

IMPACT OF WATER QUALITY ON THE ALGAL DIVERSITY IN PESHAWAR VALLEY, PAKISTAN

**BY
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**DEPARTMENT OF BOTANY
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**IMPACT OF WATER QUALITY ON THE ALGAL
DIVERSITY IN PESHAWAR VALLEY, PAKISTAN**



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**BY
AQAL ZAMAN**

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Impact of water quality on the algal diversity in Peshawar Valley Pakistan by Aqal Zaman.

Abstract

The present study, spread over two years dealt with the phycological flora of 10 representative sites of Peshawar Valley as affected by quality of water. Algal samples were taken seasonally from each of the sites. The various physical, chemical and biological features such as temperature, pH, turbidity, total dissolved solids, total suspended solids, electrical conductivity, sodium chloride, dissolved oxygen, carbon dioxide, ammonia nitrogen, nitrates, sulphates, phosphates, total alkalinity, total hardness, calcium hardness, magnesium hardness, and biological oxygen demand were analyzed.

The phycological flora consisted of 239 species belonging to 68 genera. The class Cyanophyceae was represented by 42 species and 12 genera. Chlorophyceae had 32 genera and 94 species. Bacillariophyceae had 19 genera and 86 species. Euglenophyceae had 2 genera and 11 species while Xanthophyceae had 3 genera and 6 species. Microphotographs of some important species were taken. A detailed taxonomic description of all the species is provided in appendix.

The seasonal distribution showed that there were differences in kind and number of species in various seasonal investigated sites. In spring, there were a total of 116 species that belonged to Cyanophyceae (20 species), Chlorophyceae (49 species), Bacillariophyceae (38 species), Xanthophyceae (5 species) and Euglenophyceae (3 species). The summer season had 73 species of five classes. Cyanophyceae (13 species), Chlorophyceae (26 species), Bacillariophyceae (28 species), Xanthophyceae (one species) and Euglenophyceae (5 species). There were 126 species in five classes in autumn season including Cyanophyceae (24 species), Chlorophyceae and Bacillariophyceae (each 46 species), Xanthophyceae (one species) and Euglenophyceae (9 species). There were 103 species during winter including Cyanophyceae (16 species), Chlorophyceae (39 species), Bacillariophyceae (45 species) and Euglenophyceae (3 species).

There were a wide range of variation among various parameters in different sites and seasons. To establish the possible relationship between species and various

parameters, correlation analysis was performed. Positive correlation between algal species %age and total dissolved solids, ammonia nitrogen, electrical conductivity, carbon dioxide, nitrate, phosphate, total hardness and calcium hardness were observed. With increasing TDS from 110 – 287 mg/L, the number of species increases in all the seasons. With increasing ammonia nitrogen from 0.37 – 0.75 ppm, 0.29 – 3.77 ppm and 0.21 – 2.99 ppm increased the number of species in spring, autumn and winter, respectively. Similarly, increasing of PO_4 (5 – 14.4 mg/L) in spring, (2.2 – 17 mg/L) in autumn, (0.7 – 8.6 mg/L) in winter increases the algal species. Moreover, the algal species also increases when the amount of NO_3 (0.3 – 16.5 mg/L), electrical conductivity ($31 - 150 \text{ dS m}^{-1}$), CO_2 (111 – 175 ppm), total hardness (385 – 1530 mg/L) and calcium hardness (200 – 1360 mg/L) increases in the water in winter season. On the contrary, BOD and NaCl were negatively correlated with number of species. BOD was inversely proportional to algal species %age. With increasing of BOD (20 – 71 mg/L) in spring, (14 – 93 mg/L) in summer, 15 – 55 mg/L in autumn and 18 – 70 mg/L in winter, decreases the number of species %age. Likewise high value of NaCl (103 – 4.5 mg/L) in summer season was not favourable for the growth and distribution of algae as compared to other seasons. Furthermore, there was no correlation between the water temperature, pH, turbidity, total suspended solids, dissolved oxygen, sulphate, total alkalinity, magnesium hardness and species %age. Despite that, the optimum temperature, high pH, normal turbidity, high CO_2 and SO_4 accelerate the growth and number of species whereas the increase or decrease of TSS, DO, TA and MgH had generally no effect on the addition or reduction of algal species. Further study is needed to quantify some of the parameters and to work out the productivity of these water bodies at primary and secondary level.

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Introduction

I. Size and location

Peshawar Valley is a saucer shaped semicircular basin. It includes the districts of Peshawar, Charsadda, Nowshera, Mardan, Swabi and parts of Malakand, Mohamand and Khyber Agencies. The total length of the Valley from west to east ranges up to 110 km while the width reaches up to 80 km from north to south covering almost an area of 8800 Km². It lies between 71° 15' and 72° 47' E longitudes and 33° 40' and 34° 31' N latitudes. It is surrounded by Malakand-Lower Swat mountain ranges in the north, Mohmand and Khyber hills in the west; on south by Kohat district; while in the east by the Haripur district and the Indus River separates Peshawar Valley from Potwar Plateau (Fig. 1).

The altitude of Peshawar Valley ranges from 365m (Peshawar) to 1800m (Malakand Pass). The Valley is supposed to be a lake in the past and has been turned into present fertile plains by sedimentation of the various soil particles reaching up to 300 m in thickness. It is mainly composed of lacustrine silt, sand, clay, loam, gravel and boulders. Bed rock out crops scattered throughout the Valley can be observed.

II. Physiography

Peshawar Valley is surrounded by mountains except the south east. These mountains after ending leave an opening at Attock through which the Kabul River drains into the Indus River. These mountains take their names from the tribes which inhabit them, such as Yousafzai, Mohmand, Mullazai and Shinwari, Afridi and Khattak mountains. The Yousafzai mountains are composed of metamorphic and crystalline rocks. The Mullagori range, the Afridi range and the Mohmand Mountains have thick layers of grey lime stones, shales and stones. The region up to the Khattak mountains is composed of grey colour slate. The post tertiary and recent conglomerates, sands and alluvial clay occupy large areas of the Valley.

III. Plains and Soil

The plains are also named after the tribes, i.e. Yousafzai Plains, Hashtnagwar plains, Mohmand plains, Peshawar plains, Afridi and Khattak plains and foot hills.

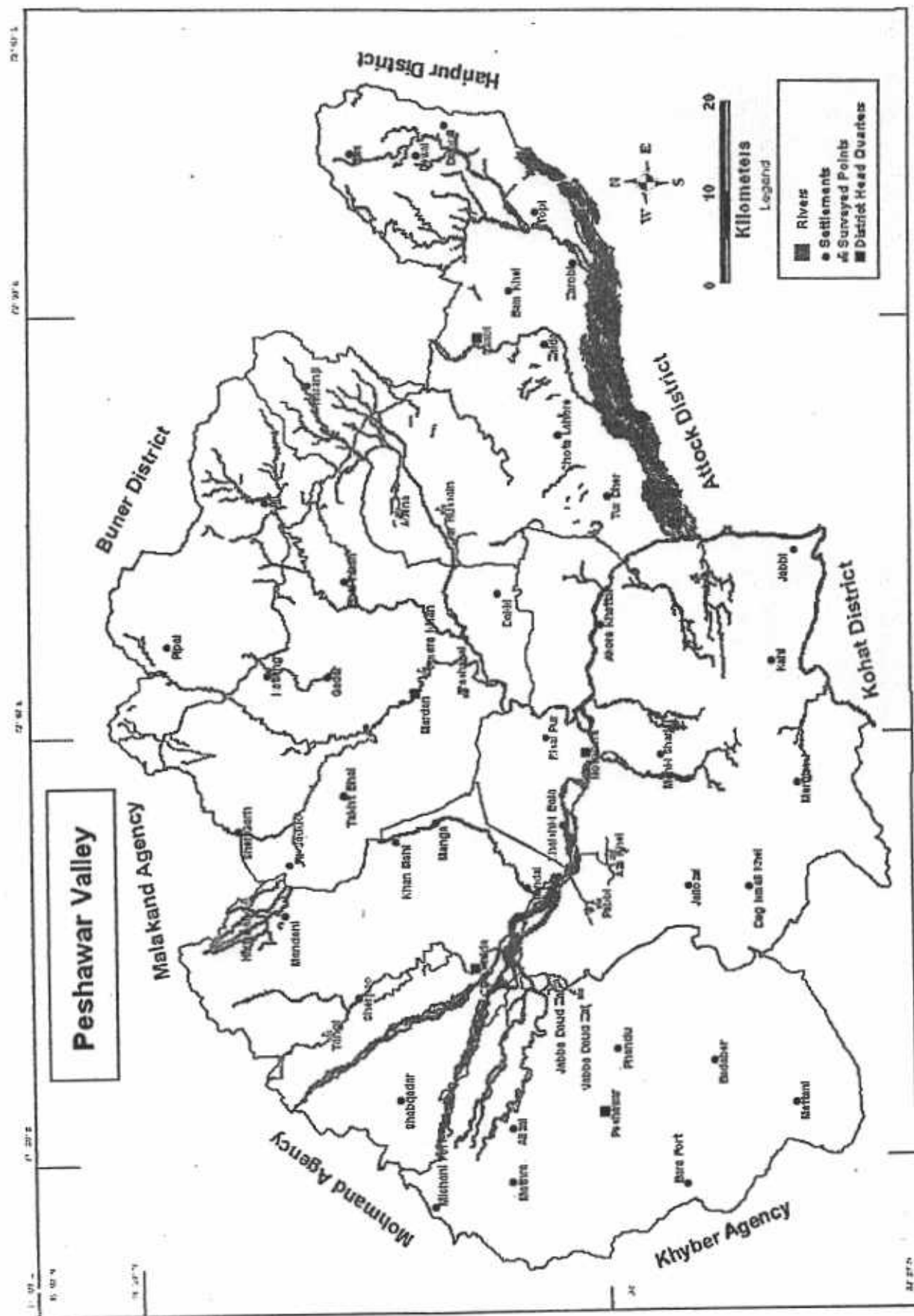


Fig. 1 Map of Peshawar valley showing investigation sites.

The Yousafzai and Mohmand plain lies to the south of the Yousafzai and Mohmand branches of the Siah Mountains. The fertile soil is cultivatable due to irrigation canal system. The plains of Mohmand are very fertile. The fertile and irrigated area is occupied by Mohmand whereas the arid and barren area is occupied by Afridis. The eastern part of the plain is occupied by Khattaks, which is in fertile and is continuously eroded by torrents. The foot hills extend right from Cherat to Nowshera. This area is barren and uncultivated and is occupied by Khattaks. The central part of the Valley consists of fine alluvial deposits rich in humus contents. The cultivated tracts consist of a rich, light and porous soil, composed of a pretty even mixture of clay and sand which is good for cultivation of wheat, sugarcane and tobacco. Most of the soil are alkaline ranging in pH from 7.80 to 8.40. The organic matter contents in most of the soil are low (Eleberson, 1967)

IV. Hydrography

The Kabul river, enters the district at Warsak and flows in a south-eastern direction in the upper northern half of the district. On entering the Peshawar plain, it is divided into several channels. The two main channels are the Adezai or Hajizai in the north and the Naguman in the south. The Adezai river flows in the district along the boundary with Charsada district. Another channel, branching from the right bank of the Naguman river, is the Shah Alam which flows parallel to it and again merges with Naguman river further in the east. The Bara river enter the district south of Jamrud fort and flows in the south-eastern direction through the district into Nowsherea district.

V. Climatology

The climate of Peshawar Valley is extreme. The mean maximum and minimum temperature, precipitation and humidity recorded at Peshawar station is given in Table 1. The summer season persists from May to September. June is extremely hot and dry. The mean maximum temperature rises to over 40 °C while the mean minimum is over 25 °C. Monsoon rains are received from July to September. The months of July and August are hot and humid. It is pleasant from September and

up to mid November. It is cold from December to mid February. The mean maximum and minimum temperature for January, the coldest month has been recorded as low as 18.35°C and 4.00°C respectively. The spring comes somewhere around the middle of March which is the most pleasant period of the year.

Rainfall is received both in winter and summer. The winter rainfall due to western disturbances shows a high record in the month of February, March and April. The highest winter rainfall has been recorded in the month of March while the highest summer rainfall in the month of August. The average winter rainfall is higher than that of summer.

Table 1 Mean monthly temperature, rainfall and relative humidity of peshawar Valley from 2000-2004.

Month	Mean Temperature ($^{\circ}\text{C}$)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
January	18.4	4.8	2.5	80
February	20.2	7.4	4.5	75
March	26.1	13.0	8.9	70
April	32.1	18.8	1.1	62
May	38.2	24.25	0.8	47
June	37.6	26.7	3.4	56
July	37.6	26.9	14.8	68
August	35.6	26.2	36.0	77
September	33.9	23.2	1.5	76
October	30.4	17.2	0.0	78
November	24.9	10.7	2.1	78
December	20.8	6.8	3.8	78
Annual Mean	29.7	17.2	6.6	70.5

Source: - Data Processing Centre, Pakistan Meteorological Department, Peshawar.

Algae

The term algae has been derived from a Latin word *Alga* which means sea weed. The study of algae is called Algology or Phycology which in itself consists of two Greek words *phykos* – *phykos* = sea weeds (algae) and *logos* = discourse (study). Algae was popularly known by the name *fucus* and Romans used to call *phykos* as *Fucus*. The algae include a large heterogenous assemblage of relatively simple plants that have little in common except for their reproduction. The group is considered to be primitive form from which more complex cryptogams and spermatophytes were evolved.

The characteristics on the basis of which algae can be defined are difficult to specify. Fritsch (1935) elucidated the term algae as “unless purely artificial limits are drawn, the designation algae must include all holophytic organisms (as well as their numerous colourless derivatives) that fail to reach the level of differentiation characteristics of archegoniate plants. Smith (1955) suggested that algae have usually unicellular sex organs and when they are multicellular, as in most brown algae, all cells are fertile. The group is autotrophic. The fundamental difference lies in the structure of reproductive organs of algae and those of higher plants. On the contrary the sex-organs and sporangia of bryophytes and other higher plants are invariably multicellular, with outermost layer sterile. Furthermore, in algae unlike higher plants, the zygote never develops into a multicellular embryo while still within the female sex-organ. Members of Charales are the exception having sterile outer cellular wall of the antheridium and plays no role in the formation of reproductive organs.

General Characters of Algae

1. Habitat

Algae are distributed every where from fathomless depth of ocean to the highest peak of the world. Their presence ranges from the boiling water of the hot springs to the ice cold (freezing) atmosphere of snow covered peaks of mountains. Thus, algae thrive well under all possible environments of the earth.

2. Structure of the Plant Body

The algae exhibit a remarkable variation in their size from a microscopic and unicellular such as *Chlamydomonas* to multicellular, complex, giant sized *Macrocystis*. Large number of forms show a marked variation in between these two limits. Giant Kelp or sea weed such as *Macrocystis macrocarpa* is more than 180 meters long.

3. Reproduction

All kinds of reproduction – vegetative, asexual and sexual reproduction are found in algae except Cyanophyceae where sexual reproduction is completely absent.

Vegetative reproduction

Algae largely reproduce by means of fragmentation which is accomplished by the separation of groups of living cells from the parent plant. The detached portion, the fragment, develops into a new plant. The fission through cell division is another common method of vegetative reproduction.

Asexual reproduction

Algae reproduce asexually under favourable conditions through spores such as zoospores, aplanospores, hypnospores, akinetes, autospores, endospores or cysts etc.

Sexual reproduction

Algae reproduce sexually under unfavourable conditions. The reproductive units called gametes (male and female) are formed in the gametangia. The plant may be homothallic or heterothallic. Sexual reproduction may be of Isogamous and Heterogamous types.

a. Isogamous

It is common among unicellular algae whereby both (male and female) gametes are morphologically similar but differ physiologically as in *Chlamydomonas* and *Ulothrix* species.

b. Heterogamous

The male and female gametes differ morphologically and physiologically. Male gametes are usually smaller in size. This kind of reproduction may be of two types: anisogamous and oogamous. In anisogamous the gametes are motile but male gametes are comparatively smaller in size and more active, e.g., *Chlamydomonas braunii* whereas in male gametes are motile and are formed in large number whereas female gametes are non-motile and bigger in size, and produced few in number. Male gametes (the antherozoids) are produced in the antheridium while the female gamete, egg or ovum, is produced in oogonium. Some complex reproductive bodies found in Rhodophyceae are called spermatium and carpogonium, the male and female reproductive bodies, respectively.

Fertilisation

In isogamous and anisogamous types of sexual reproduction both gametes are first released from their respective gametangia and fertilization takes place outside gametangia, process being called external fertilization. In oogamy, the male gametes are liberated from male gametangium which swims to the oogonium and fertilization takes place inside the oogonium called as internal fertilization.

Zygote

The fusion of two gametes forms the zygote which is diploid cell representing the sporophytic phase of the life cycle. It may undergo a period of rest or may germinate immediately after fertilization. In higher algae such as Phaeophyceae, the diploid (Sporophytic) generation is the dominant phase of the life cycle and the gametophytic generation lasts for a short time. However, in majority of algae, the gametophytic phase is the dominant phase of the life cycle.

Germination of Zygote

The zygote may germinate directly or indirectly. During direct germination, the zygote after meiotic division develops directly into a new plant without producing any intermediate spore-like structure, e.g., *Spirogyra*. While during indirect

germination, the zygote may divide meiotically and forms motile or non-motile haploid spores, of which each develops into a new plant, e.g., *Chlamydomonas* and *Ulothrix*, or the zygote may divide mitotically to form a diploid plant. Later the plant reproduces by meiotic division and produces spores. Each spore develops into a new plant, e.g., *Ectocarpus*.

4. Classification of the Algae

Although Linnaeus (1753) was the first one to use the term algae, but until 19th century there was no substantive attempt to classify this group. Harvey (1836) for the first time divided algae into three groups:

- a) Chlorospermae (green and fresh water forms).
- b) Melanospermae (living marine forms) and
- (c) Rhodospermae (small and red forms).

