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Taxonomic Study of Algal Flora of Indus River Ponds at the Vicinity of Ghazi Ghat Dera Ghazi Khan

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The present study was conducted to elucidate the fresh water algal flora of various ponds, which were located the surroundings of Ghazi Ghat Bridge at Indus River district Dera Ghazi Khan, Punjab, Pakistan during the year 2013. Four sampling sites were selected. Thirteen families of various classes, which include 17 genera, were identified. Chlorophyceae was the dominant green algae family followed by the remaining other families. All these taxa constitute new records for the study area. For the taxonomic work the keys are very important tools for the identification of genera. So in this investigation, construction and consultation of keys are paramount importance. Keys are devices useful in identifying known or unknown algal genera found in any type of habitats of the region. The key was developed with the aid of published data and recent studies.

Key words: Dichotomous key, algal forms, ponds algae; thallophyta, phytoplankton.

Punjab province of Pakistan has a great potential of fresh water algal flora diversity in various ponds establish and spread along the banks of different rivers. Algae are unicellular or multicellular organisms and range in size from minute phytoplankton to giant marine kelps that may grow to 60 meters long (Raven *et al*., 1986). According to Bold and Wynne, (1985) algae, fungi and lichens were included first time in thallophyta. All of them however, lake a differentiation of the body into true roots, stem, leaves with a few exception the algae have chlorophyll. Although many of them, particularly the red and brown algae are not green in color because of the presence of other pigments, which masks the green color of chlorophyll.

Algae have immense worth to life on earth and have long been used to evaluate environmental situations in aquatic ecosystem in all over the world (Stevenson, 2003). They retort to extensive range of pollutants and give an early warning sign of degrading ecological condition. They are greatly vulnerable to variants in their environment and consequently a good indicator (Anton 1991). Algae absorb and utilized turbidity of water and reduce the pollutants in water (Ali *et al*., 2010 a, b; 2011). They are primary producers and play a vital part in food chains mostly in aquatic habitat (Waqar-ul-Haq *et al*., 2010). Algae are found in many types of habitats, including aerial, aquatic and moist surfaces of soil. Much work has been done on different aspects of algae from various parts of Pakistan. However, there is a lack of complete knowledge on algal flora of Indus ponds at Ghazi Ghat bridge areas of Dera Ghazi Khan District. The diversity of phytoplankton was studied in these ponds with the objectives of taxonomy and population density. It must be admitted that this survey presents the algal flora recorded at a particular time of the year with no

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insight to the periodicity of the algae and contribute to the knowledge by developing the complete list of algal flora. It is very much hoped that in future study, the samples will be made at different seasons of the year. It is considered advantageous to illustrate as many of these species as possible since this study may constitute the basic information for any future investigators.

MATERIALS AND METHODS

Study area

The study area was comprised of four different fresh water ponds of mighty Indus river, at Ghazi Ghat, Dera Ghazi Khan. These were spread along the western and eastern bank of the rivers Indus. Every year during the monsoon rain the mighty Indus river replace the stagnant water with fresh water. The study of algal population was carried out from April-May 2013.

Algal Methodology

Algae specimens and samples were collected by plankton net, squeezing the aquatic vegetation, scraping and hand picking. Some necessary physico-chemical parameters were recorded at the time of collection (Fawley *et al*., 2005). Algal samples were preserved in 4% formalin solution in small glass bottles, labeled and numbered and then these samples were brought in the laboratory of Botany Department, Ghazi University, D. G. Khan. Water samples were examined under light by using microscope eye piece 5x,10x,15x, and objective 20x,40x, and 100x. manufactured by Interprise company China.

Key to identification of algal genera

Keys are devices which are very significant tools for the identification of genera. So in any taxonomic research work, construction and consultation of key are paramount importance. A key may be short, limited to one or more than one pair of contrasting statement called a couplet. Each statement of couplet is termed as lead. Only dichotomous key was used to identify the specimens of Indus ponds. In dichotomous key, each couplet has its two indented from the left hand edge of paper by the same amount they may or may not be adjacent.

