | -                | ++                      |
| <i>C. tenax</i> (Kirchner) Hieron                          | -             | -                | +                       |
| <i>C. varius</i> A. Braun                                  | -             | -                | +                       |
| <b><i>Coelosphaerium</i> Nägeli</b>                        |               |                  |                         |
| <i>C. dubium</i> Grunow                                    | -             | -                | +                       |
| <i>C. pallidum</i> Lemmermann                              | -             |                  | ++                      |
| <b><i>Gloeocapsa</i> Kützing</b>                           |               |                  |                         |
| <i>G. aeruginosa</i> Kützing                               | -             | -                | +                       |
| <i>G. alpina</i> (Nägeli) Brand                            | -             | -                | +                       |
| <i>G. dermochroa</i> Nägeli                                | -             | -                | +                       |
| <i>G. gelatinosa</i> (Meneghini) Kützing                   | -             | -                | +                       |
| <i>G. helvetica</i> (Nägeli) Starmach                      | -             | -                | +                       |
| <i>G. haematodes</i> Kützing                               | -             | -                | +                       |
| <i>G. minuta</i> (Kützing) Hollerbach                      | -             | -                | +                       |
| <i>G. rupestris</i> Kützing                                | -             | -                | +                       |
| <i>G. siderochlamys</i> (Skuja) Starmach                   | -             | -                | +                       |
| <i>G. turgida</i> (Kützing) Hollerbach                     | -             | -                | +                       |
| <b><i>Gloeotheca</i> Nägeli</b>                            |               |                  |                         |
| <i>G. linearis</i> Nägeli                                  | -             | -                | +                       |
| <b><i>Merismopedia</i> Meyen</b>                           |               |                  |                         |
| <i>M. punctata</i> Meyen                                   | -             | +                | +                       |
| <b><i>Microcystis</i> Kützing ex Lemmermann</b>            |               |                  |                         |
| <i>M. aeruginosa</i> (Kützing) Kützing                     | -             | +                | +                       |
| <i>M. flosaquae</i> (Wittrock) Kirchner                    | -             |                  | +                       |
| <i>M. incerta</i> (Lemmermann) Lemmermann                  | -             | +                | +++                     |
| <i>M. sp.</i>                                              | -             | +                | -                       |

Table 1. (Cont'd.).