West in (1916) classified algae on the basis of reproductive structures particularly on the presence and absence of flagella and their nature. He divided algae into following four classes:

- 1) Isokontae (flagella of equal size)
- 2) Heterokontae (flagella of unequal size)
- 3) Stephanokontae (flagella crowned)
- 4) Akontae (flagella absent)

Engler and Prantl (1926) believed that the fungi have been derived from algae and, therefore, he mixed the two groups and proposed following 11 classes.

- 1) Schizophyta
- 2) Phytosarcodina
- 3) Flagellata
- 4) Dinoflagellata
- 4) Bacillariophyta
- 5) Conjugatae
- 7) Chlorophyceae
- 8) Charophyta
- 9) Phaeophyceae
- 10) Rhodophyceae
- 11) Eumycetes (True fungi)

Pascher (1931) based on the phylogeny and interrelationships of various groups, divided algae into eight divisions as follows:

- 1) Chrysophyta
- 2) Pyrrophyta
- 3) Chlorophyta
- 4) Phaeophyta
- a) Chrysophyceae
- a) Cryptophyceae
- a) Chlorophyceae
- a) Phaeophyceae
- b) Diatomae
- b) Desmodontae
- b) Conjugatae
- c) Heterokontae
- c) Dinophyceae
- 5) Rhodophyta
- 6) Euglenophyta
- 7) Charophyta
- 8) Cyanophyta
- a) Bangiineae
- a) Eugleninae
- a) Charophyceae
- a) Myxophyceae
- b) Floridinae

Lady Tilden (1933) classified the algae on the basis of pigmentation, reserve food material into five classes:

- (1)Chlorophyceae. (2)Myxophyceae. (3)Rhodophyceae. (4)Phaeophyceae and (5) Chrysophyceae

Fritsch (1935) classified algae on the basis of phylogeny, affinities and inter-relationships in to the following various classes:

- 1) Chlorophyceae (Grass-green) 2) Xanthophyceae (Yellow-green)
- 3) Chrysophyceae (brown or orange) 4) Bacillariophyceae (Yellow or golden brown)
- 5) Cryptophyceae (Nearly brown) 6) Dinophyceae (Dark yellow or brown)
- 7) Chloromonadineae (Bright-green) 8) Euglenineae (Pure green)
- 9) Phaeophyceae (Brown) 10) Rhodophyceae (Red)
- 11) Myxophyceae (Cyanobacteria) (Blue-green)

With advancement in phycological knowledge Trainor (1978) divided algae in five division with thirteen classes on the basis of presence or absence of nucleus, flagella and pigmentation as follows.

Division	Classes
Cyanophyta	Cyanophyceae
Rhodophyta	Rhodophyceae
Cryptophyta	Cryptophyceae
Chlorophyta	Chlorophyceae
	Charophyceae
	Euglenophyceae
	Phaeophyceae
	Bacillariophyceae
	Xanthophyceae
	Chrysophyceae
	Haptophyceae
	Eustigmatophyceae
	Dinophyceae

Recently Shameel, (2001) proposed a new classification on the basis of micromorphological, ultrastructural and phycochemical characteristics of algae. He

divided algae into three kingdoms such as Monera, Protista and Protoctista. The kingdom Monera include 2 phyla, 3 classes and 6 orders; kingdom Protista include 12 phyla, 17 classes and 46 orders while the kingdom Protoctista include 5 phyla, 11 classes and 55 orders. The above three kingdoms include 19 phyla, 31 classes and 107 orders.

Importance of Algae

Algae are aquatic plants, which are primarily used as direct source of food by several sea animals and fishes. Some algae are food delicacy for human beings. The algae (sea weeds) form the most important part of the diet in Japan, China, Malaya, Indonesia, Burma and Thailand. *Ulva lactuca* are used in Scotland for the preparation of salad and soups. Few species of *Spirogyra* and *Oedogonium* are also used as food in south India.

Mineral elements, which are important in human and animal physiology are found in sea weeds and make them an unique supplement for well balanced diet. Potassium, sodium and chloride are found in the ionic form in sea weeds (Pillai, 1955). Several vitamins except ascorbic acid have been reported from *Chlorella* (Tamiya 1960). *Chlorella* contains thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, vitamin B₁₂ and lipoic acid. It also yields chlorellin an antibiotic, which is effective against gram positive and gram negative bacteria. Gram positive bacteria causes the diseases pharyngitis, osteomyelitis, skin infection while gram negative bacteria causes the diseases gonnoarhea, anthrox etc. *Cladophora* extract is acts a bactericidal. *Phormidium* extract is used in healing the wounds and for treatment of dermal ulcer. *Pandorina* and *Scenedesmus* produces pandorin and scenedesmine, used for curing influenza, tetanus and dysentery. Sea weeds are utilized for feeding hens and young livestock to improve the iodine deficiency in Scotland, New Zealand, Norway, France and United States. Iodine is also extracted from *Sargassum* (Joseph, 1948).

Many blue green algae are capable of fixing atmospheric nitrogen in the soil. De, P.K (1939). Various species of *Nostoc*, *Scytonema* and *Anabaena* etc have been found grow plentiful and add nitrogen to soil (Singh 1950). Due to the presence of

potassium chloride (KCl) sea weeds are used as fertilizer in many countries like Japan, France, United States, England and India.

Alginic acid derivatives are extracted from the cell wall of the members of Phaeophyceae such as *Laminaria*, *Macrocystis* and *Ascophyllum* etc, in USA, Japan, S.America and Australlia, which are used in making polishes, paints, food, textile and pharmaceutical industries. *Gelidium* (Rhodophyceae) is used as a source of agar in Japan (Thivy, 1951). In india, annual yield of agar from dry sea weeds of chilka lake has been estimated to be 4.06-5.08 metric tons (Mitra, 1946).

Germany processes sea weeds in mixture with cement to make buildings light in weight and heat resistant. Alkalies are prepared from sea weeds ashes by burning sea weeds. These alkalies are used in the manufacture of soap and alum.

In short algae have innumerable uses and are essential component of all aquatic systems since they serves as the base of food chain for all other organisms (Vernon *et al.*, 2002).

Water

Life without water is impossible. It is essential for all living organisms. Water bodies constitutes about 70% of the earth in the form of Oceans, river, lakes and glaciers etc. It is a universal solvent and therefore accommodates minerals, salts, human wastes and agrochemicals such as insecticides and pesticides. There are many uses of water in biosphere but the requirement in quantity and quality are varied. For domestic purposes, water is required for drinking, cooking, washing and bathing, flushing of toilets, gardening etc. For public uses, water is required for cleaning streets, recreational purposes like swimming pools, public fountains and ornamental ponds, fire protection and public parks. For industrial purposes, water is used for processing and cooling. For agricultural purpose, water is used for irrigation and is also used fro carrying away waste from all manner of establishments and institutions. On ecosystem level water is needed for humidity, rain fall, snow, fresh and marine water bodies. Water is the single factor that changes the fate of civilization, drought, floods and amount of rainfall are the examples.

Generally water is the most common habitat for all aquatic organisms, especially the sole habitat for the alga. Algal life and nourishment depends upon the quantity and quality of water. Optimum level of quantity and quality of water are essential for growth and distribution of alga. Various physical, chemical and biological parameters that affect the quality of water and hence growth and distribution of alga are briefly outlined below:

1. Physical Parameters

The physical parameters include temperature, colour taste, odour, electrical conductivity, total dissolved solids (TDS), total suspended solids (TSS) and turbidity.

2. Chemical Parameters

The most common chemical parameters include pH, dissolved oxygen (DO), carbon dioxide (CO_2), ammonia Nitrogen (NH_3N_2), nitrate (NO_3), sulphate (SO_4), phosphate (PO_4), total alkalinity, total hardness (TH), calcium hardness (Ca^{++}H) and magnesium hardness (Mg^{++}H).

3. Biological Parameters

The most important biological parameter is the biochemical oxygen demand (BOD). The amount of oxygen used in the metabolism of biodegradable organic substance is termed as the biological oxygen demand (BOD). Both biochemical and chemical oxidation reactions take place in the aquatic environment but the usual reactions in natural water are biochemical. In terms of oxygen demand the most important type of biochemical reaction involves the oxidation of organic material. The population of microbes, other than algae, drastically change the biological characteristics of any water body.

Review of literature

Algae are known for their diverse morphology ranging from simple unicelled organism to highly complex multi-cellular structure. Because of this diversity in form, shape, appearance and structure, they are found in a variety of habitats right from desert to alpine snow bound peaks and from tropical to tundra regions due to wide adaptations in the morphology, physiology, ecology and reproductive features. Since they are source of food, medicines, easy to use in biotechnological research, provide bio-fertilizers and many other benefits to mankind, therefore research activities regarding algae are multidirectional. Such research endeavors involve an array of avenues. The most traditional aspect is the taxonomic research that is foremost requirement for any advance and applied research. Taxonomic studies have resulted in the publication of voluminous algal flora such as those of Tilden (1910), Husted (1930), Majeed (1935), Smith (1950), Prescott (1951), Desikachary (1959), Bold (1970), Tiffany and Britton (1971), Vinyard (1979), Akiyama and Yamagishi (1981), Leghari *et al.* (2002) Zaman and Sarim (2005) etc.

The applied aspects mostly centered around envisaging ecology, physiology, biotechnology, bio-fertilizers and reproduction etc. All these avenues have their own specific objectives and trends. It would not be possible to review the entire sphere of research activities. However, it would be appropriate to restrict the present review of literature to limnological and algae-water relationships, which is the objective of this work. Algae grow from slightly moist soil to deep fresh and marine waters, in stagnant, running, fresh, polluted, saline, alkaline, and other waters that definitely varies in their physical and chemical features.

The occurrence, growth and reproduction of algae is directly related to the physical features of water such as temperature, transparency, turbidity, quality and quantity of water and light recharge of water bodies, and the seasonal fluctuation of climatic features etc and chemical parameters such as amount, type and concentration of various salts, mineral and organic enrichment. The present study is primarily focused on the algal variation in different running water bodies, that centres around limnological approach, therefore a brief review of literature on this aspect is summarized below.

Worldwide lot of work has been done on the seasonal variation of algae in relation to their occurrence and habitat. Hortobagyi (1968) working on algal bloom in Vietnam observed that the number of species of Cyanophyta and Chlorophyta were dominant. He concluded that among Chlorophyceae the number of *Scenedesmus* species over-passed other species of algal blooms. Bolas and Lund (1974) worked on factors effecting the growth of *Cladophora glomerata* in the Kentish in four year controlled growth in flow tanks. They observed that there was a casual relationship between high phosphate contents and *Cladophora* overgrowth. Tomaszewicz (1974) worked on the Desmid flora over twelve months duration along with quantitative changes in a lake near Warsaw. Bourrelly (1975) described one forty four desmids of twenty two taxa from Guinea. Hosiasluma (1976) observed that small and moderate addition of HCl and NaCl promotes the growth of *Netrium* while high concentration caused death. Dubois-Tylski (1977) observed that in non axenic strain higher concentration of nitrate inhibit sexualization in *Closterium moniliferum* while in axenic strain higher concentration inhibit sexual induction but fusion of gametes was impeded. Olding *et al.* (2000) studied the relation between phytoplankton community composition and water quality and water body morphometry in urban lakes, reservoirs and ponds. They concluded that constraints posed by water body as a result of maximum depth may modify the trophic control of phytoplankton community composition. Leland *et al.* (2001) worked on the distribution of algae in the San Joaquin River, California in relation to nutrient supply, salinity and other environmental factors. It was concluded that interaction between salinity and nitrogen affected the structure of benthic algae communities. Koehler *et al.* (2002) explored that Chlorophytes increased in shallow rivers and diatoms in deeper rivers as a result of light differences and sedimentation loss. Kalin *et al.* (2001) while examining the development of phytoplankton community in a pet lake in relation to water quality changes, concluded that there was direct relation between water variables and phytoplankton community structure, and that total phosphorus and arsenic contents were the key factors responsible for the change in phytoplankton community composition.

Winter and Duthie (2003) observed that variation in physical and chemical parameters of water had direct effect on the spatial distribution of diatoms in Laurel Creek. Krivtsov *et al.* (2003) found that there is a relation between the elements within *Stephanodiscus rotula* the cell and the water in Rostherne Mere, UK. The algal biomass production was mainly controlled by availability of silicon and any decrease in the ambient Si resulted into intracellular elemental composition. Venkataramanaiah *et al.* (2003) studied the effects of high temperature on photosynthetic electron transport activities of *Spirulina platensis*. It was observed that high temperature had multiple target sites in photosynthetic electron transport system of *Spirulina platensis*. Juettner *et al.* (2003) worked on diatoms as indicator of stream quality in the Kathmandu Valley and middle hills of Nepal and India. They concluded that diatoms can be regarded as indicator in temperate stream.

Bernharat *et al.* (2004) observed that the Hubbard Brook Experimental Forest were characterized by periphyton assemblage of low biomass. Moreover, periphyton biomass rarely responded positively to enrichment with nitrogen and phosphorus. Rangsayatorn *et al.* (2004) during their experiments on biosorption of cadmium by *Spirulina platensis* observed that temperature had no effect on metal absorption but pH did affect. Yang *et al.* (2004) in their genetic and morphological studies found that radial spokes regulate ciliary and flagellar bending. They also concluded after biochemical analysis that calmodulin in the radial spokes suggest the regulatory mechanism controlling axonemal protein phospho relation and calcium binding to spoke proteins.

In Pakistan various scientists have worked on different aspects of algae. The first ever to study algae from the Punjab part of Pakistan was Ghose (1919), who described Myxophyceae of Lahore and later on Ghose, (1924) made a systematic and ecological study of the green algae of Lahore. Majeed (1935) prepared an account of 62 diatoms from Lahore. Salim (1941, 1949, 1956) studied the marine and plankton diatoms from Karachi Coast. Ahmad (1985) described the algal flora of some ponds of Khanpur. Aizaz and Farooqi (1972) reported some Chlorococcales from Karachi. Baqai and Siddiqui (1972) described fresh water algae pertaining to fisheries. Baqai *et al.* (1974) reported the limnological studies of Haleji and Kalri

lakes from Sindh. Nazneen (1974) worked on seasonal distribution of phytoplankton in Kinjhar Lake. Amin (1974) recorded some fresh water algal flora of Rawalpindi. Ali *et al.* (1975, 1977) reported algae from Rawalpindi and the other adjacent areas of Islamabad from limnological point of view. Masud-ul-Hussan (1978a, b) contributed to the taxonomy of fresh water algae of Punjab. Ali and Qureshi (1979) prepared a checklist of fresh water algae of Rawalpindi district. Anjum and Hussain (1983) described genera *Cymbella* and *Navicula* from Quetta Pishin Valley, Baluchistan. Among them 10 species were new record to Pakistan. Hussain (1984) reported fresh water algae from Hanna-Urak Valley, Quetta. They recorded 39 genera and 89 species of Cyanophyceae, Chlorophyceae, Charophyceae, Xanthophyceae, Bacillariophyceae and Euglenophyceae. Thirty four species were new record for Pakistan. Anjum *et al.* (1986) recorded 52 species of fresh water algae growing on stones from Baluchistan. Sarim and Ali (1986) studied the effect of Copper Sulphate on the growth of *Cladophora golmerata* (Chlorophyta). Iqbal (1986) worked on the limnology of Hub lake, Karachi. Masud-ul-Hassan and Zebun-Nisa (1986) added 41 species of fresh water algae from Azad Jammu and Kashmir. Anjum *et al.* (1986) described 24 species of *Oscillatoria* from Quetta-Pishin Valley, Baluchistan for the first time including 7 species new to Pakistan. Anjum *et al.* (1986) reported 50 epilithic algae from submerged stones in fresh water streams in Baluchistan. Masud-ul-Hassan and Batool (1987) identified 39 species of fresh water algae from Attock and Sargodha.

Sarim and Faridi (1988) recorded 25 taxa belonging to 16 genera of desmids from Pakistan. Zahid (1989) investigated the relationship of chemical features of water sample with that of *Chlorella vulgaris*, *Chlorococcum humicola* and *Scenedesmus* species. It was reported that these algae were resistant to various concentration of free CO₂, NO₂, NO₃, Mn and inorganic phosphate. Inam *et al.* (1990) recorded 30 species of Diatoms, including 16 as a new record for Pakistan from Islamabad. Islam and Sarim (1990) collected 6 species of *Mougeotia* from Pakistan. Aisha and Zahid (1991) reported that *Microcystis floqua*, *Phormidium* and *Chlamydomonas oblonga* were dominant, among other algae found in industrial waste water around Karachi. Sarim (1995) identified 13 species of *Staurastrum* from

Pakistan. Saifullah *et al.* (1997) recorded 21 species of algal epiphytes growing on mangroves from coastal areas of Baluchistan. Leghari *et al.* (1997a,b) described 42 species of Euglenoids, 31 species of *Phacus*, 11 species of *Trachelomonas*, 35 species of *Closterium* and 4 species of *Pleurotaenium* from Sindh. Sarim *et al.* (1998) reported 8 species of *Chroococcus* (Cyanophyceae) from Balochistan. Sarim (1998) documented 43 taxa of *Cosmarium* from Pakistan.