Description of taxonomy of algal genera

For the sake of uniformity, under each family if there is more than one genus then key to genera is given. If a family has one genus then description of genus is given directly. The key in this study have been designed to help the reader to easily identify the algae. This has been made as simple and depends upon the distinctive botanical differences.

RESULTS

Key to algal families

1. Prokaryotic, filamentous heterocyst absent……Oscillatoriaceae
1. Eukaryotic
2. Unicellular non flagellated
3. Raphe and valves present, semi cells absent……Naviculaceae
3. Raphe and valves absent, semi cells present……..Desmidiaceae
2. Unicellular, flagellated
4. Unicellular, non coenobial, non spherical
5. Cup shaped chloroplast, pellicle absent ……..Chalamydomonadaceae
5. Disc shaped chloroplast, pellicle present……..Euglenaceae
4. Spherical Coenobial form
6. Spherical Coenobial colony flagellated……Volvocaceae
6. Flat, Net like Coenobial colony, non flagellated……Hydrodictyaceae
7. Filamentous, unbranched
8. Band and stellate chloroplast ……..Zygnemataceae
8. Not band or not stellate Chloroplast
9. Girdle Shaped chloroplasts, caps absent……Ulotrichaceae
9. Reticulate chloroplasts, caps present ……Oedogoniaceae
7. Filamentous branched
10. No shoots of limited growth
11. Branched Non Coenocytic …… Cladophoraceae
11. Branched Coenocytic…… Vaucheriaceae
10. Shoots of limited and unlimited growth ……Characeae

Description of algal families

Family: Oscillatoriaceae

The members this family are filamentous, filaments are unbranched, uniseriate. They show oscillatory movement of trichomes and hetrocysts

Table 1. Various indentified algal species with their natural form of presence. Their occurrence recorded in the form of (abundant, rare, common, and very common species)

S. No.	Algal Genera	Natural Form	Various Indus ponds			
			Pond- 1	Pond- 2	Pond- 3	Pond- 4
1	Division: Cyanophyta Class: Cyanophyaceae Order: Oscillatoriales Family: Oscillatoriaceae *Genus Oscillatoria sp.*	Layer	a	R	a	a
2	Division: Chlorophyta Class: Chlorophyaceae Order: Volvcales Family: Chlamydomonaceae *Genus Chlamydomonas sp*	Single	c	C	a	r
3	Family: Volvocaceae					
	Pandorina sp	Colony	c	C	a	a
	Volvox sp	Colony	c	C	a	a
4	Order: Chlorococcales Family: Hydrodictyaceae					
	Hydrodictyon sp.	Mat	c	C	a	r
5	Family: Scenedesmaceae					
	Scenedesmus sp.	Layer	c	C	a	a
6	Order: Ulotrichales Family: Ulotrichaceae					
	Ulothrix sp.	Mat	c	C	a	r
7	Order: Oedogoniales Family: Oedogoniaceae					
	Oedognium sp.	Mat	v.c.	v.c.	v.c.	A
8	Order: Cladophorales Family: Cladophoraceae					
	Cladophora sp.	Mat	c	C	a	R
9	Order: Zygnematales Family: Zygnemataceae					
	Zygnema sp.	Mat/layer	c	C	a	A
	Spirogyra sp.	Mat	v.c.	v.c.	v.c.	r
10	Family: Desmidiaceae					
	Closterium sp.	Single	c	C	a	a
	Cosmarium sp.	Layer	c	C	a	r
11	Class: Charophyaceae Order: Charales Family: Characaceae					
	Chara sp.	Mat, Crop	v.c.	v.c.	v.c.	-
	Nitella sp	Mat, Crop	c	A	c	-
12	Class: Xanthophyaceae Order: Vaucheriales Family: Vaucheriaceae					
	Vaucheria sp	Mat	r	A	a	r
13	Division: Chrysophyta Class: Bacillariophyaceae Order: Pennales Family: Naviculaceae					
	Pinnularia sp	Single	v.c.	v.c.	v.c.	-

are absent. They forming either an expanded plant mass or present as loose filaments, attached to submerged rocks or vegetation in a stream, color can range greatly from blue-green algae to dark red, brown or purple.