| Algal Taxa                                                  | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|-------------------------------------------------------------|------------|---------------|----------------------|
| <b>CLASS NOSTOCOPHYCEAE</b>                                 |            |               |                      |
| <b>Order Nostocales</b>                                     |            |               |                      |
| <b>Family Microchaetaceae</b>                               |            |               |                      |
| <i>Microchaete</i> Thuret ex Bornet et Flahault             |            |               |                      |
| <i>M. diplosiphon</i> Gomont ex Bornet et Flahault          | -          | -             | ++                   |
| <b>Family Nostocaceae</b>                                   |            |               |                      |
| <i>Anabaena</i> Bory de Saint-Vincent ex Bornet et Flahault |            |               |                      |
| <i>A. azollae</i> Strasburger                               | -          | -             | +                    |
| <b>Family Oscillatoraceae</b>                               |            |               |                      |
| <i>Borzia</i> Cohn ex Gomont                                |            |               |                      |
| <i>B. trilocularis</i> Cohn ex Gomont                       | -          | -             | +                    |
| <i>Lyngbya</i> C. Agardh ex Gomont                          |            |               |                      |
| <i>L. aerugineocoerulea</i> Gomont                          | -          | -             | +                    |
| <i>L. hieronymusii</i> Lemmermann                           | -          | -             | +                    |
| <i>L. versicolor</i> Wartmann ex Gomont                     | -          | -             | +                    |
| <i>Oscillatoria</i> Vaucher ex Gomont                       |            |               |                      |
| <i>O. acutissima</i> Kufferath                              | -          | -             | +                    |
| <i>O. angustissima</i> W. West et G. S. West                | -          | -             | +                    |
| <i>O. animalis</i> C. Agardh                                | -          | -             | +                    |
| <i>O. articulate</i> Gardner                                | -          | -             | +                    |
| <i>O. brevis</i> Kützing ex Gomont                          | -          | -             | +                    |
| <i>O. chalybea</i> Mertens                                  | -          | -             | +                    |
| <i>O. curviceps</i> C. Agardh                               | -          | -             | +                    |
| <i>O. claricentrosa</i> Gardner                             | -          | -             | +                    |
| <i>O. earlei</i> Gardner                                    | -          | -             | +                    |
| <i>O. formosa</i> (Bory de Saint-Vincent) Gomont            | -          | -             | +                    |
| <i>O. minima</i> Gicklhorn                                  | -          | -             | +                    |
| <i>O. pseudogeminata</i> G. Schmid                          | -          | -             | +                    |
| <i>O. quadripunctulata</i> Brühl et Biswas                  | -          | -             | +                    |
| <i>O. subbrevis</i> Schmidle                                | -          | -             | +                    |
| <i>O. tenuis</i> (C. A. Agardh) Rabenhorst                  | -          | -             | +                    |
| <i>O. sp.</i>                                               | +          | -             | +                    |
| <i>Planktolynghya</i> Anagnostidis et Komárek               |            |               |                      |
| <i>P. circumcreta</i> (G. S. West) Anagnostidis et Komárek  | -          | +             | -                    |
| <i>P. contorta</i> (Lemmermann) Anagnostidis et Komárek     | -          | +             | -                    |
| <i>P. tallingii</i> J. Komárek et H. Kling                  | -          | +             | -                    |
| <i>Pseudospirulina</i>                                      |            |               |                      |
| <i>P. amoena</i>                                            | -          | +             | -                    |
| <i>Romeria</i> Koczwara in Geitler                          |            |               |                      |
| <i>R. chlorine</i> Bocher                                   | -          | +             | -                    |
| <i>R. gracilis</i> Koszwara                                 | -          | +             | -                    |
| <i>R. leopoliensis</i> (Raciborski) Koczwara                | -          | +             | -                    |
| <b>Family Rivularaceae</b>                                  |            |               |                      |
| <i>Calothrix</i> C. Agardh ex Bornet et Flahault            |            |               |                      |
| <i>C. parietina</i> (Nägeli) Thuret                         | -          | -             | +                    |
| <i>Dichothrix</i> Zanardini ex Bornet et Flahault           |            |               |                      |
| <i>D. orsiniana</i> (Kützing) Bornet et Flahault            | -          | -             | +                    |
| <i>Homoeothrix</i> (Thuret ex Bornet et Flahault) Kirchner  |            |               |                      |
| <i>H. fluviatilis</i> Jao                                   | -          | -             | +                    |
| <i>Phormidium</i> Kützing ex Gomont                         |            |               |                      |
| <i>P. ambiguum</i> Gomont                                   | -          | -             | +                    |
| <i>P. luridum</i> (Kützing) Gomont                          | -          | -             | +                    |
| <i>Schizothrix</i> Kützing ex Gomont                        |            |               |                      |
| <i>S. muelleri</i> Nägeli ex Gomont                         | -          | -             | +                    |
| <i>Spirulina</i> Turpin ex Gomont                           |            |               |                      |
| <i>S. laxa</i> G. M. Smith                                  | -          | -             | +                    |

Table 1. (Cont'd.).