Work done on the relationships of algae with water body in Pakistan particularly includes those of Leghari and Leghari (2002) who made ecological study of phytoplankton and reported 78 species belonging to 33 genera in lake Bakar District Sanghar, District Badin. They concluded that diatoms are abundant in polluted water that increased with rising temperature. Leghari *et al.* (2002) reported 134 species of 68 genera from Jehelum River in Azad Kashmir and concluded that increase in turbidity increase the occurrence of algae. Leghari *et al.* (2003) described 179 species belonging to 69 genera from Kallar Kahar lake. They observed that low temperature increased the presence of diatoms and green algae while enhanced hardness of water promoted frequency of blue green algae. Leghari *et al.* (2003) working on the physico-chemical and biological study of rain water pools, Lanikot, Thana Bola Khan and Kohistan region of District, Dadu, Sindh, recorded 22 species of Cyarophyta, 24 species of Chlorophyta, 4 species of hydrophytes and 14 species of zooplankton. Leghari *et al.* (2004a) documented 296 algae species belonging to 114 genera of 11 phyla from Rawal Dam, Islamabad and Wah Garden Attock. They concluded that photosynthetic rate of phytoplankton was raised with increase in temperature. The phytoplankton flora of lake Bakhar, District Sanghar and lake Phossna District Badin. consisted of 122 species that belonged to 45 genera of Chlorophyceae. Leghari *et al.* (2004b), they stated that phytoplankton occurrence was directly proportional to the turbidity and temperature. Leghari *et al.* (2005a) documented 58 species belonging to 21 genera from Rawal Dam water, Islamabad. There were 40 species of 14 genera of blue green algae and 18 species of 7 genera of Chlorophyceae. They concluded that high temperature of water controlled the distribution of algae. The increase in pH was due to high concentration of dissolved organic and inorganic matters. Naz *et al.* (2005) listed 17 genera and 31 species of

Nostocophyceae (Cyanophyta) from northern areas of Pakistan. Leghari *et al.* (2005b) investigated the limnology of natural springs at Gharo Creek District Thatta, Sindh Pakistan and recorded 39 species of Cyanophyta and six species of Bacillariophyta. They concluded that various parameters such as pH, conductivity, salinity, TDS, hardness, chlorides, sulphate, Na, K, Ca and Mg had no correlation between algae and water quality.

In NWFP some phycological studies have been made on various aspects. Shah *et al.* (1977, 1984, 1986, 1989, 1998, 1999) reported fresh water algae from different parts of NWFP. Shameel (1978) described genus *Ulothrix* from Swat Valley. Anjum *et al.* (1982) recorded 245 species of soil algae from various locations in NWFP. Anjum and Faridi (1985) added 5 genera and 14 species of fresh water algae as a first record for Pakistan from dry soils of NWFP. Anjum and Faridi (1986) documented 24 species of 13 genera of Chlorophyceae from the dry lands of Peshawar, Kohat, Bannu and D.I. Khan Districts. Twenty two genera with 50 species belonging to Chlorophyceae, Cyanophyceae and Bacillariophyceae were described from fresh water from the District Manshera Haleem (1988). Sarim (1989) listed four species of Euglenophyceae from Swat Valley. Sarim *et al.* (1990) identified twelve species of fresh water algae of Chlorophyceae from Kalam-Utrorr, District Swat. Sarim (1991, 1995) reported six aerophilous species of Chlorophyceae from Swat Valley, and identified nine taxa of fresh water algae from Dir, NWFP Pakistan respectively. In most of the a fore mentioned studies, no correlation of water quality with algae has been worked out.

Most of the work done in Peshawar Valley is of taxonomic nature. Siddiqui and Faridi (1964) recorded 102 species of Chlorococcales from Peshawar Valley. Salim and Khan (1965) recorded 102 species fresh water diatoms of Peshawar Valley. Anjum *et al.* (1987) documented 113 species of 25 genera that belonged to Cyanophyceae, Chlorophyceae, Xanthophyceae and Bacillariophyceae from maize fields of Peshawar. Farooq and Faridi (1976) reported 22 taxa of *Oedogonium* from Peshawar Valley. The genus *Closterium* from Peshawar Valley has been described by Sarim (1976). Hussain and Faridi (1977) studied the effect of constant light on *Vaucheria sessilis* and concluded that starch is not formed as a result of the constant

light, so the plant belongs to Xanthophyceae. Fourteen species of *Zygnema* and three of *Zygnemopsis* were described from Peshawar Valley by Khan and Faridi (1977). Siddiqui and Faridi (1977) investigated the life cycle of *Cladophora crisptata*. The genus *Spirogyra* from Peshawar Valley was reported by Ara and Faridi (1978). Sarim and Ali (1979) recorded *Cocconeis flesella* and *Diploneis elliptica* from Mardan and also described 9 taxa of fresh water algae from Khyber Hills Peshawar. Anjum *et al.* (1980) recorded 4 species of algae from turtle shells. Anjum and Hussain (1980) cultured 13 species of algae from the air at Peshawar University. Anjum *et al.* (1982) studied 32 species, including 29 species of Cyanophyta, as soil binding in soils of Peshawar. Hussain and Anjum (1982) isolated 22 species of Cyanophyceae and Desmids from snail shells. Anjum *et al.* (1983) described a new alga *Ankistrodesmus ishtiaquii* from Peshawar. Anjum and Hussain (1984) discovered two new algae from polluted ponds of Peshawar Valley. Anjum *et al.* (1985) worked on the seasonal variation of algae in polluted pond in Yar Hussain, District Mardan and listed 23 genera and 49 species that showed seasonal variation. Sarim (1987) provided a checklist of the fresh water algae of Mardan District while Sarim and Faridi (1988) added desmids to the phycological flora of Peshawar Valley. Hadi *et al.* (1988) reported 16 diatoms species of fresh water algae from Kabul River. Sarim (1989) reported 4 species of *Phacus* from Peshawar Valley. Sarim *et al.* (1989) estimated the algal productivity in spring. Sarim and Faridi (1990) described species of *Staurodesmus* from Peshawar Valley. Sarim and Faridi (1990) described four species of *Staurodesmus* from Peshawar Valley. Islam and Sarim (1990) identified six species of *Mougeotia* from Pakistan including Peshawar Valley. *Xanthidium* and 4 species of *Oocystis* of Chlorophyta were reported from Peshawar Valley by Sarim (1992).

Protococcus viridis, *Chlorococcum hypnosporum*, *C. echinozygotum* and *Tetracystis isobilateralis* of Chlorophyceae were described from Azakhel District Peshawar by Shah and Chughtai (1994). Nine species of *Pleurotaenium*, 13 species of *Staurostrum*, *Gloeotilopsis planctonica* and *Ulotrichopsis cylindrical*, 43 taxa of *Cosmarium* and 4 species of *Bulbochaete* have been described from Peshawar Valley by Sarim (1995, 1998, 1999). Nishat *et al.* (1999) studied 11 species of 11 genera of

Maiz fields of district Mardan. Zaman and Sarim (2005) recorded 14 genera and 47 species belonging to Chlorophyceae, Cyanophyceae, Bacillariophyceae and Xanthophyceae from various localities of Peshawar Valley. Zaman and Sarim (2005) recorded 31 genera and 89 species of Chlorophyceae, Bacillariophyceae, Xanthophyceae and Cyanophyceae from various localities of district Charsadda. Burni *et al.* (2005) described 9 species of *Spirogyra* (Chlorophyta) from Peshawar Vally.

The review shows that little and fragmentary work on the algae in relation to seasonal changes in quality of water has been done. The only available references on the taxonomy are those Siddiqui and Faridi (1964), Salim and Khan (1965), Farooq and Faridi (1976), Faridi (1976), Hussain and Faridi (1977), Khan and Faridi (1977), Siddiqui and Faridi (1977), Ara and Faridi (1978), Sarim and Ali (1979), Anjum *et al.* (1980), Anjum and Hussain (1980, 1984, 1985), Anjum *et al.* (1982), Hussain (1982), Anjum (1983), Sarim and Faridi (1987, 1988, 1989, 1990, 1992), Hadi *et al.* (1988), Islam and Sarim (1990), Shah and Chughtai (1994) and Sarim *et al.* (1998), Zaman and Sarim (2005) Burni *et al.* (2005) etc.

No effort has been made to find limnological inter relationships of water quality, quantity, seasonal effect of climate on the distribution of algae. Similarly, the above referred work is either concerned with a genus or some small pond. No information is available on the distribution of algae on wider scale in Peshawar Valley. The present study was therefore undertaken to fill this gap of knowledge.

Objectives of the Study

The objectives of the study are: -

1. To detect relationship between water bodies and algal flora.
2. To find out the present algal diversity in Peshawar Valley.
3. To analyze the seasonal physical and chemical characteristics of water.
4. To see seasonal algal diversity.
5. To determine the correlation of various parameters of water with algae.

Statement of the problem

The study is concerned with the preparation of phycological flora, seasonal variation in the quality of water bodies and the possible impact of water quality on the algal diversity in Peshawar Valley. Determination of relationship between water quality and algal diversity will help to find out the impact of different parameters of water on the distribution of algae. The findings will help understanding the affect of various parameters on the distribution of algae. Moreover, algal species are indicators of water pollution (Patric and Reiner, 1966) and envisaging this relation will help finding indicator species .

Significance of the study

The aims of the study are:

1. To provide database on algal diversity.
2. To determine correlation of algae with water bodies.
3. To identify indicator species for water quality.

Delimitations of the Study

Peshawar Valley occupies a very vast tract and was not possible to cover all the sites located in the Valley. Due to limited resources and time it was decided to select few major representative sites from districts Peshawar, Charsadda, Mardan, Swabi and Nowshera districts with in Peshawar Valley.

Materials and Methods

1. Selection of Sites

A general survey was made through out the Peshawar Valley to select representative water bodies. The selection of sampling sites was based on the type of water: running/stagnant, depth of water, seasonality, condition of pollution and evenness of distribution so as to get an over all picture of the Valley. Based on these visual criteria two sites in each of the districts namely; Peshawar, Charsadda, Swabi, Mardan and Nowshera were finally selected (Fig.1) for regular sampling of algae and water. The various sites selected for detailed study in Peshawar Valley have the following topographic features.

1. Site -1 Jabba Daud Zai, Peshawar was flate, polluted, slow running water and near to settlement. The site was covered with the sparse vegetation. The texture of sediments was silt + loam.
2. Site -2 Jabba Daud Zai, Peshawar was also flate, polluted with standing water and near to the settlement. It was covered with thick shrubs and ground vegetation and the texture of sediments was also silt + loam.
3. Site -3 Harichand, Charsadda was steep, polluted and near to settlement. The site was devoid of vegetation. Sediments texture was loam.
4. Site -4 Gendai Bridge, Charsadda was also steep but far away from the settlement. The locality of this site was covered with thick vegetation. The texture of sediments in this locality was sand + loam sand.
5. Site -5 Yar Hussain, Swabi was flate, polluted pond and shallow. There were ground vegetation all around the site. The soil was silt loam.
6. Site -6 Adina, Swabi was comparatively steep with fast running perennial water. The texture of sediments in was silt loam.
7. Site -7 Umara Khan, Mardan has shallow, standing, seasonal water body and cemented floor. It has no vegetation all around and the soil texture of the locality was silt loam.
8. Site -8 Rashakai, Mardan has steep and fast running deep water. The water body of this site receives poisonous effluent from near by sugar and stone crushing

industries. The locality is surrounded by thick trees and shrubs vegetation. The texture of sediments of the site was loomy sand.

9. Site -9 Azakhel Nowshera was flate, polluted, with seasonal and standing water. The locality was situated near the settlement and covered with sparse vegetation. The soil was loam.

10. Site -10 Pabbi, Nowshera the nature of the was steep with running water. The site was surrounded by the local inhabitants. The areas was occupied by sparse ground vegetation. The nature of the texture of sediments was silty clay loam.

2. Sampling of Algae

In each of the sites algae was sampled by using various methods including planktonic net, hand picking, squeezing by hand, scratching of stones/wood/plant material with in water etc, and by dipping bottles to different depths etc. At each of the sites 10 samples were collected during Spring (1st February 2004 – 30th April 2004), Summer (1st May 2004 – 31st July 2004), Autumn (1st August 2004 – 31st October 2004) and Winter (1st November 2004 – 31st January 2005). Five samples were collected from bank up to centre to depth of 60 cm, while other five were collected also from bank to centre below the depth of 60 cm. Both these samples were mixed to get 5 composite samples for each site. Algae were preserved in 3% formalin at the time of collection. It was labeled and numbered properly Ecological notes were taken at the spot. The specimens were deposited in the Herbarium, Department of Botany, University of Peshawar for future reference.

3. Phycological Flora

Listing of algae found in any area in the fore most requirement of any ecological and limnological studies. Therefore, first of all a phycological list was prepared for reference to subsequent studies. Algae was macro and microscopically identified with the help of available literature (Tilden, 1910 Husted, 1930; Majeed, 1935; Smith, 1950; Prscott, 1951; Tiffany and Britton, 1952; Desikachary, 1959; Vinyard, 1979; Akiyama and yamagishi, 1981; Leghari *et al.* 2002. Algae was listed according to their taxonomic classes and seasonal distribution. Description of the

species were provided in appendix. Photomicrographs of some important species were taken with the help of photographic microscope Olympus BH₂ made in Japan.

4. Seasonal distribution

Seasonal distribution of algae within and among the sites were determined by recording the presence of species in 10 samples. Each sampling was considered as one replicate. A species was considered present when atleast 10 individuals of the same species were seen in one microscopic field (10 x 40 magnifications). Frequency was determined to know the distribution of species at a particular sites, while constancy was known to work out the distribution of species among different sites through out the Valley. Frequency was calculated after Hussain (1989) using following formula:

$$\% \text{ Frequency: } \frac{\text{No. of samples in which species was present}}{\text{Total number of sampling bottle (10)}} \times 100$$

Constancy was calculated after Braun-Blanquet (1932) as follows:

$$\% \text{ Constancy: } \frac{\text{No. of sites in which a species was present}}{\text{Total number of sites sampled (10)}} \times 100$$

5. Analysis of Water Quality

The quality of water governs the occurrence and distribution of algae. Since these sites were located away from each other and might differ in the physical and chemical features that might affect algal distribution, therefore water was also sampled from each of the sites for determining its quality. Some of the features such as temperature, turbidity, electrical conductivity, dissolved oxygen and pH were recorded at the spot. While other parameters were analysed in the laboratory.

The water samples as far as possible were quickly shifted to laboratory and kept at temperature of 10 – 15 °C where they were immediately analyzed. Following analysis were carried out:

a. Physical characteristics

- i. Temperature was determined by dipping ordinary thermometer in water for 5 minutes at the spot. There were 5 observation taken at distance of 6 m from each other, which were averaged.
- ii. EC was determined on the spot with the help of HATCH EC spectrophotometer model DR/3, 1987 made in USA. There were 5 points at distance of 6 m at each sampling site which were averaged.
- iii. Total dissolved solids was determined in laboratory using HATCH spectrophotometer model DR/3, 1987 made in USA. One hundred ml water was evaporated and the dry residue was weighed and expressed as mg/L
- iv. Total suspended solid were determined by gravimetric method following Richards (1954) and Hussain (1989).
- v. Turbidity was recorded at 5 points on the spot by using turbidometer (Hach, 1972; Talley *et al.* 1972).
- vi. Dissolved oxygen was determined by azide modification method at the spot and expressed as mg/L. (Richards, 1958; Hussain, 1989).
- vii. Flow of water was rated visually as fast, slow or stagnant water.
- viii. Light conditions of sampling points was recorded visually by classifying it as shaded water or direct light.

b. Chemical characteristics

- i. pH was determined by pH paper at 5 locations with in a site at the spot. It was confirmed in laboratory by using pH meter (Hussain, 1989).
- ii. Total alkalinity expressed as mg/L was determined using titration methods as described by Richards (1954) and Hussain (1989).

- iii. Total Hardness expressed as CaCO_3 was determined by titration method following Goetz, and Smith (1959), Richards (1954) and Hussain (1989).
- iv. Ca^{++} and Mg^{++} Hardness were determined by titration method following Katz and Navone (1964) and expressed as mg/L.
- v. CO_2 was determined by titration method using HACH model DR/3, 1987 and expressed as ppm.
- vi. Total nitrates (NO_3) were determined by Spectrophotometrically using UV/VIS spectrophotometer model DR/3, 1987 made in USA. following methods of Armstrong (1963) and Evans and Stevens (1972).
- vii. Sulphates (SO_4) were determined by using UV/VIS Spectrophotometer Hitachi model DR/3, 1987 made in USA as described by Sheen *et al.* (1935) and Thomas and Cotton (1954).
- viii. Phosphates (PO_4) were determined by using UV/VIS Spectrophotometer Hitachi model DR/3, 1987 made in USA after Sheen *et al.* (1935) and Thomas and Cotton (1954).
- ix. Ammonia (NH_3) was determined by using UV/VIS Spectrophotometer Hitachi model DR/3, 1987 made in USA. (Booth and Thomas, 1973).
- x. Biological oxygen demand was determined using 5 days method as described by Hussain (1989). The O_2 contents were determined at the time of sampling by Azide modification method. The sample were kept at $5 - 10^\circ\text{C}$ and after 5 days O_2 was again determined. BOD was calculated as follows (Mckeown *et al.* 1967):

$$(\text{BOD})_5 (\text{mg/L}) = \frac{\text{Zero day DO} - \text{after 5 days DO} \times 300}{\text{ml of sample}}$$

6. Statistical Analysis

The data collected during the study was analyzed by using computer based statistical program MINITAB Release 11.12 for Windows. The objective of analysis

was in the context of making sense of data to infer about species population in the study area based on information obtained from sample measurements.

The data was gathered by the combination actual survey and observational study of selected sites. It was assumed that the data of variables approximate a linear trend with species % recorded for different sites, therefore, simple regression analysis of data was appropriate to determine correlation and trend. Moreover, such solution had the virtue of being much affected by sampling fluctuation than one based on the individual sample means. The analysis was based on two paired measures i.e. X and Y wherein X represents species in percents and Y indicates variable to be correlated.

Based on the above analogy, the data collected from different sites was subjected to regression analysis in MINITAB computer program. The data column of species in percents was used as predictor variable (X) whereas other variables having statistically significant relationship were used as response variables (Y).

The data for columns X and Y variants were graphed and regressed simultaneously for better understanding. The equation predicated for "best fit" with the regression analysis is presented in tabulated form along with all requisite statistical inferences. The table of coefficients provided estimated coefficients along with their standard deviation, t -value for testing if the coefficient is zero (0), and p -value for the test. The estimated standard deviation about the regression line was abbreviated as " S ". The coefficient of determination was abbreviated as " $R-Sq$ ". The table for analysis of variance contained sum of square (SS) for model, residual error and total, means square for model and residual error, F -value is the test value for hypothesis (H_0). P -value is the value significance for the test.