Genus: Oscillatoria

It is a fresh water filamentous blue green alga. The trichomes of Oscillatoria are cylindrical and unbranched. The individual's cell is often shorter than broad, except for the apical cell, which may be capped and attenuated. Unbranched filaments lacking a sheath, filaments cylindrical and not tapering along their length, heterocysts absent, can be either single filaments or aggregated in small colonies, when live, filaments often exhibit a characteristic "oscillating" movement.

Family: Chlamydomonaceae

This family includes unicellular forms of the volvocales. The cells are uninucleate with the definite cell wall. Each cell has two or four flagella, of equal length and a cup shaped chloroplast.

Genus: Chlamydomonas

It is simplest unicellular fresh water alga. The cell is biflagellate spherical and ellipsoidal or pear shaped. The cell is bounded by thin but firm cellulose wall. The chloroplast varies in form among the many species of Chlamydomonas. It may be parietal and cup or urn shaped, or H shaped. One or two too many contractile vacuoles and a single nucleus occur in the colourless cytoplasm.

Family: Volvocaceae

The family Volvocaceae includes coenobic colonial organisms. Almost all the genera have biflagellate cells with typical Volvocalena, organizations .A number of Volvocacean algae secrete substances in to their surrounding medium, which are self inhibitory to some other organisms.

Table 2. Presence, absence data of algal species observed under a microscope from samples collected from various ponds of Indus River

S. No.	Name of algal genera	Specimens indentified from sampling sites			
		Pond- 1	Pond-2	Pond-3	Pond- 4
1	Closterium	√	√	×	×
2	Cosmarium	√	√	√	×
3	Pinnularia	√	√	√	×
4	Scenedesmus	√	√	×	×
5	Vaucharia	√	×	×	×
6	Volvox	×	√	√	×
7	Oscillatoria	×	×	√	×
8	Nitella	×	√	√	×
9	Oedogonium	√	√	√	×
10	Cladophora	√	√	√	×
11	Zygnema	√	√	√	×
12	Spirogyra	√	√	√	×
13	Hydrodictyon	√	√	√	×
14	Chlamydomonas	√	√	√	×
15	Pandoria	√	√	√	×

Table 3. Chemical properties of Fresh water ponds of Indus River

Indus River fresh water ponds	EC×10^6	$Ca^{++}+Mg^{++}$	Na^+	CO_3^-	HCO_3^{--}	Cl^-	SAR	pH
1	2970	16.10	13.60	NIL	12.28	14.02	4.80	6.75
2	1348	9.25	4.23	NIL	8.18	3.20	1.96	5.62
3	2560	14.18	11.42	NIL	12.76	10.62	4.29	4.75
4	1286	8.96	3.90	NIL	7.02	4.24	1.48	5.45

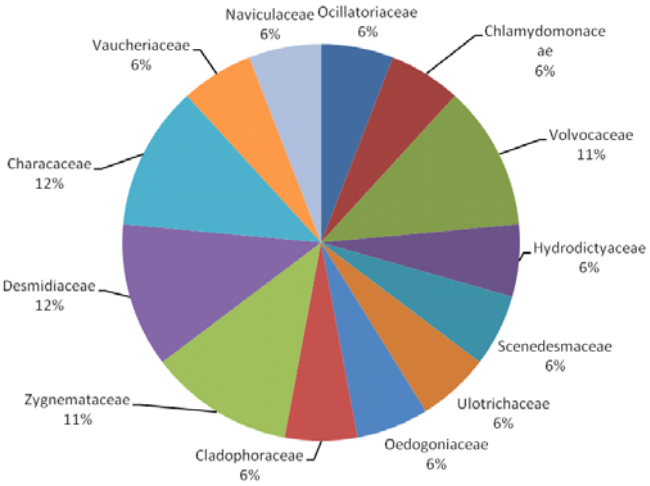

Fig. 1. Diversity of algal families found in study area

Key to Genera

1. Alga ellipsoidal Coenobial colony……..
1 .Pandorina.

1. Alga spheroidal Coenobial colony……..
2.Volvox.

Genus: Pandorina

In Pandorina 16-32 cells with truncate apices are arranged to form an ellipsoidal coenobium. Polarity is manifested is that stigmata of the interior cell of the colony are larger than those at the posterior.