| Algal Taxa                                            | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|-------------------------------------------------------|------------|---------------|----------------------|
| <i>S. laxissima</i> G. S. West                        | -          | -             | +                    |
| <i>S. major</i> Kützing                               | -          | -             | +                    |
| <i>S. princeps</i> (W. West et G. S. West) G. S. West | -          | -             | +                    |
| <i>S. subsalsa</i> Ørsted                             | -          | -             | ++                   |
| <i>S. sp.</i>                                         | +          | -             | -                    |
| <b>KINGDOM PROTISTA:</b>                              |            |               |                      |
| <b>PHYLUM VOLVOPHYCOTA</b>                            |            |               |                      |
| <b>CLASS VOLVOPHYCEAE</b>                             |            |               |                      |
| <b>Order Chlorococcales</b>                           |            |               |                      |
| <b>Family Characiaceae</b>                            |            |               |                      |
| <b><i>Characium</i> A. Braun in Kützing</b>           |            |               |                      |
| <i>C. acuminatum</i> A. Braun                         | -          | -             | +                    |
| <b>Family Chlorococcaceae</b>                         |            |               |                      |
| <b><i>Chlorococcum</i> Meneghini</b>                  |            |               |                      |
| <i>C. humicola</i> (Nägeli) Rabenhorst                | -          | -             | +                    |
| <b><i>Tetracystis</i> R. M. Brown et Bold</b>         |            |               |                      |
| <i>T. isobilateralis</i> R. M. Brown et Bold          | -          | -             | +                    |
| <b>Family Coleastraceae</b>                           |            |               |                      |
| <b><i>Coelastrum</i> Nägeli</b>                       |            |               |                      |
| <i>C. pseudomicroporum</i> Korshikov                  | -          | +             | -                    |
| <i>C. verrucosum</i> (Reinsch) Reinsch                | -          | +             | -                    |
| <b>Family Hydrodictyaceae</b>                         |            |               |                      |
| <b><i>Pediastrum</i> Meyen</b>                        |            |               |                      |
| <i>P. boryanum</i> (Turpin) Meneghini                 | -          | +             | -                    |
| <i>P. duplex</i> Meyen                                | +          | +             | -                    |
| <i>P. simplex</i> Meyen                               | -          | -             | +++                  |
| <i>P. tetras</i> (Ehrenberg) Ralfs                    | ++         | -             | -                    |
| <b>Family Micractinaceae</b>                          |            |               |                      |
| <b><i>Golenkinia</i> R. Chodat</b>                    |            |               |                      |
| <i>G. paucispina</i> W. West et G. S. West            | -          | +             | -                    |
| <i>G. radiata</i> Chodat                              | -          | -             | -                    |
| <b>Family Oocystaceae</b>                             |            |               |                      |
| <b><i>Ankistrodesmus</i> Corda</b>                    |            |               |                      |
| <i>A. convolutus</i> Corda                            | +          | ++            | -                    |
| <i>A. densus</i> Korshikov                            | -          | +             | -                    |
| <b><i>Kirchneriella</i> Schmidle</b>                  |            |               |                      |
| <i>K. elongata</i> G. M. Smith                        | -          | -             | +                    |
| <i>K. lunaris</i> (Kirchner) K. Möbius                | -          | -             | -                    |
| <i>K. obesa</i> (G. S. West) Schmidle                 | -          | +             | ++                   |
| <b><i>Lauterborniella</i> W. Schmidle</b>             |            |               |                      |
| <i>L. elegantissima</i> W. Schmidle                   | -          | +             | -                    |
| <b><i>Nephrocytium</i> Nägeli</b>                     |            |               |                      |
| <i>N. agardhianum</i> Nägeli                          | +          | -             | -                    |
| <i>N. lunatum</i> West                                | +          | -             | -                    |
| <b><i>Oocystis</i> A. Braun</b>                       |            |               |                      |
| <i>O. borgei</i> J. Snow                              | -          | +             | -                    |
| <i>O. marssonii</i> Lemmermann                        | -          | +             | -                    |
| <b><i>Schroederia</i> Lemmermann</b>                  |            |               |                      |
| <i>S. setigera</i> (Schröder) Lemmermann              | -          | +             | -                    |
| <b><i>Sorastrum</i> Kützing</b>                       |            |               |                      |
| <i>S. americanum</i> (Bohlin) Schmidle                | -          | +             | -                    |
| <i>S. spinulosum</i> Nägeli                           | -          | +             | -                    |
| <b><i>Tetraedron</i> Kützing</b>                      |            |               |                      |
| <i>T. caudatum</i> (Corda) Hansgirg                   | -          | -             | +                    |
| <i>T. pentaedricum</i> W. West et G. S. West          | -          | -             | +                    |

Table 1. (Cont'd.).