RESULTS

The results of the present study have been separated in to following three aspects.

- A. Phycological flora
- B. Seasonal distribution
- C. Correlation analysis

A. Phycological flora

The study indicated that in all there were 239 species, 68 genera and 25 orders, which were classified into 5 major classes (Table 2). Cyanophyceae had 3 orders, 12 genera and 42 species. Chlorophyceae was represented by 11 orders, 32 genera and 94 species. Bacillariophyceae contributed 8 orders, 19 genera and 86 species towards the algal flora of Valley. Class Xanthophyceae contained 2 orders, 3 genera and 6 species. While Euglenophyceae added one order, 2 genera and 11 species. Description and systemic account of the species and some figures have been given in appendix.

Table. 2: Floristic list of algae found in Peshawar Valley.

A. Class Cyanophyceae

Order. Chroococcales

1. *Aphnocapsa elachista* West & West
2. *A. grevillei* (Hass) Rabenhorst
3. *A. richteriana* Hieronymus
4. *Aphanothece castagnei*(Breb) Rabenhorst
5. *A. nidulans* P. Richter
6. *Chroococcus turgidus* (Kuetzing) Naegeli
7. *Gloeocapsa magma* (Breb) Kuetzing
8. *Gomphosphaeria aponina* Kuetzing
9. *G. lacustris* Chodat
10. *Merismopedia convoluta* Brebisson
11. *M. glauca* (Ehrenberg) Kuetzing
12. *M. punctata* Meyen
13. *Microcystis aeruginosa* Kuetzing
14. *M. flos-aquae* (Wittr) Kirchner

15. *M. marginata* (Menegh) Kuetzing

Order. Oscillatoriales

16. *Lyngbya aestuarii* (Mertens) Liebmann
 17. *L. birgei* G.M. Smith
 18. *L. diguetii* Gomont
 19. *L. taylorii* Drouet and Strickland
 20. *L. polysiphoniae* Frey
 21. *L. versicolor* (Wartm) Gomont
 22. *Oscillatoria agardhii* Gomont
 23. *O. animalis* C.A. Agardh
 24. *O. curviceps* C.A. Agardh
 25. *O. formosa* Bory
 26. *O. limosa* (Roth) C.A. Agardh
 27. *O. minnesotensis* Tilden
 28. *O. ornata* Kuetzing
 29. *O. princeps* Vaucher
 30. *O. sancta* (Kuetzing) Gomont
 31. *O. tenuis* Agardh
 32. *Phormidium foveolarum* (Montagne) Gomont
 33. *P. fragile* (Menegh) Gomont
 34. *P. inundatum* Kuetzing
 35. *P. purpurascens* (Kuetzing) Gomont
 36. *P. tenue* (Meneghini) Gomont
 37. *P. uncinatum* (Agardh) Gomont
 38. *Spirulina laxissima* G.S. West
 39. *S. subtilissima* Kuetzing

Order. Nostocales

40. *Anabaena aequalis* Borge
 41. *A. gelatinicola* Ghose
 42. *A. viguieri* Denis & Frey

B. Class Chlorophyceae

Order Chlorococcales

43. *Ankistrodesmus falcatus* (Corda) Ralfs
 44. *Characium ambiguum* Hermann
 45. *Chlorococcum humicola* (Naeg) Rabenhorst
 46. *Crucigenia rectangularis* (Naegeli) Gay
 47. *Hydrodictyon reticulatum* (Linnaeus) Lagerheim
 48. *Oocystis borgei* Snow
 49. *O. crassa* Wittrock
 50. *O. elliptica* W. West
 51. *O. solitaria* Wittrock

- 52. *Pediastrum biradiatum* Prescott
- 53. *P. duplex* Meyen
- 54. *P. simplex* Meyen
- 55. *P. tetras* (Ehrenberg) Ralfs
- 56. *Scenedesmus acuminatus* (Lag) Chodat
- 57. *S. arcuatus* Lemmerman
- 58. *S. dimorphus* (Turpin) Kuetzing
- 59. *S. longus* Meyen
- 60. *S. obliquus* (Turpin) Kuetzing
- 61. *S. quadricauda* (Turpin) Brebisson
- 62. *Schroederia setigera* (Schroeder) Lemmermann
- 63. *Tetraedron muticum* (A. Braun) Hansgirg
- 64. *T. trigonum* (Naegeli) Rabenhorst

Order Cladophorales

- 65. *Basycladia chelonum* (Collins) Hoffman and Tilden
- 66. *B. crassa* Hoffman and Tilden
- 67. *Cladophora crispata* (Roth) Kuetzing
- 68. *C. fracta* (Dillw) Kuetzing
- 69. *C. glomerata* (Linnæus) Kuetzing
- 70. *C. insignis* (C.A. Ag) Kuetzing
- 71. *Pithophora oedogonia* (Montagne) Wittrock
- 72. *Rhizoclonium fontanum* Kuetzing

Order Zygnematales

- 73. *Mougeotia gracillima* (Hassall) Wittrock
- 74. *M. scalaris* Hassal
- 75. *M. spaerocarpa* Wille
- 76. *M. virescens* (Hassal) Borge
- 77. *M. viridis* (Kuetzing) Wittrock
- 78. *Spirogyra aequinoctialis* G. S. West
- 79. *S. borgeana* Transeau
- 80. *S. collinsii* (Lewis) Printz
- 81. *S. condensata* (Vaucher) Kuetzing
- 82. *S. crassa* Kuetzing
- 83. *S. daedaleoides* Czurda
- 84. *S. ellipsospora* Transeau
- 85. *S. fluvialis* Hilse
- 86. *S. majuscula* Kuetzing
- 87. *S. mirabilis* (Hass) Kuetzing
- 88. *S. porticalis* (Muell) Cleve
- 89. *S. pratensis* Transeau
- 90. *S. punctiformis* Transeau

- 91. *S. rectangularis* Transeau
- 92. *S. scrobiculata* (Stockmayer) Czurda
- 93. *S. setiformis* (Roth) Kuetzing
- 94. *S. subsalsa* Kuetzing
- 95. *Zygnema sterile* Transeau

Order Chaetophorales

- 96. *Chaetophora attenuate* Hazen
- 97. *C. elegans* (Roth) Agardh
- 98. *Stigeoclonium longipilum* Kuetzing
- 99. *S. lubricum* (Dillwyn) Kuetzing
- 100. *S. pachydermum* Prescott
- 101. *S. stagnatile* (Hazen) Collins
- 102. *S. subsecundum* Kuetzing
- 103. *S. tenue* (Agardh) Kuetzing

Order Desmidiaceae

- 104. *Closterium acerosum* (Schramk) Ehrenberg
- 105. *C. cornu* Ehrenberg
- 106. *C. diana* Ehrenberg
- 107. *C. ehrenbergii* Meneghini
- 108. *C. juncidum* Ralfs
- 109. *C. lanceolatum* Kuetzing
- 110. *C. leibleinii* Kuetzing
- 111. *C. littorale* Gay
- 112. *C. moniliferum* (Bory) Ehrenberg
- 113. *C. turgidum* (Bory) Ehrenberg
- 114. *Cosmarium constrictum* Delponte
- 115. *C. nitidulum* DeNotaris
- 116. *C. protractum* (Naegeli) Bory
- 117. *C. subimpressulum* Borge
- 118. *Penium margaritaceum* (Ehrenberg) Brebisson

Order Tetrasporales

- 119. *Asterococcus limneticus* G.M. Smith
- 120. *Palmella miniata* Leiblein
- 121. *P. mucosa* Kuetzing

Order Volvocales

- 122. *Chlamydomonas globosa* Snow
- 123. *Haematococcus lacustris* (Girod) Rostafinski

Order Ulothrichales

- 124. *Geminella minor* (Naegeli) Heering
- 125. *Ulothrix subconstricta* West
- 126. *U. tenuissima* Kuetzing

- 127. *U. variabilis* Kuetzing
- 128. *U. zonata* (Weber and Mohr) Kuetzing
- 129. *Uronema elongatum* Hodgetts

Order Microsporales

- 130. *Microspora loefgrenii* (Nordst) Lagerheim
- 131. *M. pachyderma* (Wille) Lagerheim
- 132. *M. quadrata* Hazen
- 133. *M. tumidula* Hazen
- 134. *M. willeana* Lagerheim

Order Oedogoniales

- 135. *Oedogonium illinoisense* Transeau

Order Sphaeropleales

- 136. *Sphaeroplea annulina* (Roth) C.A. Agardh

C. Class Bacillariophyceae

Order Achnanthalales

- 137. *Achnanthes exilis* Kuetzing
- 138. *A. inflata* Kuetzing
- 139. *A. lanceolata* (Brebisson) Grunow
- 140. *A. lancolata* Var. *rostrata* Hustedt
- 141. *A. microcephala* (Kuetzing) Cleve
- 142. *A. minutissima* (Kuetzing) Cleve
- 143. *Cocconeis flexella* (Kuetzing) Cleve
- 144. *C. pediculus* Ehrenberg
- 145. *C. placentula* Ehrenberg

Order Centrales

- 146. *Cyclotella antique* Smith
- 147. *C. glomerata* Bachmann

Order Epithemiales

- 148. *Epithemia argus* (Ehrenberg) Kuetzing

Order Eunotiales

- 149. *Eunotia pectinalis* (Kuetzing) Rabenhorst

Order Fragilariales

- 150. *Diatoma anceps* (Ehren) Kirchner
- 151. *D. elongatum* Agardh
- 152. *D. hiemale* (Lyngbye) Heiberg
- 153. *Fragilaria capucina* Desmazieres
- 154. *F. construens* (Ehrenberg) Grunow
- 155. *F. intermedia* Grun
- 156. *F. pinnata* Ehrenberg
- 157. *Synedra acus* Var. *radians* (Kuetzing) Hustedt
- 158. *S. acus* Kuetzing

- 159. *S. capitata* Ehrenberg
- 160. *S. parasitica* (Wm. Smith) Hustedt
- 161. *S. pulchella* (Ralfs) Kuetzing
- 162. *S. rumpens* Kuetzing
- 163. *S. tenera* Wm. Smith
- 164. *S. ulna* Var. *danica* (Kuetzing) Grunow
- 165. *S. ulna* (Nitzsch) Ehrenberg
- 166. *S. ulna* Var. *aequalis* (Kuetzing) Hustedt

Order Naviculales

- 167. *Amphora normani*
- 168. *A. ovalis* Kuetzing
- 169. *Cymbella aequalis* Wm. Smith
- 170. *C. amphicephala* Nageli
- 171. *C. cistola* (Hemprich) Grunow
- 172. *C. cymbiformis* (Kuetzing) Brebisson
- 173. *C. leptoceros* (Her) Grunow
- 174. *C. parva* (Wm. Smith) Cleve
- 175. *C. tumidula* (Brebisson) Van Heurck
- 176. *C. ventricosa* Kuetzing
- 177. *Gomphonema acuminatum* Ehrenberg
- 178. *G. angustatum* (Kuetzing) grunow
- 179. *G. constrictum* Var. *capitulum* (Ehrenberg) Grunow
- 180. *G. intricatum* Kuetzing
- 181. *G. geminatum* (Lyngbye) C.A. Agardh
- 182. *G. olivaceum* (Lyngbye) C.A. Agardh
- 183. *G. olivaceum* (Lyngbye) Kuetzing
- 184. *G. olivaceum* var. *calcareum* Cleve
- 185. *G. parvulum* (Kuetzing) Grun
- 186. *G. sphaerophorum* Ehrenberg
- 187. *Gyrosigma kuetzingii* (Grun) Cleve
- 188. *G. scalproides* (Rabenhorst) Cleve
- 189. *G. wormleyi* (Sullivant) Boyer
- 190. *Navicula anglica* Ralfs
- 191. *N. bacillum* Ehrenber
- 192. *N. confervacea* (Kuetzing) Grunow
- 193. *N. cryptocephala* Kuetzing
- 194. *N. cuspidata* Kuetzing
- 195. *N. dicephala* (Ehrenberg) Wm. Smith
- 196. *N. exigua* (Gregory) Mueller
- 197. *N. gastrum* Ehrenberg
- 198. *N. gracilis* Ehrenberg

- 199. *N. mutica* Kuetzing
- 200. *N. protracta* (Grun) Cleve
- 201. *N. radiosa* Kuetzing
- 202. *N. rhyncephala* Kuetzing
- 203. *N. seminulum* Grunow
- 204. *N. solinarum* (Grunow) Cleve
- 205. *N. tuscula* (Ehrenberg) Grunow
- 206. *N. viridula* Kuetzing
- 207. *Pinnularia major* (Kuetzing) Wm. Smith
- 208. *P. parva* Gregory
- 209. *Pleurosigma angulatum* (Quekett) Wm. Smith
- 210. *Rhopalodia gibba* (Ehr) O. Muell
- 211. *Stauroneis anceps* Ehrenberg

Order Nitzschiales

- 212. *Nitzschia acicularis* (Kuetzing) Wm. Smith
- 213. *N. amphibian* Grun
- 214. *N. angustata* (W. Smith) Grun
- 215. *N. denticula* Grunow
- 216. *N. vermicularis* (Kuetzing) Hantzsch

Order Surirelliales

- 217. *Cymatopleura elliptica* (Breb) Wm. Smith
- 218. *C. solea* (Breb) Wm. Smith
- 219. *C. solea* Var. *subconstricta* Muller
- 220. *Surirella apiculata* Wm. Smith
- 221. *S. elegans* Ehrenberg
- 222. *S. oregonica* Ehrenberg

D. Xanthophyceae

Order Mischococcales

- 223. *Botryococcus braunii* Kuetzing
- 224. *Ophiocytium majus* Naegeli

Order Vaucheriales

- 225. *Vaucheria aversa* Hassal
- 226. *V. hamata* (Vaucher) Decandole
- 227. *V. longipes* Collins
- 228. *V. sessilis* (Vaucher) Decandole

E. Class Euglenophyceae

Order Euglenales

- 229. *Euglena acutissima* Lemmermann
- 230. *E. acus* Ehrenberg
- 231. *E. deses* Ehrenberg
- 232. *E. gracilis* Klebs

- 233. *E. polymorpha* Dangeard
- 234. *E. spirogyra* Ehrenberg
- 235. *E. splendor* Ehrenberg
- 236. *E. torta* Stokes
- 237. *Phacus acuminata* Stokes
- 238. *P. ogicauda* (Ehrenberg) Dujardin
- 239. *P. triqueter* (Ehrenberg) Dujardin

B. Seasonal distribution

The distribution of various species in different sites of Valley has been described under four seasonal aspects: spring, summer, autumn and winter separately as follows.

I. Spring Aspect

a. Species Distribution

The spring aspect started from 1st February 2004 and came to end on 30th April. There were 116 species of 54 genera (Table 3). Cyanophyceae was represented by 9 genera and 20 species; Chlorophyceae by 24 genera and 49 species; Bacillariophyceae by 17 genera and 38 species; Xanthophyceae by 2 genera and 5 species, and Euglenophyceae by 2 genera and 3 species. The species of Cyanophyceae had an average frequency from 0.1 to 3.2. No cyanophyceae species registered near than 32 % frequency in the area. All the species except *Oscillatoria animalis* fell in to constancy class I. This means that this group was poorly distributed with in the Valley (Table 3). The average frequency ranged from 0.06 to 5.92 in various sites among Chlorophyceae. Only four species viz; *Ankistrodesmus falcatus*, *Basicladia chelonum*, *Oocystis borgei* and *Ulothrix zonata* gained constancy class II. All the remaining species were in class I. The average frequency among the species of Bacillariophyceae varied from 0.1 to 9.05 with maximum frequency of 42.55 exhibited by *Synedra ulna*. These species occupied constancy class III. *Amphora ovalis*, *Cyclotella glomerata*, *Cymbella ventricosa*, *Fragilaria capucina*, *Gyrosigma scalpoides*, *Navicula cryptocephala* and *Nitzschia vermicularis* were in class II while all the remaining species were in class I. The species of Xanthophyceae shared as frequency from 0.14 to 1.29 and were in constancy class I indicating poor occurrence in the area. In Euglenophyceae, the average frequency varied from 0.2 to 2.31 with a maximum of 16.0 by *Euglena acus* at site Umara Khan, Mardan and occupied constancy class II while the remaining species were in class I.

It appears that majority of the species had low constancy value that is indicator of poor distribution in the Valley. Similarly, the frequency at a particular site was also poor as reflected by average frequency of the species. Only *Synedra*

ulna exhibited 42.55% frequency in one of the sites. In all the remaining cases i.e. species and sites none of the species achieved a frequency of more than 10% with few exceptions. The number of species in Harichand, Charsadda was maximum, followed by Jabba Daud Zai 1, Peshawar, Jabba Daud Zai 2, Peshawar and Gendai Bridge, Charsadda having respectively 26, 23 and 19 species. The least number of species were recorded in Rashakai, Mardan.

b. Distribution of classes and genera

Site No.1 had maximum number of genera i.e.19. It was followed by 16 and 15 at sites Nos 2, 3, 4 and 5 respectively. Similarly, site No. 3 had the highest number of species (27) which was followed by 26, 23, 19, 17 respectively at Sites Nos 2, 3, 4 and 5 (Table 4). The diversity of species ranged from 9 to 27 while generic diversity varied from 6 to 19 among the sites. Cyanophyceae was recorded in 8 sites while Chlorophyceae in 9 sites and Bacillariophyceae in all the sites. Xanthophyceae was present in 6 sites and Euglenophyceae in 5 sites. As a class Chlorophyceae and Bacillariophyceae could be regarded as constant classes falling in to Constancy class V followed by Xanthophyceae class IV and Euglenophyceae (class III).

c. Physico – chemical characteristics

The physicochemical characteristics of water during spring aspect is presented in Table 5. It appears that, with few exceptions, generally a wide range of variation existed in various parameters. The Temperature varied from 18 – 20 °C, pH from 7.63 to 8.26, Turbidity 12 to 57 NTU, Total Dissolved Solids from 177 – 285 mg/L, Total Suspended Solids from 42 – 110 mg/L, Electrical conductivity from 20 – 155 dS m⁻¹, Sodium Chloride 1 – 3.8 mg/L, Dissolved oxygen 2.3 – 5.7 mg/L, Carbon dioxide 110 – 186 ppm, Ammonia nitrogen 0.37 – 0.75 ppm, Nitrates 1.1 – 11.5 mg/L, Sulphates 17 – 162 mg/L, Phosphates 5 – 14.4 mg/L, Total alkalinity 108 – 573 mg/L, Total hardness 127 – 380 mg/L, Calcium hardness 64 – 197 mg/L, Magnesium hardness 43 – 231mg/L and Biochemical oxygen demand 20 – 71 mg/L among the sites.