Genus: Volvox

It is a fresh water green alga. Numbers of cells in various species are range from 1000 and 50000. All the species have cytoplasmic connections between the cells during embryonic development but in some time they break as the young individual enlarges. The cytoplasmic bridges or connections are the stretched remnants of protoplasm of incompletely divide protoplast.

Family: Scenedesmaceae

The member of this family is coenobic and occurs in the plankton, among benthic algae in quite bodies of fresh water, or they may be present in soil. The cells are uninucleate, variable in shaped, and specifically arranged with respect to one another.

Genus: Scenedesmus

Scenedesmus species are widely distributed in fresh water and soil. The terminal cells of some species have spines. Some species have tuft of bristles which help in buoyancy. Cell wall is smooth.

Family: Ulotrichaceae

The members of this family are unbranched filaments or bacilliform cells that may be associated in short filament. The latter may be firmly attached to a substrate. The aquatic species occur in both marine and fresh water.

Genus: Ulothrix

Ulothrix is filamentous and unbranched, basal cell act as hold fast, each cell uninucleate with girdle shaped chloroplast usually with one to several pyrenoids. Cells are broader than long.

Family: Oedogoniaceae

Unbranched filaments of cylindrical cells can form dense mats of coiled filaments, yellowish-green in color, epilithic or epiphytic on submerged surface in streams.

Genus: Oedogonium

Oedogonium is a green fresh water alga found in pools and ponds. It remains attached to submerged objects to stone or inanimate objects. The filaments unbranched chloroplast a reticulate network, Characteristics " rings" present at one end of many cells due to unequal cell divisions. The filaments composed of cylindrical cells arranged end to end in a single row. The basal cell is holdfast which attaches the filaments to the substratum. The cell wall is consists of inner cellulose layer, middle pectose, and inner chitinous layer.

Family: Cladophoraceae

Branched filaments forming feathery tuft or coarse clusters, bright green to yellow-green in

colour, can form large growths in slower flowing stream area, less than 30 cm in length.

Genus: Cladophora

It is usually attached to the substratum by rhizoidal cell. The filament is branched consisting of elongated cells which are multinucleate. The cells contain a large vacuole and a reticulate parietal with numerous pyrenoids.

Family: Zygnemataceae

The members of this family have short or long cylindrical cells and are unbranched; except for occasional short rhizoidal branches that attaches some species to the substrate. The wall is continuous and often surrounded by slimy sheaths. The cell wall lacks pores. Unbranched filaments with one or more spiral chloroplast can from dense mats, clots or tufts, yellow- green to grass-green to brownish in color; can grow rapidly into the dominant species of a stream region.

Key to Genera

1. Chloroplast spiral form……..
1.Spirogyra
1. Chloroplast stellate form……
2.Zegnema

Genus: Spirogyra

Spirogyra is a free floating green alga found on the surface of stagnant ponds on still fresh water. The silky masses of this alga occur resting on the bottom or floating on a variety of body of fresh water. The cylindrical cell of the spirogyra contains a large central vacuole in which the non spherical nucleus is suspended by thread of the cytoplasm. The filaments are unbranched, uniform in diameter along their length, chloroplast one or more spiral in a regular pattern through the cell, sexual reproduction occasionally observed.

Genus: Zygnema

Zygnema is a fresh water alga forming bright green free floating masses in stagnant water. It has unbranched filaments, filaments uniform in diameter along their length, each cell contain axial, stellate chloroplast, each with a pyrenoid. The cells are surrounded with gelatinous sheath of varying thickness depending on the species. The cell wall is composed of two layers, the outer layer is pectose and inner is cellulose. Sexual reproduction takes place through conjugation of filament and subsequent development of zygospores.