| Algal Taxa                                           | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|------------------------------------------------------|------------|---------------|----------------------|
| <i>T. minimum</i> (A. Braun) Hansgirg                | -          | -             | +                    |
| <i>T. muticum</i> (A. Braun) Hansgirg                | -          | ++            | -                    |
| <i>T. quadratum</i> (Reinsch) Hansgirg               | +          | -             | +                    |
| <b>Treubaria C. Bernad</b>                           |            |               |                      |
| <i>T. crassispina</i> G. M. Smith                    | -          | -             | +                    |
| <b>Westella De Wildermann</b>                        |            |               |                      |
| <i>W. linearis</i> G. M. Smith                       | +          | -             | -                    |
| <b>Family Scenedesmaceae</b>                         |            |               |                      |
| <b>Scenedesmus Meyen</b>                             |            |               |                      |
| <i>S. abundans</i> (O. Kirchner) Chodat              | -          | +             | -                    |
| <i>S. acuminatus</i> (Lagerheim) Chodat              | -          | +             | ++                   |
| <i>S. acutiformis</i> Schröder                       | -          | +             | +                    |
| <i>S. acutus</i> Meyen                               | -          | +             | -                    |
| <i>S. arcuatus</i> Lemmermann                        | -          | -             | +                    |
| <i>S. bijuga</i> (Reinsch.) Hansgirg                 | -          | -             | +                    |
| <i>S. circumfusus</i> Hortobagyi                     | -          | +             | -                    |
| <i>S. dimorphus</i> (Turpin) Kützing                 | +          | ++            | +                    |
| <i>S. denticulatus</i> Legerheim                     | +          | -             | -                    |
| <i>S. falcatus</i> Chodat                            | -          | +             | -                    |
| <i>S. hystrix</i> Lagerheim                          | -          | -             | +                    |
| <i>S. incrassatulus</i> Bohlin                       | +          | -             | -                    |
| <i>S. obliquus</i> (Turpin) Kützing                  | -          | +             | -                    |
| <i>S. perforatus</i> Lemmermann                      | -          | -             | +                    |
| <i>S. quadricauda</i> (Turpin) de Brébisson          | +          | -             | ++                   |
| <i>S. raciborskii</i> Wlozynska                      | -          | +             | -                    |
| <i>S. semipulcher</i> Hortobagyi                     | -          | +             | -                    |
| <i>S. sp.</i>                                        | -          | +             | -                    |
| <b>Tetrastrum Chodat</b>                             |            |               |                      |
| <i>T. glabrum</i> (Y. V. Roll) Ahlstrom et Tiffany   | -          | +             | -                    |
| <i>T. heteracanthum</i> (Nordstedt) Chodat           | +          | -             | -                    |
| <b>Order Chlorosarcinales</b>                        |            |               |                      |
| <b>Family Chlorosarcinaceae</b>                      |            |               |                      |
| <b>Chlorosarcinopsis W. Hernodon</b>                 |            |               |                      |
| <i>C. minuta</i> R. D. Groover et H. C. Bold         | -          | -             | +                    |
| <b>Family Palmellaceae</b>                           |            |               |                      |
| <b>Chloranomala Mitra</b>                            |            |               |                      |
| <i>C. cuprecola</i> Mitra                            | -          | -             | +                    |
| <b>Gloeocystis Nägeli</b>                            |            |               |                      |
| <i>G. major</i> Gerneck ex Lemmermann                | -          | -             | +                    |
| <b>Order Volvocales</b>                              |            |               |                      |
| <b>Family Volvocaceae</b>                            |            |               |                      |
| <b>Pandorina Bory de Saint-Vincent</b>               |            |               |                      |
| <i>P. morum</i> (O. F. Müller) Bory de Saint-Vincent | -          | -             | +                    |
| <b>Order Tetrasporales</b>                           |            |               |                      |
| <b>Family Coccomyxaceae</b>                          |            |               |                      |
| <b>Diogenes W. Pennington</b>                        |            |               |                      |
| <i>D. bacillaris</i> (Naum.) W. Pennington           | -          | -             | +                    |
| <b>Dispora H. Printz</b>                             |            |               |                      |
| <i>D. crucigenioides</i> H. Printz                   | -          | -             | +                    |
| <b>Family Gloeocystaceae</b>                         |            |               |                      |
| <b>Palmellopsis O. Korshikov</b>                     |            |               |                      |
| <i>P. gelatinosa</i> O. Korshikov                    | -          | -             | +                    |

Table 1. (Cont'd.).