Water samples of site Nos 1, 3, 4, 6, 8 and 10 were collected from fast running, deep and perennial water bodies while the remaining sites had stagnant, shallow and seasonal water. Sites No 1, 3, 6, 7, 8, 9 and 10 were located near the settlement whereas sites No 2, 4 and 5 were away from settlements. Therefore, the water samples of site Nos 1, 3, 6, 7, 8, 9 and 10 were appeared more polluted than site No 2 and 5. The water samples of site No 4 (Gendai Bridge) was taken from fresh running water. Site No 7 had cemented floor while site No 8 received effluents from near by industry. The cemented nature of bed in case of site No 7 and contaminated water of site No 8 reduced the number of species during all the seasons. It is concluded that the variation in number of species was obviously due to location of sites and local conditions of the water bodies.

II. Summer Aspect

a. Species Distribution

The summer aspect represents partly the hottest part of the year as it starts from 1st May till to 31st July. This aspect recorded a total of 73 species of 31 genera (Table 6). The distribution of species and genera differed in different classes. Cyanophyceae (5 genera, 13 species), Chlorophyceae (10 genera, 26 species), Bacillariophyceae (13 genera, 28 species), Xanthophyceae (one genus, one species) and Euglenophyceae (2 genera, 5 species) were the recorded classes. The average frequency among Cyanophyceae species varied from 0.22 to 7.32 with a maximum frequency of 71.1 contributed by *Merismopedia convoluta* at site No 2. The remaining species fell in to constancy class I showing poor distribution within the Valley (Table 6) except *Oscillatoria princeps* occupied class II. The average frequency of Chlorophyceae species differed from 0.2 to 5.08 in various sites. All the species had constancy class I showing least distribution in the Valley except *Spirogyra crassa* had constancy class II. Among Bacillariophyceae, the average frequency exhibited from 0.17 to 4.81 in various sites. *Gomphonema intricatum*, *Navicula cryptocephala* and *Synedra ulna* were in class III; and *Achananthes minutissima*, *Cymbella cymbiformis*, *Diatoma anceps*, *Gyrosigma kuetzingii*, *Navicula protracta*, *Navicula radiosa* and *Synedra acus* had constancy class II. The

remaining species were in class I. Xanthophyceae includes only one species with average frequency 0.43 and occupying class I. In Euglenophyceae, the average frequency varied from 0.38 to 1.43 with maximum frequency of 11.7% by *Euglena deses* which was included in constancy class I. It seemed that most species had frequency at a particular sites and low constancy in the area. Both these feature resulted in their poor distribution in the Valley. Only *Merismopedia convoluta* exhibited 71.1 % frequency in one of the sites. The total number of species among the various sites varied from 9 to 16. This is because of variation in the water quality and related features of the water body.

b. Distribution of classes and genera

The generic diversity varied from 6 to 13 among the sites. There were 13 genera at site No. 1 and 3 followed by 11 at sites No. 4 and 6 respectively. Likewise, the highest number of species recorded were 16 at site No. 1, followed by 15, 14 respectively at sites No. 6 and 4 (Table 7). Least number of species 11, 9 were recorded at site 7. Cyanophyceae, Chlorophyceae and Bacillariophyceae were constantly present in the area as they occupied constancy class V. Xanthophyceae was recorded in one site only while Euglenophyceae recorded in 6 sites, was classified in constancy class III.

c. Physico – chemical characteristics

Table 8 shows the physicochemical characteristics of water during summer aspect. The Temperature varied from 29 – 31°C, pH 7.23 – 8.55, Turbidity 10.7 to 84 NTU, Total Dissolved Solids 174 – 243 mg/L, Total Suspended Solids 15 – 270mg/L, Electrical conductivity 15.2 – 182 dS m⁻¹, Sodium Chloride 1.3 – 4.5 mg/L, Dissolved oxygen 0.7 – 6.7 mg/L, Carbon dioxide 112 – 136 ppm, Ammonia nitrogen 0.17 – 0.6 ppm, Nitrates 0.2 – 5 mg/L, Sulphates 22 – 68 mg/L, Phosphates 0.4 – 4.8 mg/L, Total alkalinity 108 – 1204 mg/L, Total hardness 63 – 438 mg/L, Calcium hardness 42 – 165 mg/L, Magnesium hardness 21 – 273 mg/L and Biochemical oxygen demand 14 – 93 mg/L among the sites. There is conspicuous variation in TU,

TDS, TSS, DO, PO₄, TA, TH, CaH, MgH, and BOD. These variations are explainable on the basis of habitat ecology of sites.

III Autumn Aspect

a Species Distribution

The autumn aspect lasting from 1st August 2004 to 31st October had a total of 126 species of 52 genera (Table 9). Cyanophyceae (12 genera, 24 species), Chlorophyceae (22 genera, 46 species), Bacillariophyceae (15 genera, 46 species), Xanthophyceae (one genus, one species) and Euglenophyceae (2 genera, and 9 species) were the major classes found during this period. The average frequency among species of Cyanophyceae varied from 0.15 to 1.76 with a maximum of 11.42%. Only *Oscillatoria formosa* occupied constancy class III while *Aphanocapsa grevillei*, *Oscillatoria agardhii*, *Oscillatoria tenuis* and *Phormidium uncinatum* were in class II. The remaining species fell in to class I. The average frequency ranged from 0.11 to 4.12 in various sites among the members of Chlorophyceae. All the species had constancy class I showing poor distribution in the Valley except *Spirogyra aequinoctialis* and *Spirogyra rectangularis*, in class II (Table 9). The average frequency among species of Bacillariophyceae varied from 0.11 to 5.05. *Navicula solinarum* occupied constancy class III. *Diatoma anceps*, *Gyrosigma kuetzingii*, *Gyrosigma scalproides*, *Nitzschia vermicularis* and *Synedra acus* occupied constancy class II. All the remaining species were in class I. The only species of, *Ophiocytium majus* of Class Xanthophyceae was placed in constancy class I. Among Euglenophyceae, the average frequency differed from 0.37 to 2.03 with *Euglena deses* in class II. The remaining species were in class I.

The number of species was highest i.e., 31 in Site No 4 that declined gradually to 28, 24, 21, respectively in site 10, 3, 2 and with a least number of species in site 7.

Most species had low constancy which is indicator of their poor distribution in the Valley. Likewise frequency at a particular site was also poor.

b. Distribution of classes and genera

The highest number of genera were 22 at Site No 4, followed by 20 and 18 at Sites 10, 3 and 9 respectively. Similarly, the highest number of species recorded were 31 at Site No 4 followed by 28 and 24 at Sites 10 and 3 respectively (Table 10). Least number of species were 7 at site 7. Generic diversity varied from 5 to 22. Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae were constantly recorded and placed in constancy class V. Xanthophyceae was recorded only in one site with one species only.

c. Physico – chemical characteristics

The physico – chemical characteristics of sampled water during autumn aspect is presented in Table 11. It was seen that a wide range of variation existed in various parameters. The Temperature varied from 22 – 24 °C, pH 7.21 to 8.38, Turbidity 6.2 to 92 NTU, Total Dissolved Solids 110 – 287 mg/L, Total Suspended Solids from 7.4 – 902 mg/L, Electrical conductivity from 40 – 140 dS m⁻¹, Sodium Chloride 1 – 4 mg/L, Dissolved oxygen 2.4 – 7.8 mg/L, Carbon dioxide 113 – 175 ppm, Ammonia nitrogen 0.29 – 3.7 ppm, Nitrates 1 – 10.6 mg/L, Sulphates 12.4 – 106 mg/L, Phosphates 2.2 – 17 mg/L, Total alkalinity 106 – 712 mg/L, Total hardness 117 – 659 mg/L, Calcium hardness 54 – 190 mg/L, Magnesium hardness 63 – 469 mg/L and Biochemical oxygen demand 15 – 55 mg/L among the sites. There is a wide variation in TU, TDS, TSS, DO, SO₄, TA, TH CaH, MgH and BOD due to location of sites and local conditions of the water bodies.

IV. Winter Aspect

a. Species Distribution

The winter aspect lasted from 1st November to 31st January. During this period a total of 103 species of 44 genera were collectively recorded from all the investigated sites (Table 12). They represented Cyanophyceae (7 genera, 16 species), Chlorophyceae (20 genera, 39 species), Bacillariophyceae (15 genera, 45 species) and Euglenophyceae including two genera and three species. The average frequency among species of Cyanophyceae varied from 0.07 to 5.61. None of the species had

more than 23.5% frequency in the area. All the species fell into constancy class I showing poor distribution with in the Valley (Table 12). Among the members of Chlorophyceae, the average frequency ranged from 0.07 to 6.39 in various sites. Only two species viz; *Basycladia chelonum* and *B. crassa* were constancy class III showing moderate occurrence in the Valley. While *Spirogyra setiformis* was in class II. All the remaining species were in class I. In class Bacillariophyceae, the average frequency among the species ranged from 0.15 to 6.84 with maximum frequency of 21.6 and 20.68 exhibited by *Synedra ulna* and *Gomphonema intricatum*, respectively. *Diatoma anceps* occupied class IV. *Achnanthes minutissima*, *Fragilaria capucina* and *Navicula cryptocephala* were in class III. *Gyrosigma kuetzingii*, *Navicula radiosa* and *N. tuscula* had constancy class II. All the remaining species were in class I. The average frequency among Euglenophyceae varied from 0.07 to 10.9 with a maximum frequency of 90.9% contributed by *Euglena acus* at site No 8 (Rashakai - Mardan). The constancy of species was low (Table 12).

It was seen that majority of the species had low constancy value that indicates their poor distribution in the Valley. Similarly, the frequency at a particular site was also poor as reflected by average frequency of the species. Only *Euglena acus* exhibited 90.9% frequency in one of the sites. In all the remaining cases i.e., species and sites none of the species achieved a frequency of more than 10% with few exceptions. When the total number of species in different sites are considered, it was obvious that site No 4 had 24 species, followed by 21, 20 and 19 by site Nos 6, 1 and 2, respectively. The range fluctuated from 11 to 24 among the sites.

b. Distribution of classes and genera

The maximum number of genera were 15 at site No. 6, followed by 14 at sites No. 1 and 4 respectively. Similarly, the highest number of species recorded were 24 at site No. 4, followed by 21, 20 and 19 respectively at site Nos. 6, 1 and 2 (Table 13). The diversity of species ranged from 9 to 24 while generic diversity varied from 10 to 15 among the sites Chlorophyceae and Bacillariophyceae was present in all the sites and Cyanophyceae in 9 sites. Euglenophyceae was present only in three sites. As a class Cyanophyceae, Chlorophyceae and Bacillariophyceae were constantly

recorded during winter in the investigated area as were placed in to constancy class V.

c. Physico-chemical characteristics.

The physico-chemical characteristics of sampled water during winter aspect is presented in Table 14. It was seen that, with few exceptions, generally a wide range of variations existed in various parameters. The water Temperature varied from 10 - 10.5 °C, pH 7.4 to 8.2, Turbidity 2.6 to 26NTU, Total Dissolved Solids 180 - 276 mg/L, Total Suspended Solids from 20 - 297 mg/L, Electrical conductivity from 31 - 150 dS m⁻¹, Sodium Chloride 1.4 - 3.9 mg/L, Dissolved oxygen from 3.2 - 7.1 mg/L, Carbon dioxide 111 - 175 ppm, Ammonia nitrogen 0.21 to 2.9 ppm, Nitrates 0.3 to 16.5 mg/L, Sulphates 21 - 103 mg/L, Phosphates 0.7 - 8.6, Total alkalinity 90 - 680 mg/L, Total hardness 385 - 1530 mg/L, Calcium hardness 200 - 1360 mg/L, Magnesium hardness 120 - 280 mg/L, and Biochemical oxygen demand from 18 to 70 mg/L among the sites.

As explained earlier the quality of water was influenced by the location of sites, amount of water and edaphic features of the water body.

The overall seasonal distribution Profile

There were 126, 116, 103 and 73 species respectively during autumn, winter, spring and summer, respectively in the Valley (Table 15, 16, Fig. 2). Xanthophyceae was absent in winter aspect and was poorly represented in other aspects. Class Cyanophyceae had 13, 24 (summer, autumn) species in various aspects. While Chlorophyceae had highest (49) number of species in spring followed by 46, 39 and 26 respectively in autumn, winter and summer, respectively. Similarly, Bacillariophyceae had 46, 45, 38 and 28 species in autumn through winter.

If one looks at the constancy of different species, it was obvious that majority of the recorded species had low average constancy values. Only *Oscillatoria animalis*, *Oscillatoria formosa*, *Oscillatoria princeps*, *Oscillatoria tenuis*, *Merismopedia punctata*, *Basycladia crassa*, *Spirogyra setiformis*, *Ulothrix zonata*, *Achnanthes minutissima*, *Amphora ovalis*, *Cocconeis placentula*, *Cymatopleura*

solea, *Cymbella ventricosa*, *Diatoma anceps*, *Fragilaria capucina*, *Gomphonema olivaceum*, *Gyrosigma scalproides*, *Navicula cryptocephala*, *Navicula protracta*, *Navicula radiosa*, *Nitzschia vermicularis*, *Synedra ulna* and *Euglena acus* were present through out the year in all the seasons. Considering the average constancy values by averaging the mid point value for each class, it was evident that only *Oscillatoria formosa*, *Basiacladia crassa*, *Ulothrix zonata*, *Achnanthes minutissima*, *Diatoma anceps*, *Fragilaria capucina*, *Gyrosigma scalproides*, *Navicula cryptocephala*, *Navicula radiosa*, *Synedra ulna* and *Euglena acus* had the highest average constancy value. They could be regarded as constant species in the Valley. The remaining species because of low average constancy value could be considered as sporadic species.

When the number of species and genera were compared with seasonal variation, it was obvious that the highest number of species occurred in autumn follow respectively by spring, winter and summer (Table 16; Fig. 2). Likewise, spring had the maximum number of genera, respectively followed by autumn, winter and summer. It was obvious that the algal diversity was lowest during summer aspect.

Table 3. Species, their frequency and constancy in 10 sites of Peshawar Valley during spring aspect, 2004.

S.No	Species / Class	Sites										Minimum frequency	Maximum frequency	Average frequency	Constancy Class	
		1	2	3	4	5	6	7	8	9	10					
A. Cyanophyceae																
1	<i>Anabaena viguieri</i> Denis and Fremys	-	5.26	-	-	-	-	-	-	-	-	0	5.26	0.52	1	
2	<i>Aphanocapsa grevillei</i> (Hass) Rabenhorst	-	-	1.61	-	-	-	-	-	-	-	0	1.61	0.16	1	
3	<i>Chroococcus turgidus</i> (Kuetzing) Naegeli	-	-	-	-	-	-	8	-	-	-	0	8	0.8	1	
4	<i>Gomphosphaeria lacustris</i> Chodat	-	-	-	-	1.06	-	-	-	-	-	0	1.06	0.10	1	
5	<i>G. apantina</i> Kuetzing	-	-	-	-	-	-	4	-	-	-	0	4	0.40	1	
6	<i>Lyngbya dipetiti</i> Gomont	2.08	-	-	-	-	-	-	-	-	-	0	2.08	0.20	1	
7	<i>L. versicolor</i> (Wartmann) Gomont	-	-	-	-	-	-	-	5.26	-	-	0	5.26	0.52	1	
8	<i>Merismopedia convoluta</i> Brebisson	-	-	-	-	-	-	4	-	-	-	0	4	0.40	1	
9	<i>M. punctata</i> Meyen	-	1.75	-	-	-	-	4	-	-	-	1.75	4	0.57	1	
10	<i>Oscillatoria formosa</i> Bory	-	3.5	3.22	-	-	-	4	-	10.2	-	3.22	10.2	2.09	II	
11	<i>O. princeps</i> Vaucher	-	-	3.22	-	-	-	-	-	6.12	-	3.22	6.12	0.93	1	
12	<i>O. animalis</i> C.A. Agardh	-	-	-	-	-	-	-	32	-	-	0	32	3.2	1	
13	<i>O. curvicauda</i> Agard	-	-	1.61	-	-	-	-	-	-	-	0	1.61	0.16	1	
14	<i>O. ornata</i> Kuetzing	8.33	-	-	-	-	-	-	-	-	7.69	7.69	8.33	1.60	1	
15	<i>O. tenuis</i> C.A. Agardh	2.08	-	-	-	-	-	-	21.1	-	-	2.08	21.1	2.31	1	
16	<i>Phormidium foeniculorum</i> (Montagne) Gomont	-	-	-	-	-	-	-	5.26	-	-	0	5.26	0.52	1	
17	<i>P. fragile</i> (Mantegh) Gomont	-	-	-	-	-	-	-	5.26	-	-	0	5.26	0.52	1	
18	<i>P. purpurascens</i> (Kuetzing) Gomont	-	-	-	-	-	-	-	-	-	3.84	0	3.84	0.38	1	
19	<i>P. uncinatum</i> (Agardh) Gomont	4.16	-	-	-	-	-	-	-	-	-	0	4.16	0.41	1	