Family: Desmidiaceae

The members of this family are unicellular, colonial or filamentous. Their cell wall are composed of two halves of different age because of the manner of cell division, and furthermore, they are interrupted by pores through which mucilaginous substance are secreted. The cells are composed of two mirror images, counter parts or semi-cells that contain conspicuous chloroplast with pyrenoids.

Key to Genera

1. Cells elongated and pointed at both ends……
1. Closterium
1. Cells not elongated not pointed ……
2.Cosmarium

Genus: Closterium

They are elongated, unicell, narrowed toward both poles, sometimes slightly tumid at the equator and the slightly accurate. The semi cells contain single axial chloroplast that may be readily rich. There is a vacuole near each pole of the cell in which one or more granules of Barium sulphate may be observed in Brownian movement. The cell wall is three layered.

Genus: Cosmarium

Cosmarium is a free floating alga. It occur in fresh water, ponds, pools, Ditches, either singly or in amorphous. The cells of Cosmarium are deeply incised at the isthmus to form a sinus and conspicuously divide into semi cells.

Family: Characeae

The member of this family are generally floating or only mildly embedded in substrate of slow-flowing or pooled areas, occasionally found in areas of moderate flow, yellowish-green to grass-green in color. The thallus is well organized and is differentiated into rhizoids and erect branch axis. This axis is dividing into nodes and internodes. At the nodes of main axis whorls of branches of unlimited growth are present; bear branches of limited growth are present. Coarse plant may be easily mistaken for a higher plant, composed of a main axis with unbranched branchlets extending from nodes.

Key to Genera

1. Main axis corticated stipulodes present……
1. Chara
1. Main axis uncorticated stipulodes absent……
2. Nitella

Genus: Chara

Most of the species are fresh water found submerged in shallow water ponds, tanks, or lakes a few species grow in alkaline water and hot

springs. The plant body of Chara is multicellular and macroscopic. It is 20-30 cm in height and is differentiated in to rhizoids and main axis.

Genus: Nitella

Plant body is comparatively more branched mucilaginous and does not have calcareous deposition. Vegetative body and sexual structure are smaller than Chara. Branched are furcated. The globule is directed upward while is downwardly directed.

Family: Vaucheriaceae

The members of this family are found in fresh water habitat in temperate region. The aseptate, siphonaceous and Coenocytic thalli are found attached to the substratum by branched hepteron. They form green felty patches on damp surfaces, or growing attached to surfaces within a stream, usually a grass-green color, coarse in texture.

Genus: Vaucheria

Most of the species are fresh water but a few are marine. Vaucheria has a springly branched Coenocytic and siphonaceous thallus. The wall of the filament is relatively thin and lack elasticity. It is differentiated into on outer pectic and inner cellulose layer. There is well developed siphon like central vacuole with in the filament.

Family: Naviculaceae

Valves with raphe system running along apical axis: valves symmetrical along apical and transapical axis.

Genus: Pinnularia

It is widely distributed in fresh water or stagnant water, ponds, lakes and ditches. The cells are elongated and elliptical in outline. The cell wall (Frustule) is characteristic and is composed of pectic and silica. Each cell has two valves, upper valves are called epitheca and lower valves are called hypotheca. On the dorsal side of each valve is present a structure called raphe which helps in locomotion.

Family: Hydrodictyaceae

The members of this family are organized as coenobic colonies and occur in quite or slowly moving water. They reproduce asexually by zoospores. The sexual reproduction is isogamous and the gametes are motile.

Genus: Hydrodictyon

Hydrodictyon or water net is a free floating fresh water alga. The coenobia of this species are typically cylinderical and closed at the poles. The mature coenobium is Sausage shaped and hollow in center.