| Algal Taxa                                          | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|-----------------------------------------------------|------------|---------------|----------------------|
| <b>CLASS DESMIDOPHYCEAE</b>                         |            |               |                      |
| <b>Order Desmidales</b>                             |            |               |                      |
| <b>Family Desmidiaceae</b>                          |            |               |                      |
| <b><i>Arthrodesmus</i> C. G. Ehrenberg ex Ralfs</b> |            |               |                      |
| <i>A. fuelleborni</i> Schmidle                      | -          | -             | +                    |
| <b><i>Closterium</i> Nitzsch ex Ralfs</b>           |            |               |                      |
| <i>C. moniliferum</i> Ehrenberg                     | -          | -             | +                    |
| <i>C. parvulum</i> Nägeli                           | -          | -             | +                    |
| <b><i>Cosmarium</i> Ralfs</b>                       |            |               |                      |
| <i>C. angulosum</i> de Brébisson                    | -          | +             | -                    |
| <i>C. arctoum</i> Nordstedt et Krieger              | -          | +             | -                    |
| <i>C. leave</i> Rabenhorst                          | -          | +             | -                    |
| <i>C. geometricum</i> W. West et G. S. West         | -          | +             | -                    |
| <i>C. margaritatum</i> (Lund) Roy et Bisset         | -          | -             | +                    |
| <i>C. phaseolus</i> de Brébisson ex Ralfs           | -          | +             | -                    |
| <i>C. pseudoprotuberans</i> Krichner                | -          | +             | -                    |
| <i>C. sulcatum</i> Nordstedt                        | -          | +             | -                    |
| <b><i>Eurastrum</i> C. G. Ehrenberg ex Ralfs</b>    |            |               |                      |
| <i>E. pectinatum</i>                                | -          | -             | +                    |
| <b><i>Staurastrum</i> (Meyen) Ralfs</b>             |            |               |                      |
| <i>S. anatinum</i> Cooke et Wills                   | -          | -             | +                    |
| <i>S. cyrtocerum</i> Brébisson                      | -          | +             | -                    |
| <i>S. leptocladum</i> L. N. Johanson                | -          | -             | +                    |
| <i>S. manfeldtii</i> Deleporte                      | -          | -             | +                    |
| <i>S. muticum</i> de Brébisson ex Ralfs             | -          | -             | +                    |
| <i>S. sebalzii</i> Nordstedt                        | -          | +             | -                    |
| <i>S. taylorii</i> R. L. Grönblad                   | -          | +             | -                    |
| <i>S. sp.</i>                                       | -          | +             | -                    |
| <b>PHYLUM EUGLENOPHYCOTA</b>                        |            |               |                      |
| <b>CLASS EUGLENOPHYCEAE</b>                         |            |               |                      |
| <b>Order Euglenales</b>                             |            |               |                      |
| <b>Family Euglenaceae</b>                           |            |               |                      |
| <b><i>Euglena</i> Ehrenberg</b>                     |            |               |                      |
| <i>E. spirogyra</i> Ehrenberg                       | -          | -             | +                    |
| <i>E. sp.</i>                                       | -          | ++            | -                    |
| <b><i>Phacus</i> Dujardin</b>                       |            |               |                      |
| <i>P. curvicauda</i> Swirenko                       | +          | -             | -                    |
| <i>P. orbicularis</i> K. Hübner                     | +          | -             | -                    |
| <b>PHYLUM CHRYSOPHYCOTA</b>                         |            |               |                      |
| <b>CLASS CHRYSOPHYCEAE</b>                          |            |               |                      |
| <b>Order Ochromonales</b>                           |            |               |                      |
| <b>Family Chrysocapsaceae</b>                       |            |               |                      |
| <b><i>Chrysocapsa</i> Pascher</b>                   |            |               |                      |
| <i>C. planctonica</i> (West et West) Pascher        | -          | -             | +                    |
| <b>Family Synuraceae</b>                            |            |               |                      |
| <b><i>Mallomonas</i> Perty</b>                      |            |               |                      |
| <i>M. caudata</i> Iwanoff                           | -          | -             | +                    |
| <b>PHYLUM BACILLAROPHYCOTA</b>                      |            |               |                      |
| <b>CLASS BACILLAROPHYCEAE</b>                       |            |               |                      |
| <b>Order Bacillariales</b>                          |            |               |                      |
| <b>Family Achnanthaceae</b>                         |            |               |                      |
| <b><i>Achnanthes</i> Bory de Saint-Vincent</b>      |            |               |                      |
| <i>A. linearis</i> W. Smith                         | -          | -             | ++                   |