20	<i>Spirulina laxissima</i> G.S. West	-	-	7.01	-	-	-	-	-	-	-	-	-	-	-	0	7.01	0.7	1
B. Chlorophyceae																			
21	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	2.08	-	-	-	5.63	-	2.94	20	-	-	-	-	-	-	2.08	20	3.06	11
22	<i>Asterococcus limneticus</i> G.M. Smith	6.25	-	-	-	2.83	-	-	-	-	-	-	-	-	-	2.83	6.25	0.90	1
23	<i>Basiclethia chelonum</i> (Collins) Hoffman & Tilden	-	-	-	9.67	-	7.44	-	-	-	-	-	-	-	19.2	7.44	19.2	3.63	11
24	<i>B. crassa</i> Hoffman and Tilden	-	-	-	3.22	-	11.7	-	-	-	-	-	-	-	-	3.22	11.7	1.49	1
25	<i>Chlorella attenuata</i> Hazen	-	-	-	-	-	-	8.82	-	-	-	-	-	-	-	0	8.82	0.88	1
26	<i>Chlamydomonas globosa</i> Snow	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2.08	0.20	1
27	<i>Characium ambiguum</i> Hermann	-	-	-	-	-	-	-	4	-	-	-	-	-	-	0	4	0.4	1
28	<i>Chlorococcum humicola</i> (Naeg) Rabenhorst	4.16	1.75	-	-	-	-	-	-	-	-	-	-	-	-	1.75	4.16	0.59	1
29	<i>Cladophora crispata</i> (Roth) Kuetzing	-	-	-	-	-	-	11.76	-	-	-	-	-	-	11.5	11.5	11.76	2.32	1
30	<i>Cladophora acerosum</i> (Schramk) Elrenberg	-	-	-	-	-	-	-	-	-	-	-	-	30.6	-	0	30.6	0.06	1
31	<i>C. lanceolatum</i> Kuetzing	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2.08	0.20	1
32	<i>Cosmarium nitidulum</i> De Notaris	-	-	-	-	-	-	-	4	-	-	-	-	-	-	0	4	0.4	1
33	<i>C. subimpressulum</i> Borge	-	-	-	-	-	-	-	4	-	-	-	-	-	-	0	4	0.4	1
34	<i>Microspora laevis</i> (Nordst) Lagerheim	-	-	-	-	-	1.06	-	-	-	-	-	-	-	-	0	1.06	0.10	1
35	<i>M. pachyderma</i> (Wille) Lagerheim	-	-	-	4.83	-	-	-	-	-	-	-	-	-	-	0	4.83	0.48	1
36	<i>M. quadrata</i> Hazen	-	-	-	3.22	-	-	-	-	-	-	-	-	-	-	0	3.22	0.32	1
37	<i>M. williana</i> Lagerheim	-	-	-	1.61	-	-	-	-	-	-	-	-	-	-	0	1.61	0.16	1
38	<i>Mougeotia scalaris</i> Hassall	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	0	5.26	0.52	1
39	<i>M. spirocarpa</i> Wille	-	3.5	-	-	-	-	-	-	-	-	-	-	-	-	0	3.5	0.35	1
40	<i>Oocystis borgei</i> Snow	-	-	-	-	11.26	4.25	23.52	-	-	-	-	-	-	-	4.25	23.52	3.90	11
41	<i>O. elliptica</i> W. West	-	-	-	-	-	-	-	-	-	-	-	-	-	8	0	8	0.8	1
42	<i>Palmella miniata</i> Leiblein	2.08	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2.08	0.20	1
43	<i>P. mucosa</i> Kuetzing	-	-	-	-	-	1.06	-	-	-	-	-	-	-	-	0	1.06	0.10	1

44	<i>Pediastrium simplex</i> Meyen	-	-	-	-	-	-	-	-	-	0	8	0.8	I
45	<i>Rhizoclonium fontanum</i> Kuetzing	-	-	-	1.4	-	-	-	-	-	0	1.4	0.14	I
46	<i>Scenedesmus dimorphus</i> (Turpin) Kuetzing	-	-	-	-	-	-	-	-	-	0	4	0.4	I
47	<i>S. obliquus</i> (Turpin) Kuetzing	4.16	-	-	1.4	-	-	-	-	-	1.4	4.16	0.41	I
48	<i>S. quadricauda</i> (Turpin) Brebisson	-	-	-	-	-	-	-	-	-	0	4	0.4	I
49	<i>Sphaeroplea annulina</i> (Roth) C.A. Agardh	-	-	-	-	1.06	-	-	-	-	0	1.06	0.10	I
50	<i>Spirogyra condensata</i> (Vaucher) Kuetzing	-	8.77	-	-	-	-	-	-	-	0	8.77	0.87	I
51	<i>S. ellipsospora</i> Transeau	-	-	3.22	-	-	-	-	-	-	0	3.22	0.32	I
52	<i>S. mirabilis</i> (Hass) Kuetzing	-	3.5	-	-	-	-	-	-	-	0	3.5	0.35	I
53	<i>S. poricalis</i> (Muell.) Cleve	-	-	1.61	-	3.19	-	-	-	-	1.61	3.19	0.48	I
54	<i>S. pratensis</i> Transeau	-	1.75	-	-	-	-	-	-	-	0	1.75	0.17	I
55	<i>S. punctiformis</i> Transeau	-	-	1.61	-	-	-	-	-	-	0	1.61	0.16	I
56	<i>S. scrobiculata</i> (Stockmayer) Cruxda	-	5.26	-	-	-	-	-	-	-	0	5.26	0.52	I
57	<i>S. setiformis</i> (Roth) Kuetzing	-	3.5	3.22	-	-	-	-	-	-	3.22	3.5	0.67	I
58	<i>Stigeoclonium longipilum</i> Kuetzing	6.25	-	-	-	-	-	-	-	-	0	6.25	0.62	I
59	<i>S. lubricum</i> (Dillwyn) Kuetzing	2.08	-	-	-	-	-	-	-	3.84	2.08	3.84	5.92	I
60	<i>S. stagnatile</i> (Hazen) Collins	8.33	-	-	-	-	-	-	-	-	0	8.33	0.83	I
61	<i>S. subcerandum</i> Kuetzing	2.08	-	-	-	-	-	-	-	-	0	2.08	0.20	I
62	<i>S. tenue</i> (Agardh) Kuetzing	2.08	-	-	-	-	-	-	-	-	0	2.08	0.20	I
63	<i>Tetradon muticum</i> (A. Braun) Hansgirg	-	-	-	2.81	-	-	-	-	-	0	2.81	0.28	I
64	<i>T. trigonum</i> (Naegeli) Rabenhorst	-	-	-	1.4	-	-	-	-	-	0	1.4	0.14	I
65	<i>Ulothrix tenuissima</i> Kuetzing	-	-	-	-	-	-	-	2.04	-	0	2.04	0.20	I
66	<i>U. variabilis</i> Kuetzing	4.16	-	-	-	-	-	-	-	-	0	4.16	0.41	I
67	<i>U. zonata</i> (Weber and Mola) Kuetzing	2.08	1.75	1.61	-	4.25	-	-	-	-	1.61	4.25	0.96	II
68	<i>Urceolina elongatum</i> Hodggets	4.16	-	-	-	-	-	-	-	-	0	4.16	0.41	I

69	<i>Zygnema sterile</i> Transeau	-	*	*	-	1.4	-	-	-	-	-	-	-	0	1.4	0.14	I
C. Bacillariophyceae																	
70	<i>Achnanthes lanceolata</i> Var. <i>rostrata</i> Hustedt	-	-	-	-	-	-	-	5.26	-	-	-	-	0	5.26	0.52	I
71	<i>A. minutissima</i> (Kuetzing) Cleve	6.25	-	-	-	1.4	7.44	-	10.5	4.08	-	-	-	1.4	10.5	2.96	III
72	<i>Anaphora ovalis</i> Kuetzing	4.16	7.01	-	-	-	-	-	-	-	-	3.84	3.84	0	7.01	1.50	II
73	<i>Cocconeis flexella</i> (Kuetzing) Cleve	-	-	-	-	-	-	-	-	-	-	3.84	3.84	0	3.84	0.38	I
74	<i>C. placentalis</i> Ehrenberg	-	-	3.22	2.81	-	-	-	-	-	-	-	2.81	3.22	6.03	I	
75	<i>C. pediculus</i> Ehrenberg	-	-	4.83	-	-	-	-	-	-	-	-	0	4.83	0.48	I	
76	<i>Cyclotella glomerata</i> Bachmann	2.08	-	3.22	-	-	-	-	-	-	3.84	2.08	3.84	0.91	II		
77	<i>Cynatopleura solea</i> (Bréb) Wm. Smith	-	-	-	-	-	-	4	-	-	-	0	4	0.4	I		
78	<i>C. solea</i> Var. <i>subconstricta</i> Mueller	-	-	8.06	-	-	-	-	-	-	-	0	8.06	0.80	I		
79	<i>Cymbella cistola</i> (Hemprich) Grunow	-	-	-	1.4	-	-	-	-	-	-	0	1.4	0.14	I		
80	<i>C. parva</i> (Wm. Smith) Cleve	-	-	-	2.81	-	-	-	-	-	-	0	2.81	0.28	I		
81	<i>C. ventricosa</i> Kuetzing	-	-	-	1.4	-	-	-	-	2.04	3.84	1.4	3.84	0.72	II		
82	<i>Diatoma anceps</i> (Ehrenberg) Kirehnar	-	-	-	-	-	5.88	-	5.26	-	-	5.26	5.88	1.11	I		
83	<i>Epithemia argus</i> (Ehrenberg) Kuetzing	-	-	1.67	1.4	-	-	-	-	-	-	1.4	1.67	0.30	I		
84	<i>Eunotia pectinatis</i> (Kuetzing) Rabenhorst	-	1.75	-	-	-	-	-	-	-	-	0	1.75	0.17	I		
85	<i>Fragilaria capucina</i> Desmazieres	-	3.5	-	-	6.38	8.82	-	6.12	3.84	3.5	8.82	2.48	II			
86	<i>F. intermedia</i> Grun	2.08	-	-	-	1.06	-	-	-	-	1.06	2.08	0.31	I			
87	<i>Gomphonema acuminatum</i> Ehrenberg	-	-	-	-	-	8.82	-	-	-	-	0	8.82	0.88	I		
88	<i>G. constrictum</i> Var. <i>capitulum</i> (Ehrenberg) Grunow	-	-	6.45	-	-	-	-	-	-	-	0	6.45	0.64	I		
89	<i>G. intricatum</i> Kuetzing	-	-	-	-	-	-	-	-	-	3.84	0	3.84	0.38	I		
90	<i>G. olivaceum</i> Var. <i>Calcareo</i> Cleve	-	8.77	-	-	-	5.88	-	-	-	-	5.88	8.77	1.46	I		
91	<i>G. olivaceum</i> (Lyngbye) Kuetzing	-	-	-	-	19.71	-	-	-	-	-	0	19.71	0.19	I		
92	<i>G. parvulum</i> (Kuetzing) Grun	-	-	-	-	4.25	-	-	-	4.08	-	4.08	4.25	0.83	I		

93	<i>Gyrasigma scalproides</i> (Rabenhorst) Cleve	-	-	3.5	4.83	-	1.06	-	-	-	-	-	1.06	4.83	0.99	II
94	<i>Navicula cryptocephalo</i> Kuetzing	-	-	7.01	6.45	-	-	14.7	-	2.04	-	-	2.04	14.7	3.2	II
95	<i>N. gastrum</i> Ehrenberg	-	-	5.26	-	-	-	-	-	-	-	-	0	5.26	0.52	I
96	<i>N. gracilis</i> Ehrenberg	-	-	-	-	-	-	-	4	-	-	-	0	4	0.4	I
97	<i>N. protraxia</i> (Grunow) Cleve	-	-	3.5	-	-	-	-	-	-	-	-	0	3.5	0.35	I
98	<i>N. radiosa</i> Kuetzing	-	-	-	-	-	1.06	-	-	-	-	-	0	1.06	0.10	I
99	<i>N. rhyncephala</i> Kuetzing	-	-	-	6.45	-	-	-	-	-	-	-	0	6.45	0.64	I
100	<i>N. tuxcula</i> (Ehrenberg) Grunow	-	-	-	-	-	-	-	-	-	-	7.69	0	7.69	0.76	I
101	<i>Nitzschia angustata</i> (W. Smith) Grun	2.08	-	-	-	-	-	-	-	-	-	-	0	2.08	0.20	I
102	<i>N. ridiosa</i> Kuetzing	-	-	-	-	-	-	-	-	-	-	3.84	0	3.84	0.38	I
103	<i>N. vermicularis</i> (Kuetzing) Hantzsch	8.33	-	-	1.61	-	-	-	-	-	8.16	-	1.61	8.33	1.81	II
104	<i>Pinnularia parva</i> Gregory	-	-	-	1.61	-	-	-	-	-	-	-	0	1.61	0.16	I
105	<i>Pleurosigma angulatum</i> (Quekett) Wm. Smith	-	-	-	-	-	-	-	-	2.04	-	-	0	2.04	0.20	I
106	<i>Synedra acus</i> Var. <i>radiata</i> (Kuetzing) Hustedt	-	-	-	4.83	4.22	-	-	-	-	-	-	4.22	4.83	9.05	I
107	<i>S. ulna</i> (Nitzsch) Ehrenberg	-	-	1.75	3.22	19.71	42.55	2.94	-	-	-	-	1.75	42.55	7.01	I
D. Xanthophyceae																
108	<i>Botryococcus braunii</i> Kuetzing	-	-	-	-	2.81	-	5.88	-	-	-	-	2.81	5.88	0.86	I
109	<i>Paucieria aerea</i> Hassall	-	-	-	-	-	-	-	-	10.5	-	-	0	10.5	1.05	I
110	<i>P. hamata</i> (Vaucher) Decandolle	-	-	-	-	-	-	-	-	-	14.3	-	0	14.3	0.14	I
111	<i>P. longipes</i> Collins	-	-	-	-	14.08	-	-	-	-	-	-	0	14.08	0.14	I
112	<i>P. sessilis</i> (Vaucher) Decandolle	-	-	5.26	-	-	-	-	-	-	-	7.69	5.26	7.69	1.29	I

E. Euglenophyceae															
113	<i>Euglena acus</i> Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	<i>E. acutissima</i> Lemmermann	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	<i>E. polymorpha</i> Dangeard	6.25	-	-	-	-	-	-	-	-	-	-	-	-	-
116	<i>Phacus acuminatus</i> Stokes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Genera = 54		19	16	16	15	15	15	10	12	6	12	16	16	16	16
Total Species = 116		26	23	27	19	17	17	11	16	9	14	16	16	16	16

Key to sites:

1. Jabba Daud Zal, Peshawar
2. Jabba Daud Zal, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table 4. Distribution of classes/genera/species recorded from 10 sites of spring aspect in Peshawar Valley.

Class / Genera /Species	Sites										Constancy Class
	1	2	3	4	5	6	7	8	9	10	
A. Cyanophyceae											IV
<i>No of Genera</i>	3	4	2	-	1	-	4	3	1	2	
<i>No of Species</i>	4	4	4	-	1	-	5	5	2	2	
B. Chlorophyceae											V
<i>No of Genera</i>	10	4	4	7	7	4	5	-	2	4	
<i>No of Species</i>	15	9	10	8	8	4	8	-	2	4	
C. Bacillariophyceae											V
<i>No of Genera</i>	5	7	10	6	6	5	2	2	7	8	
<i>No of Species</i>	6	9	13	9	7	6	2	3	7	8	
D. Xanthophyceae											III
<i>No of Genera</i>	-	1	-	2	-	1	-	1	1	1	
<i>No of Species</i>	-	1	-	2	-	1	-	1	1	1	
E. Euglenophyceae											III
<i>No of Genera</i>	1	-	-	-	1	-	1	-	1	1	
<i>No of Species</i>	1	-	-	-	1	-	1	-	2	1	
Total Genera	19	16	16	15	15	10	12	6	12	16	
Total Species	26	23	27	19	17	11	16	9	14	16	

Key to sites:

1. Jabba Daud Zai, Peshawar
2. Jabba Daud Zai, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table 5. Physico-chemical characteristics of water from 10 sites of Peshawar Valley in spring aspect, 2004.

S.No	Site	Parameters																	
		WT	pH	Tu	TDS	TSS	EC	NaCl	DO	CO ₂	NH ₃ N ₂	NO ₃	SO ₄	PO ₄	TA	TH	CAH	MgH	BOD
1	Daudzal-1	18	7.78	36	280	42	103	2.9	4.6	186	0.6	11.5	72	13.3	564	380	197	183	67
2	Daudzal-2	18	7.76	46	275	110	100	1.8	4.1	152	0.55	6.7	79	11.2	573	317	124	193	63
3	Haichand	18	7.82	23	285	106	65	1	4.9	164	0.42	7.5	22	14.4	381	375	145	230	27
4	Gendalbridge	18	8.26	12	257	56	61	1.7	5.7	145	0.43	5.9	37	8	262	233	124	109	71
5	Yarhussain	18	7.63	29	250	60	54	2.8	5.7	148	0.41	5.4	21	7.5	292	195	132	63	32
6	Adina	18	7.94	26	218	95	46	2.9	4.3	126	0.43	2.7	18	5	253	127	84	43	63
7	Umarakhan	18	8.16	23	243	70	20	3.8	4.1	150	0.75	7.8	17	7.8	108	348	125	223	20
8	Rashaki	20	7.92	31	177	101	50	3.4	3.2	111	0.37	1.9	25	6	260	309	78	231	35
9	Azakhel	19	7.90	57	235	97	155	2.2	2.3	110	0.52	1.1	162	6.6	530	171	64	107	64
10	Pabbi	18	7.75	31	245	98	75	2.6	3.9	121	0.39	1.9	61	7.4	320	182	83	99	34
Minimum		18	7.63	12	177	42	20	1	2.3	110	0.37	1.1	17	5	108	127	64	43	20
Maximum		20	8.26	57	285	110	155	3.8	5.7	186	0.75	11.5	162	14.4	573	380	197	231	71
Average		18.3	7.892	31.4	246.5	83.5	72.9	2.51	4.28	141.3	0.487	5.24	51.4	8.72	354.3	263.7	115.6	148.1	45.5

Key:

WT	Water temperature (°C)	NaCl	Sodium chloride (mg/L)	PO ₄	Phosphates (mg/L)
pH	H ⁺ concentration	DO	Dissolved oxygen (mg/L)	TA	Total alkalinity (mg/L)
Tu	Turbidity (NTU)	CO ₂	Carbon dioxide (ppm)	TH	Total hardness (mg/L)
TDS	Total dissolved solids (mg/L)	NH ₃ N ₂	Ammonia nitrogen (ppm)	CAH	Calcium hardness (mg/L)
TSS	Total suspended solids (mg/L)	NO ₃	Nitrates (mg/L)	MgH	Magnesium hardness (mg/L)
EC	Electrical conductivity (dS m ⁻¹)	SO ₄	Sulphates (mg/L)	BOD	Biochemical oxygen demand (mg/L)

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Table 6. Species, their frequency and constancy in 10 sites of Peshawar valley during summer aspect, 2004.