Diversity and Morphological Features of Algal Genera

The diversity of the algal families in connection to the presence of genera in the various ponds of Indus River at the vicinity of Ghazi Ghat, Dera Ghazi Khan district showed in Fig .1 algal families were observed from all the study areas. Among them, Desmidiaceae and Characeae were abundant and shared 12% respectively of the algal diversity in fresh water ponds followed by Volvocaceae and Zygnemataceae and shared 11 % respectively. But all the rest of the observed families were shared equally approximately 6% from the total diversity of the algal species (Fig 1). The natural form of the algal species was also varied. From the total 17 genera only three were found in single natural form such as *Chlamydomonas sp, Closterium sp. and Pinnularia sp*. and two species like *Pandorina sp.* and *Volvox sp.* were found in colony form. But the highest number (9) of algal species like Hydrodictyon, Chara, Cladophora and Nitella etc were found naturally in Mat form. Few algal species were found in layer form (Table 1). All the genera of algae were found in different diversity like abundant, very abundant, rare and common and this diversity were showed in this investigation in the Table (2). The chemical properties of ponds water where the algal samples were collected were shown in the Table 3. The chemical properties of various ponds were showed the habitats where different varieties of the algal species were grown happily.

DISCUSSION

The factor which testifies connection between number of species, genera and families determines the 'face' of flora with the greatest clarity (Tolmachev, 1974). Shmidt, 1980, 1984 was argued that the richer floras differ from less rich floras by higher values of these parameters. Additionally, generic factor is considered as a factor of taxonomic diversity that does not depend on area.

A comparison of taxonomic spectrum of algal flora of different habitats of Indus River in Pakistan. The choice of the habitats was arbitrary.

The only generalized data brought in the various literatures across the world like Muzafarov, 1965; Kogan, 1973; Tien, 1982; Chkhaidze, 1987; Wasser and Tsarenko, 2000; Tsarenko and Petlevanniy, 2001 were used in the investigation. The compared habitats and regions rather differ on the terrain, natural settings, remoteness from fresh water ponds at different range of Indus river of Pakistan, a degree of a level of algal flora knowledge and many other attributes. However, ostensibly such comparison is useful to reveal general regularity and characteristic features in the algal structures of these regions. Absolute values of all comparable floras differ markedly and indeed depend on degree of algal study in the country. Therefore, proportion in percent a division occupies in the total algal flora was preferred than its absolute value.

In all the compared floras in various investigated ponds as presented in Table 1, the basic role is played by two divisions, namely Chlorophyta and Bacillariophyta, occupying top two positions in taxonomic spectra. Contribution of these two divisions in the algal flora of Pakistan looks very close to the algal flora of various parts of the globe. This can be explained by the geographical location and presence of the general orographical and climatic attributes of the region.

An examination of the number of fresh water algal records from each broad taxonomic category from Indus River, indicates that approximately equal proportions of taxa are represented on each habitat (Fig 1). This trend is very similar to that previously observed for the stream macro algal flora, in that the cyanobacteria and Chlorophyta are most strongly represented, followed by the Rhodophyta, with a much smaller proportion represented by the Tribophyta (Sherwood, 2006). This is a first inclusive taxonomic study from Ghazi Ghat pond areas and findings will be of great benefits to scientists in future who dearth to discover more and more about fresh water algae.

CONCLUSIONS

Based on current study of the fresh water ponds algal flora of Indus River, most taxa are cosmopolitan in distribution, and very few are endemic to the fresh water ponds at the vicinity of Ghazi Ghat, Dera Ghazi Khan. However, a true estimate of the endemism of this flora will not be available until molecular methods are employed on a routine basis to confirm or refute the endemic or cosmopolitan nature of the collections. For many studies, however, such as general ecological investigations, a fine taxonomic scale may not be necessary for the kinds of conclusions being drawn. In any study of fresh water ponds algae, the taxonomic structure used for identification should be noted so that investigators will be aware of the taxonomic limitations of that study. These patterns may correspond to morphological characters provided sufficient time and effort is spent searching for these connections e.g. at the electron microscopic level. In any case, increased use of molecular data in stream algal taxonomic studies will aid our understanding of the breadth of geographic distribution and the evolutionary diversification of these organisms.

Furthermore, algal flora studies need laborious and long-term struggle, examining and measuring of new records will avert errors.

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