Table 1. (Cont'd.).

| Algal Taxa                                                     | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|----------------------------------------------------------------|------------|---------------|----------------------|
| <b>Cocconeis Ehrenberg</b>                                     |            |               |                      |
| <i>C. pediculus</i> Ehrenberg                                  | -          | -             | +                    |
| <b>Family Cymbellaceae</b>                                     |            |               |                      |
| <b>Amphora Ehrenberg ex Kützing</b>                            |            |               |                      |
| <i>A. coffeaformis</i> Agardh                                  | -          | -             | +                    |
| <i>A. ovalis</i> Kützing                                       | -          | -             | +                    |
| <i>A. sp.</i>                                                  | -          | -             | +                    |
| <b>Cymbella C. A. Agardh</b>                                   |            |               |                      |
| <i>C. cistula</i> (Hempr.) Kirchner                            | +          | -             | +                    |
| <i>C. ventricosa</i> Kützing                                   | -          | +             | -                    |
| <i>C. sp.</i>                                                  | -          | +             | +                    |
| <b>Family Epithemaceae</b>                                     |            |               |                      |
| <b>Denticula Ehrenberg</b>                                     |            |               |                      |
| <i>D. elegans</i> Kützing                                      | -          | -             | +                    |
| <b>Epithemia de Brébisson</b>                                  |            |               |                      |
| <i>E. ocellata</i> Kützing                                     | -          | +             | -                    |
| <i>E. sorex</i> Kützing                                        | -          | +             | -                    |
| <b>Rhopalodia O. F. Müller</b>                                 |            |               |                      |
| <i>R. gibba</i> (Ehrenberg) O. Müller                          | -          | -             | +                    |
| <i>R. sp.</i>                                                  | -          | -             | ++                   |
| <b>Family Fragilaraceae</b>                                    |            |               |                      |
| <b>Ceratonei Ehrenberg</b>                                     |            |               |                      |
| <i>C. arcus</i> (Hempr.) Kirchner                              | -          | -             | +                    |
| <b>Fragilaria Lyngbye</b>                                      |            |               |                      |
| <i>F. crotonensis</i> Kitt.                                    | -          | +             | -                    |
| <i>F. alpestris</i> Krasske                                    | -          | +             | -                    |
| <i>F. ulna</i> Nitzsch) Lange-Bertalot                         | +          | +             | -                    |
| <b>Fragilariforma (J. Ralfs) D. M. Williams et F. E. Round</b> |            |               |                      |
| <i>F. virescens</i> (J. Ralfs) D. M. Williams et F. E. Round   | -          | +             | -                    |
| <i>F. sp.</i>                                                  | -          | +             | +                    |
| <b>Grammatophora Ehrenberg</b>                                 |            |               |                      |
| <i>G. serpentine</i> Ralfs                                     | -          | -             | ++                   |
| <b>Synedra Ehrenberg</b>                                       |            |               |                      |
| <i>S. acus</i> Ehrenberg                                       | +          | -             | -                    |
| <i>S. minuscule</i> Grunow                                     | +          | +             | -                    |
| <b>Family Naviculaceae</b>                                     |            |               |                      |
| <b>Anomoeoneis Pfitzer</b>                                     |            |               |                      |
| <i>A. sphaerophora</i> (Kützing) Pfitzer                       | -          | -             | +                    |
| <b>Diatomella Greville</b>                                     |            |               |                      |
| <i>D. sp.</i>                                                  | -          | -             | +                    |
| <b>Mastogloia Thwaites ex W. Smith</b>                         |            |               |                      |
| <i>M. danseii</i> Thwait                                       | -          | -             | +                    |
| <i>M. smithii</i> Thwait                                       | -          | -             | +                    |
| <b>Navicula Bory emend. Cleve</b>                              |            |               |                      |
| <i>N. anglica</i> Ralfs                                        | -          | +             | -                    |
| <i>N. cocconeiformis</i> Gregory                               | -          | +             | -                    |
| <i>N. platystoma</i> Ehrenberg                                 | -          | +             | -                    |
| <i>N. virids</i> Kützing                                       | -          | -             | +                    |
| <i>N. viridula</i> (Kützing) Kützing emend. Van Heurck         | -          | -             | +                    |
| <i>N. sp.</i>                                                  | -          | +             | -                    |