S.No	Class / Species	Sites										Minimum frequency	Maximum frequency	Average frequency	Constancy Class	
		1	2	3	4	5	6	7	8	9	10					
A. Cyanophyceae																
1	<i>Aphanizomenon nidulans</i> P. Richter	3.7	-	-	-	-	-	-	-	-	-	0	3.7	0.37	I	
2	<i>Lyngbya birgei</i> G.M. Smith	-	-	-	-	3.84	-	-	-	-	-	0	3.84	0.38	I	
3	<i>Merismopedia convoluta</i> Brebisson	-	71.1	-	2.17	-	-	-	-	-	-	2.17	71.1	7.32	I	
4	<i>M. punctata</i> Meyen	-	-	-	-	-	-	-	-	11.7	-	0	11.7	1.17	I	
5	<i>Oscillatoria animalis</i> C.A. Agardh	-	-	-	-	-	-	6.81	-	-	-	0	6.81	0.68	I	
6	<i>O. formosa</i> Bory	-	2.22	-	-	-	5	4.34	27.2	-	-	2.22	27.2	3.87	II	
7	<i>O. ornata</i> Kuetzing	-	2.22	-	-	-	-	-	-	-	-	0	2.22	0.22	I	
8	<i>O. princeps</i> Vaucher	-	-	3.33	-	12	-	-	-	5.88	-	3.33	12	2.12	II	
9	<i>O. sancta</i> (Kuetzing) Gomont	-	-	-	-	-	-	-	-	-	10.3	0	10.3	1.03	I	
10	<i>O. tenuis</i> C.A. Agardh	-	-	-	-	3.84	-	-	-	-	-	0	3.84	0.38	I	
11	<i>Phormidium foveolarum</i> (Mont) Gomont	-	-	-	-	-	-	-	2.27	-	-	0	2.27	0.22	I	
12	<i>P. fragile</i> (Menegh) Gomont	-	-	-	-	-	-	8.69	-	-	-	0	8.69	0.86	I	
13	<i>P. purpurascens</i> (Kuetzing) Gomont	3.7	-	-	-	-	-	-	-	-	-	0	3.7	0.37	I	
B. Chlorophyceae																
14	<i>Basillaria crassa</i> Hoffman and Tilden	-	-	-	2.17	-	-	-	-	-	-	0	2.17	0.21	I	
15	<i>Chlamydomonas globosa</i> Saow	-	-	-	-	-	-	13	-	-	-	13	13	2.60	I	
16	<i>Cladophora fracta</i> (Dillw) Kuetzing	-	-	-	6.52	-	-	-	-	-	-	0	6.52	0.65	I	
17	<i>C. glomerata</i> (Linnaeus) Kuetzing	-	-	-	-	-	-	-	-	-	3.44	0	3.44	0.34	I	
18	<i>C. insignis</i> (C.A. Agardh) Kuetzing	-	-	-	4.34	-	-	-	-	-	-	0	4.34	0.43	I	

19	<i>Closterium leibleinii</i> Kuetzing	-	-	-	-	-	-	-	-	-	-	5.88	-	0	5.88	0.58	1
20	<i>Microspora hofgrenii</i> (Nordst) Lagerheim	-	-	-	-	-	-	-	-	-	-	-	3.44	0	3.44	0.34	1
21	<i>Mougeotia spirocarpa</i> Wolle	3.7	-	-	-	-	-	-	-	-	-	-	-	0	3.7	0.37	1
22	<i>M. virescens</i> (Hassall) Borge	3	-	-	-	-	-	-	-	-	-	-	-	0	3	0.3	1
23	<i>Oedogonium illinoense</i> Transeau	-	-	-	-	-	-	-	-	2	-	-	-	2	2	0.2	1
24	<i>Spirogyra aequinoctialis</i> G. S. West	-	-	-	-	-	-	-	-	-	-	5.88	-	0	5.88	0.58	1
25	<i>S. borgeana</i> Transeau	-	6.66	-	-	-	-	-	-	-	-	-	-	0	6.66	0.66	1
26	<i>S. condensata</i> (Vaucher) Kuetzing	-	-	-	-	-	-	15	-	-	-	-	-	0	15	1.5	1
27	<i>S. crassa</i> Kuetzing	-	-	-	6.6	-	-	20	-	-	-	5.88	-	5.88	20	3.24	11
28	<i>S. ellipsoidea</i> Transeau	-	4.44	-	-	15.3	-	-	-	-	-	-	-	4.44	15.3	1.97	1
29	<i>S. fluvialis</i> Hilse	-	-	-	-	12	13.3	-	-	-	-	-	-	12	13.3	2.53	1
30	<i>S. porticalis</i> (Muell) Cleve	-	4.44	-	-	19.2	-	-	-	-	-	-	-	4.44	19.2	2.36	1
31	<i>S. punctiformis</i> Transeau	-	-	-	-	3.8	-	-	-	-	-	-	-	0	3.8	0.38	1
32	<i>S. rectangularis</i> Transeau	-	-	-	2.17	-	-	-	-	-	-	-	-	0	2.17	0.21	1
33	<i>S. scrobiculata</i> (Stockmayer) Cnarda	-	-	10	-	-	-	-	-	-	-	-	-	0	10	1.0	1
34	<i>S. setiformis</i> (Roth) Kuetzing	25.9	-	-	-	-	-	-	-	-	-	-	-	0	25.9	2.59	1
35	<i>S. subulsa</i> Kuetzing	-	2.22	-	-	-	-	-	-	-	-	-	27	2.22	27	2.92	1
36	<i>Stigeoclonium tenue</i> (Agardh) Kuetzing	7.4	-	-	-	-	-	-	-	43.4	-	-	-	7.4	43.4	5.08	1
37	<i>Ulothrix tenuissima</i> Kuetzing	3.7	2.22	-	-	-	-	-	-	-	-	-	-	2.22	3.7	0.59	1
38	<i>U. variabilis</i> Kuetzing	-	-	-	-	-	-	-	-	-	-	2.27	-	0	2.27	0.22	1
39	<i>U. zonata</i> (Weber & Mohr) Kuetzing	3.7	-	-	-	-	-	-	-	-	-	-	-	0	3.7	0.37	1
C. Bacillariophyceae																	
40	<i>Achnanthes inflata</i> Kuetzing	3.7	-	-	-	-	1.66	-	-	-	-	-	-	1.66	3.7	0.53	1
41	<i>A. minutissima</i> (Kuetzing) Cleve	11.1	-	3.33	-	-	6.6	-	-	-	-	5.88	-	3.33	11.1	2.69	11
42	<i>Amphora ovalis</i> Kuetzing	-	-	-	2.17	-	5	-	-	-	-	-	-	2.17	5	0.21	1

43	<i>Cocconeis placenticula</i> Ehrenberg	-	-	6.66	23.9	-	-	-	-	-	-	-	6.66	23.9	3.05	I
44	<i>Cymatopleura solea</i> (Breb) Wm. Smith	-	-	-	-	-	-	4.34	-	-	-	-	0	4.34	0.43	I
45	<i>Cymbella cymbiformis</i> (Kuetzing) Brebisson	-	-	3.33	2.17	-	10	-	2.27	-	-	-	2.17	10	1.77	II
46	<i>C. ventricosa</i> Kuetzing	-	-	-	4.34	-	-	-	-	-	-	-	0	4.34	0.43	I
47	<i>Diatoma anceps</i> (Ehrenberg) Kirchner	-	-	3.33	-	-	1.66	-	36.3	-	6.89	-	1.66	36.3	4.81	II
48	<i>D. elongatum</i> Agardh	-	-	-	-	-	-	-	2.27	-	-	-	0	2.27	0.22	I
49	<i>Fragilaria capucina</i> Desmazieres	3.7	-	-	-	-	-	-	-	-	3.44	-	3.44	3.7	0.71	I
50	<i>Gomphonema intricatum</i> Kuetzing	-	-	3.33	17.3	-	3.33	-	9.09	-	6.89	-	3.33	17.3	3.99	III
51	<i>G. olivaceum</i> (Lyngbye) C. A. Agardh	-	-	-	-	-	-	-	-	-	17.2	-	0	17.2	0.17	I
52	<i>G. olivaceum</i> (Lyngbye) Kuetzing	-	-	-	6.52	-	-	-	-	-	-	-	0	6.52	0.65	I
53	<i>G. olivaceum</i> Var. <i>calcareum</i> Cleve	3.7	-	-	-	-	3.33	-	-	-	-	-	3.33	3.7	0.71	I
54	<i>G. sphaerophorum</i> Ehrenberg	-	-	-	4.34	-	-	-	-	-	-	-	0	4.34	0.43	I
55	<i>Gyrodinium kuetzingii</i> (Grun) Cleve	-	-	6.66	-	-	5	-	-	17.6	-	-	6.66	17.6	2.92	II
56	<i>G. scalpellum</i> (Rabenhorst) Cleve	-	-	-	-	-	-	-	2.27	-	-	-	0	2.27	0.22	I
57	<i>Navicula cryptocephala</i> Kuetzing	-	-	10	-	12	1.66	-	2.27	-	6.89	-	1.66	12	3.28	III
58	<i>N. exigua</i> (Gregory) Mueller	-	2.22	-	-	-	-	-	-	-	-	-	0	2.22	0.22	I
59	<i>N. gracilis</i> Ehrenberg	-	-	-	-	-	-	8.69	-	-	-	-	0	8.69	0.86	I
60	<i>N. protacta</i> (Grunow) Cleve	-	-	13.3	-	3.84	-	-	-	11.7	-	-	3.84	13.3	2.88	II
61	<i>N. radiosa</i> Kuetzing	7.4	-	-	2.17	-	-	-	4.54	-	-	-	2.17	7.4	1.44	II
62	<i>Nitzschia vermicularis</i> (Kuetzing) Hantzsch	-	-	6.66	-	-	-	-	-	5.88	-	-	5.88	6.66	1.25	I
63	<i>Sarirella apiculata</i> Wm. Smith	-	-	3.33	-	-	-	-	-	-	-	-	0	3.33	0.33	I
64	<i>Synedra acus</i> Var. <i>radians</i> (Kuetzing) Hustedt	-	-	3.33	-	-	-	-	-	5.88	-	-	3.33	5.88	0.92	I
65	<i>S. acus</i> Kuetzing	-	-	-	20	3.84	-	-	2.27	-	-	-	2.27	20	2.61	II
66	<i>S. ulna</i> (Nitzsch) Ehrenberg	7.4	2.22	6.66	-	7.69	1.66	-	-	-	-	-	1.66	7.69	2.56	III
67	<i>S. ulna</i> Var. <i>aequalis</i> (Kuetzing) Hustedt	-	-	-	-	-	-	-	-	-	6.89	-	0	6.89	0.68	I

D. Xanthophyceae																
68	<i>Ophiocytium majus</i> Naegeli	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E. Euglenophyceae																
69	<i>Euglena acus</i> Ehrenberg	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
70	<i>E. acutissima</i> Lemmermann	-	-	-	-	-	-	-	-	-	-	-	5.88	-	-	-
71	<i>E. densa</i> Ehrenberg	-	-	-	-	-	-	-	-	-	-	-	11.7	-	-	-
72	<i>E. toria</i> Stokes	-	-	-	-	-	-	-	3.84	-	-	-	-	-	-	-
73	<i>Phacus longicauda</i> (Ehrenberg) Dajardin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total Genera = 31	11	6	13	10	10	6	11	9	9	9	12	12	10	10	10
	Total Species = 73	14	10	16	14	14	12	15	9	9	12	12	12	11	11	11

Key to sites:

1. Jabba Daud Zai, Peshawar
2. Jabba Daud Zai, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table 7. Summary of classes/genera/species recorded from 10 sites of summer aspect in Peshawar Valley.

Class / Genera /Species	Sites										11 Constancy Class
	1	2	3	4	5	6	7	8	9	10	
A. Cyanophyceae											V
<i>No of Genera</i>	2	2	1	1	2	1	2	2	2	1	
<i>No of Species</i>	2	3	1	1	3	1	2	3	2	1	
B. Chlorophyceae											V
<i>No of Genera</i>	4	2	1	3	1	1	3	1	2	3	
<i>No of Species</i>	6	5	2	4	4	3	3	1	3	3	
C. Bacillariophyceae											V
<i>No of Genera</i>	5	2	10	6	2	8	2	6	5	5	
<i>No of Species</i>	6	2	12	9	4	10	2	8	5	6	
D. Xanthophyceae											I
<i>No of Genera</i>	-	-	-	-	-	-	1	-	-	-	
<i>No of Species</i>	-	-	-	-	-	-	1	-	-	-	
E. Euglenophyceae											III
<i>No of Genera</i>	-	-	1	-	1	1	1	-	1	1	
<i>No of Species</i>	-	-	1	-	1	1	1	-	2	1	
<i>Total Genera</i>	11	6	13	10	6	11	9	9	10	10	
<i>Total Species</i>	14	10	16	14	12	15	9	12	12	11	

Key to sites:

1. Jabba Daud Zai, Peshawar
2. Jabba Daud Zai, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table 8. Physico-chemical characteristics of water from 10 sites of Peshawar valley during summer aspect, 2004.

S.No	Site	Parameters																	
		WT	pH	Tu	TDS	TSS	EC	NaCl	DO	CO ₂	NH ₃ N ₂	NO ₃	SO ₄	PO ₄	TA	TH	CAH	MgH	BOD
1	Daudzai-1	29	7.23	13.5	227	30	61.2	3.0	1.1	136	0.33	4.0	44	0.8	340	220	107	113	64
2	Daudzai-2	29	8.49	14	213	48	182	4.5	0.7	128	0.6	1.6	47	1.7	1204	438	165	273	63
3	Haichand	31	8.42	12	243	20	72	1.3	2.5	112	0.25	4.7	59	4.8	406	270	107	163	73
4	Gendalbridge	30	8.55	11	230	15	56	1.8	6.2	123	0.17	0.2	52	0.4	321	230	102	118	93
5	Yarhussain	30	7.81	29	218	70	87	3.4	3.3	122	0.34	0.3	50	1.0	464	220	98	122	59
6	Adina	30	7.91	10.7	240	140	49	1.6	3.5	117	0.25	3.9	24	4.5	252	158	115	43	43
7	Umarakhan	30	8.14	22.6	174	280	15.2	3.7	6.7	120	0.5	5.0	22	2.2	108	63	42	21	14
8	Rashaki	29	7.92	84	219	149	58	2.5	5.2	113	0.45	1.2	39	0.9	356	162	104	58	22
9	Azakhel	29	7.9	24.9	221	370	50.4	2.9	6.5	119	0.53	0.6	56	4.2	280	96	61	35	64
10	Pabbi	30	7.81	56	215	87	78	3.1	5.6	121	0.27	4.0	68	0.9	412	228	128	100	79
	Minimum	29	7.23	10.7	174	15	15.2	1.3	0.7	112	0.17	0.2	22	0.4	108	63	42	21	14
	Maximum	31	8.55	84	243	370	182	4.5	6.7	136	0.6	5	68	4.8	1204	438	165	273	93
	Average	29.7	8.018	27.77	220	120.9	70.88	2.9	4.13	121.1	0.369	2.55	46.1	2.14	414.3	208.5	102.9	104.6	57.4

Key:

WT	Water temperature (°C)	NaCl	Sodium chloride (mg/L)	PO ₄	Phosphates (mg/L)
pH	H ⁺ concentration	DO	Dissolved oxygen (mg/L)	TA	Total alkalinity (mg/L)
Tu	Turbidity (NTU)	CO ₂	Carbon dioxide (ppm)	TH	Total hardness (mg/L)
TDS	Total dissolved solids (mg/L)	NH ₃ N ₂	Ammonia nitrogen (ppm)	CAH	Calcium hardness (mg/L)
TSS	Total suspended solids (mg/L)	NO ₃	Nitrates (mg/L)	MgH	Magnesium hardness (mg/L)
EC	Electrical conductivity (dS m ⁻¹)	SO ₄	Sulphates (mg/L)	BOD	Biochemical oxygen demand (mg/L)

Table 9. Species, their frequency and constancy in 10 sites of Peshawar valley during autumn aspect, 2004.