Table 1. (Cont'd.).

| Algal Taxa                                              | Sadar Town | Jamshaid Town | Gulshan-e-Iqbal Town |
|---------------------------------------------------------|------------|---------------|----------------------|
| <b><i>Pinnularia</i> (Ehrenberg) Ehrenberg</b>          |            |               |                      |
| <i>P. major</i> Kützing                                 | -          | +             | -                    |
| <i>P. sp.</i>                                           | -          | +             | -                    |
| <b>Family Nitzschaceae</b>                              |            |               |                      |
| <b><i>Gyrosigma</i> Hassall</b>                         |            |               |                      |
| <i>G. sp.</i>                                           | -          | -             | +                    |
| <b><i>Nitzchia</i> Hassall</b>                          |            |               |                      |
| <i>N. sp.</i>                                           | -          | -             | +                    |
| <b>Order Biddulphales</b>                               |            |               |                      |
| <b>Family Coscinodiscaceae</b>                          |            |               |                      |
| <b><i>Cyclotella</i> (Kützing ) de Brébisson</b>        |            |               |                      |
| <i>C. glomerata</i> Bochmann                            | -          | -             | +                    |
| <i>C. sp.</i>                                           | +          | -             | +                    |
| <b>KINGDOM PHYCOTA:</b>                                 |            |               |                      |
| <b>PHYLUM CHLOROPHYCOTA</b>                             |            |               |                      |
| <b>CLASS ULVOPHYCEAE</b>                                |            |               |                      |
| <b>Order Ulotrichales</b>                               |            |               |                      |
| <b>Family Cylandrocapsaceae</b>                         |            |               |                      |
| <b><i>Cylindrocapsa</i> Reinsch</b>                     |            |               |                      |
| <i>C. conferta</i> W. West                              | -          | -             | +                    |
| <b><i>Gloeotaenium</i> Itasgr</b>                       |            |               |                      |
| <i>G. ioilesbergereanum</i> Hasgird                     | -          | -             | +                    |
| <b>Family Ulotrichaceae</b>                             |            |               |                      |
| <b><i>Geminella</i> Turpin emend. Lagerheim</b>         |            |               |                      |
| <i>G. mutabilis</i> (de Brébisson) Wille                | -          | -             | +                    |
| <b><i>Ulothrix</i> Kützing</b>                          |            |               |                      |
| <i>U. sp.</i>                                           | +          | -             | -                    |
| <b>CLASS ZYGNEMOPHYCEAE</b>                             |            |               |                      |
| <b>Order Oedogonales</b>                                |            |               |                      |
| <b>Family Oedogonaceae</b>                              |            |               |                      |
| <b><i>Oedogonium</i> Link</b>                           |            |               |                      |
| <i>O. grande</i> Kützing                                | -          | -             | +                    |
| <b>Order Zygnemales</b>                                 |            |               |                      |
| <b>Family Zygnemaceae</b>                               |            |               |                      |
| <b><i>Spirogyra</i> Link</b>                            |            |               |                      |
| <i>S. longata</i> (Vaucher) Kützing                     | -          | -             | +                    |
| <b><i>Zygnemopsis</i> (Skuja) Transeau</b>              |            |               |                      |
| <i>Z. desmidioides</i> (W. West et G. S. West) Transeau | -          | -             | +                    |
| <b>CLASS SIPHONOCLADOPHYCEAE</b>                        |            |               |                      |
| <b>Order Cladophorales</b>                              |            |               |                      |
| <b>Family Cladophoraceae</b>                            |            |               |                      |
| <b><i>Pithophora</i> Wittrock</b>                       |            |               |                      |
| <i>P. oedogonia</i> (Montagne) Wittrock                 | -          | +             | -                    |
| <b><i>Rhizoclonium</i> Kützing</b>                      |            |               |                      |
| <i>R. crassipellitum</i> W. West et G. S. West          | -          | -             | ++                   |
| <i>R. hookeri</i> Kützing                               | -          | -             | ++                   |

+ = Common, ++ = Frequent, +++ = Dominant, - = Absent.

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