S.No	Class / Species	Sites										Minimum frequency	Maximum frequency	Average frequency	Constancy Class	
		1	2	3	4	5	6	7	8	9	10					
A . Cyanohyceeae																
1	Anabaena gelatinicola Chose	-		-	-	3.12	-	-	-	-	-	0	3.12	0.31	I	
2	A. viguieri Denis & Fremys	-	3.07	-	-	-	-	-	-	11.42	-	3.07	11.42	1.44	I	
3	Aphanocapsa elachista G.S. West	-	-	-	-	-	-	-	5.71	-	-	0	5.71	0.57	I	
4	A. grevillei (Haas) Rabenhorst	-	-	-	-	-	-	-	-	2.85	1.78	1.78	2.85	0.74	II	
5	A. castagnei (Breb) Rabenhorst	-	-	-	-	-	-	-	2.85	-	-	0	2.85	0.28	I	
6	Chroococcus turgidus (Kuetzing) Naegeli	-	-	-	-	-	-	5.88	-	-	-	0	5.88	0.58	I	
7	Gloeocapsa magna (Breb) Kuetzing	-	-	-	-	-	-	5.88	-	-	1.78	1.78	5.88	0.76	I	
8	Gomphosphaeria locustaris Chodat	5.66	-	-	-	-	-	-	-	-	-	0	5.66	0.56	I	
10	Lyngbya polysiphonias Frey	-	-	-	-	9.37	-	-	-	-	-	0	9.37	0.93	I	
9	L. taylori Drouet and Strickland	-	-	-	2.24	-	-	-	-	-	-	0	2.24	0.22	I	
11	L. verrucosus (Wurm) Gomont	-	1.53	-	-	-	-	-	6	-	-	1.53	6	0.75	I	
12	Merismopedia convoluta Brebisson	-	-	1.96	-	-	-	-	-	-	-	0	1.96	0.19	I	
13	M. glauca (Ehrenberg) Kuetzing	-	-	-	-	-	-	-	-	-	1.78	0	1.78	0.17	I	
14	M. punctata Meyen		-	-	1.12	-	-	-	-	5.71	-	1.12	5.71	0.68	I	
15	Microcystis aeruginosa Kuetzing	-	-	-	-	-	-	5.88	-	-	-	0	5.88	0.58	I	
16	Oscillatoria agardhii Gomont		3.07	-	-	6.25	-	-	-	-	1.78	1.78	6.25	1.11	II	
17	O. animalis C. A. Agardh	-	1.53	-	1.12	-	-	-	-	-	-	1.12	1.53	0.26	I	
18	O. coarctatus Gieckhorns	-	-	-	1.12	3.12	-	-	-	-	-	1.12	3.12	0.42	I	

19	<i>O. formosa</i> Bory	1.83	-	-	-	-	3.12	4.54	2.85	-	5.35	1.83	5.35	1.76	III
20	<i>O. princeps</i> Vaucher	9.43		1.96	-	-	-	-	-	-	-	1.96	9.43	1.13	I
21	<i>O. tenuis</i> C.A. Agardh	1.83	1.53	-	-	-	-	4.54	-	2.85	-	1.53	4.54	1.07	II
22	<i>Phormidium insidians</i> Kuetzing	-	1.53	-	-	-	-	4.54	-	-	-	1.53	4.54	0.6	I
23	<i>P. uicinatum</i> (Agardh) Gomont	-	1.53	3.92	1.12	-	-	4.54	-	-	-	1.12	4.54	1.11	II
24	<i>Spirulina subtilissima</i> Kuetzing	-	1.53	-	-	-	-	-	-	-	-	0	1.53	0.15	I
B. Chlorophyceae															
25	<i>Asterococcus lineaticus</i> G.M. Smith	-	-	-	1.12	-	-	-	-	-	-	0	1.12	0.11	I
26	<i>Baricladia cheiloneum</i> (Collins) Hoffman & Tilden	-	-	-	-	-	-	13.63	-	-	-	0	13.63	1.36	I
27	<i>B. crassa</i> Hoffman & Tilden	-	-	7.84	-	-	-	-	-	-	-	0	7.84	0.78	I
28	<i>Chlorophora elegans</i> (Roth) Agardh	-	-	-	13.48	-	-	-	-	-	-	0	13.48	1.34	I
29	<i>Chlamydomonas globosa</i> Snow	-	-	-	2.24	-	-	-	-	-	-	0	2.24	0.22	I
30	<i>Chlorococcum humicola</i> (Naeg) Rabenhorst	1.83	-	-	1.12	-	-	-	-	-	-	1.12	1.83	0.29	I
31	<i>Chlosterium acerosum</i> (Schrank) Ehrenberg	-	-	-	1.12	-	-	-	-	-	-	0	1.12	0.11	I
32	<i>C. diuiae</i> Ehrenberg	-	-	3.92	-	-	-	-	-	-	1.78	1.78	3.92	0.57	I
33	<i>C. ehrenbergii</i> Meneghini	-	-	-	-	-	-	-	-	2.85	1.78	1.78	2.85	0.46	I
34	<i>C. lathleini</i> Kuetzing	-	-	-	1.12	-	-	-	-	-	-	0	1.12	0.11	I
35	<i>C. littorale</i> Gay	-	-	1.96	-	-	-	-	-	-	-	0	1.96	0.19	I
36	<i>C. moniliforme</i> (Bory) Ehrenberg	-	3.07	-	2.24	-	-	-	-	-	-	2.24	3.07	0.53	I
37	<i>C. nysidum</i> (Bory) Ehrenberg	-	1.53	-	-	-	-	-	-	-	-	0	1.53	0.15	I
38	<i>Cosmarium prostratum</i> (Naegeli) Bory	-	-	3.92	-	-	-	-	-	-	-	0	3.92	0.39	I
39	<i>C. subimpressulum</i> Borge	-	-	-	-	-	-	-	-	2.85	-	0	2.85	0.28	I
40	<i>Crucigenia rectangularis</i> (Naegeli) Gay	-	-	-	-	-	-	-	-	2.85	-	0	2.85	0.28	I
41	<i>Haematococcus lacustris</i> (Gruod) Rostafinski	-	1.53	-	-	-	-	-	-	-	-	0	1.53	0.15	I
42	<i>Microspora pachyderma</i> (Wille) Lagerheim	-	-	11.76	-	-	-	-	-	-	-	0	11.76	1.17	I

43	<i>Mougeotia gracillima</i> (Hassall) Wittrock	-	-	3.92	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.92	0.39	I
44	<i>M. scalaris</i> Hassall	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.83	0.18	I
45	<i>M. viridis</i> (Kuetzing) Wittrock	-	-	5.88	-	-	-	-	-	-	-	-	-	-	-	-	-	0	5.88	0.58	I
46	<i>Oocystis elliptica</i> W. West	-	-	-	1.12	-	-	-	-	-	-	-	-	-	-	-	-	0	1.12	0.11	I
47	<i>O. solitaria</i> Wittrock	-	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.53	0.15	I
48	<i>Palmella miniata</i> Leibelin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.78	0	1.78	0.17	I
49	<i>Pediastrum bibrachiatum</i> Prescott	-	-	-	1.12	-	-	-	-	-	-	-	-	-	-	-	-	0	1.12	0.11	I
50	<i>P. duplex</i> Meyen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	35.29	3.52	I
51	<i>P. simplex</i> Meyen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	23.52	2.35	I
52	<i>P. leirus</i> (Ehrenberg) Ralfs	-	-	-	1.12	-	-	-	-	-	-	-	-	-	-	-	-	1.12	17.64	1.76	I
53	<i>Penium margaritaceum</i> (Ehrenberg) (Ehrenberg) Chodat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.78	0	1.78	0.17	I
54	<i>Scenedesmus acuminatus</i> (Lagerheim) Chodat	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.96	0.19	I
55	<i>S. longus</i> Meyen	-	-	-	3.37	-	-	-	-	-	-	-	-	-	-	-	-	0	3.37	0.33	I
56	<i>Schroederia setigera</i> (Schroeder) Lemmermann	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.83	0.18	I
57	<i>Spirogyra acuinotialis</i> G.S. West	15.09	23.07	-	-	3.12	-	-	-	-	-	-	-	-	-	-	-	3.12	23.07	4.12	II
58	<i>S. dactyloides</i> Czarda	-	6.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	6.15	0.61	I
59	<i>S. ellipsoidea</i> Transeau	-	-	-	-	3.12	-	-	-	-	-	-	-	-	-	-	-	0	3.12	0.31	I
60	<i>S. majuscula</i> Kuetzing	-	-	-	3.37	-	-	-	-	-	-	-	-	-	-	-	-	0	3.37	0.33	I
61	<i>S. portulalis</i> (Muell) Cleve	11.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	11.32	1.13	I
62	<i>S. punctiformis</i> Transeau	-	4.61	-	-	3.12	-	-	-	-	-	-	-	-	-	-	-	3.12	4.61	0.77	I
63	<i>S. rectangularis</i> Transeau	-	-	-	-	9.37	9.09	-	-	-	-	-	-	-	-	-	5.35	5.35	9.37	2.38	II
64	<i>S. setiformis</i> (Roh) Kuetzing	-	-	-	4.49	-	-	-	-	-	-	-	-	-	-	-	-	0	4.49	0.44	I
65	<i>S. subulsa</i> Kuetzing	-	-	-	-	15.62	-	-	-	-	-	-	-	-	-	-	11.42	11.42	15.62	2.7	I
66	<i>Stigeoclonium lubricum</i> (Dillwyn) Kuetzing	7.54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	7.54	0.75	I
67	<i>Tetradon muticum</i> (A. Braun) Hansgirg	-	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.53	0.15	I

68	<i>Ulobozia tenuissima</i> Kuetzing	3.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.77	0.37	I
69	<i>U. zonata</i> (Weber & Mohr) Kuetzing	1.83	-	-	5.61	-	-	-	-	-	-	-	-	-	-	-	-	1.83	5.61	0.74	I
70	<i>Uronema elongatum</i> Hodgetts	1.83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.83	0.18	I
C. Bacillariophyceae																					
71	<i>Achnanthes microcephala</i> (Kuetzing) Cleve	-	-	-	-	2.12	-	-	-	-	-	-	-	-	-	-	-	0	2.12	0.21	I
72	<i>A. minutissima</i> (Kuetzing) Cleve	-	-	-	-	-	4.54	-	2.85	5.71	3.57	2.85	5.71	3.57	2.85	5.71	3.57	2.85	5.71	1.66	II
73	<i>Amphora nitzsiana</i> Rabenhorst	-	-	3.92	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.92	0.39	I
74	<i>A. ovalis</i> Kuetzing	-	-	-	-	-	4.54	-	-	-	-	-	-	-	-	-	-	0	4.54	0.45	I
75	<i>Cocconeis flaccida</i> (Kuetzing) Cleve	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.96	0.19	I
76	<i>C. placenta</i> Ehrenberg	-	-	-	-	-	-	-	-	2.85	-	-	2.85	-	-	-	-	0	2.85	0.28	I
77	<i>Cyclotella antiqua</i> Smith	-	-	1.96	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.96	0.19	I
78	<i>Cymatopleura elliptica</i> (Breb) Wm. Smith	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.57	0.35	I
79	<i>C. solida</i> (Breb) Wm. Smith	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.78	0.17	I
80	<i>Cymbella aequalis</i> Wm. Smith	-	-	3.92	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.92	0.39	I
81	<i>C. nana</i> Grun	-	-	11.76	-	-	-	-	-	-	-	-	-	-	-	-	-	0	11.76	1.17	I
82	<i>C. ventricosa</i> Kuetzing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.78	0.17	I
83	<i>Diatoma anceps</i> (Ehren) Kirchner	1.83	-	-	6.74	-	4.54	-	-	-	-	-	-	-	-	-	-	1.78	6.74	1.48	II
84	<i>D. isemale</i> (Lyngbye) Heiberg	-	-	-	-	3.12	-	-	-	-	-	-	-	-	-	-	-	0	3.12	0.31	I
85	<i>Fragilaria capucina</i> Desmazieres	5.66	-	-	1.12	-	-	-	-	-	-	-	-	-	-	-	-	1.12	5.66	0.67	I
86	<i>F. pinnata</i> Ehrenberg	-	-	-	-	-	-	-	-	2.85	5.35	2.85	5.35	5.35	2.85	5.35	5.35	2.85	5.35	0.82	I
87	<i>Gomphonema angustatum</i> (Kuetzing) Grunow	-	-	-	2.24	-	-	-	-	-	-	-	-	-	-	-	-	0	2.24	0.22	I
88	<i>G. geminatum</i> (Lyngbye) C.A. Agardh	-	-	3.92	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3.92	0.39	I
89	<i>G. olivaceum</i> Var. <i>calcareum</i> Cleve	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1.78	0.17	I
90	<i>Gyrodinium kuetzingii</i> (Grun) Cleve	-	13.8	5.88	-	-	-	-	-	2.85	-	-	2.85	-	-	-	-	2.85	13.8	2.25	II
91	<i>G. scalpoides</i> (Rabenhorst) Cleve	-	-	-	-	-	4.54	-	8.57	-	-	8.57	-	-	-	-	-	4.54	8.57	2.2	II

92	G. wormleyi (Sullivant) Boyer	-	-	-	-	-	-	-	-
93	Navicula anglica Ralfs	-	-	-	-	-	-	-	-
94	N. bacillum Ehrenberg	-	-	-	-	-	-	-	-
95	N. cryptocephala Kuetzing	-	-	-	-	-	-	-	-
96	N. dicephala (Ehrenberg) Wm. Smith	-	-	-	-	-	-	-	-
97	N. gastrum Ehrenberg	-	-	-	-	-	-	-	-
98	N. mutica Kuetzing	-	-	-	-	-	-	-	-
99	N. praeoeca (Grun) Cleve	-	-	-	-	-	-	-	-
100	N. radiosa Kuetzing	-	-	-	-	-	-	-	-
101	N. seminulum Grunow	-	-	-	-	-	-	-	-
102	N. solinarum (Grunow) Cleve	-	-	-	-	-	-	-	-
103	N. tuxcula (Ehrenberg) Grunow	-	-	-	-	-	-	-	-
104	N. viridula Kuetzing	-	-	-	-	-	-	-	-
105	Nitzschia acicularis (Kuetzing) Wm. Smith	-	-	-	-	-	-	-	-
106	N. amphibia Grun	-	-	-	-	-	-	-	-
107	N. angustata (W Smith) Grun	-	-	-	-	-	-	-	-
108	N. vermicularis (Kuetzing) Hustach	-	-	-	-	-	-	-	-
109	N. vermicularis (Kuetzing) Hustach	-	-	-	-	-	-	-	-
110	Pinnularia major (Kuetzing) Wm. Smith	-	-	-	-	-	-	-	-
111	P. parva Gregory	-	-	-	-	-	-	-	-
112	Stauroneis anceps (Ehrenberg) Cleve	-	-	-	-	-	-	-	-
113	Synedra acus Kuetzing	-	-	-	-	-	-	-	-
114	S. pulchella (Ralfs) Kuetzing	-	-	-	-	-	-	-	-
115	S. tenera Wm. Smith	-	-	-	-	-	-	-	-
116	S. ulna (Nitzsch) Ehrenberg	-	-	-	-	-	-	-	-

D. Xanthophyceae																		
117	<i>Ophiocytium majus</i> Naegeli	-	-	-	-	-	-	-	-	-	-	-	-	-	0	5.88	0.58	1
E. Euglenophyceae																		
118	<i>Euglena acutissima</i> Lemmermann	3.77	-	-	-	-	-	-	-	-	-	-	-	-	0	3.77	0.37	1
119	<i>E. acus</i> Ehrenberg	7.54	-	-	-	-	-	-	-	-	-	2.85	-	2.85	2.85	7.54	1.03	1
120	<i>E. densa</i> Ehrenberg	-	-	7.84	-	-	-	-	-	-	5.71	5.71	-	5.71	5.71	7.84	1.92	11
121	<i>E. gracilis</i> Klebs	-	-	-	-	-	-	3.12	-	-	-	-	-	-	0	3.12	0.31	1
122	<i>E. polymorpha</i> Dangeard	-	-	-	-	-	-	-	-	-	-	-	-	8.92	0	8.92	0.89	1
123	<i>E. splendens</i> Ehrenberg	-	6.15	-	-	-	-	-	-	-	-	-	-	-	0	6.15	0.61	1
124	<i>Phacus ocellatus</i> Stokes	-	-	-	-	7.86	-	-	-	-	-	-	-	-	7.86	12.5	2.03	1
125	<i>P. logicauda</i> (Ehrenberg) Dujardin	-	-	-	-	2.24	-	4.54	-	-	-	-	-	-	2.24	4.54	0.67	1
126	<i>P. triquetra</i> (Ehrenberg) Dujardin	-	-	-	-	-	3.12	-	-	-	-	14.28	-	-	3.12	14.28	1.74	1
	Total Genera = 52	14	14	18	22	31	17	15	7	10	21	28						
	Total Species = 126	19	21	24	31	31	17	15	7	10	21	28						

Key to sites:

1. Jabba Daud Zai, Peshawar
2. Jabba Daud Zai, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi
6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table. 10 Distribution of classes/genera/species recorded from 10 sites of autumn aspect in Peshawar Valley.

Class / Genera /Species	Sites										Constancy Class
	1	2	3	4	5	6	7	8	9	10	
A. Cyanophyceae											
No of Genera	2	5	3	4	3	2	3	4	4	4	V
No of Species	4	8	3	5	5	4	3	4	4	5	
B. Chlorophyceae											
No of Genera	7	5	6	10	1	2	1	-	4	4	V
No of Species	9	8	8	14	5	2	3	-	4	5	
C. Bacillariophyceae											
No of Genera	4	3	8	7	4	7	-	4	8	10	V
No of Species	4	4	12	10	5	8	-	5	10	16	
D. Xanthophyceae											
No of Genera	-	-	-	-	-	-	1	-	-	-	I
No of Species	-	-	-	-	-	-	1	-	-	-	
E. Euglenophyceae											
No of Genera	1	1	1	1	2	1	-	1	2	2	V
No of Species	2	1	1	2	2	1	-	1	3	2	
Total Genera	14	14	18	22	10	12	5	9	18	20	
Total Species	19	21	24	31	17	15	7	10	21	28	

Key to sites:

1. Jabba Daud Zai, Peshawar
2. Jabba Daud Zai, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table. 11 Physico-chemical characteristics of water from 10 sites of Peshawar valley in autumn aspect, 2004.

S.No	Site	Parameters																	
		WT	pH	Tu	TDS	TSS	EC	NaCl	DO	CO ₂	NH ₃ N ₂	NO ₃	SO ₄	PO ₄	TA	TH	CAH	MgH	BOD
1	Daudzal-1	22.5	7.81	14	256	19	66	3.3	5.2	154	1.2	6.7	101	3.8	332	520	138	382	38
2	Daudzal-2	22.5	7.92	16	268	21	140	3.4	4.2	147	0.9	5.8	12.4	9.6	352	466	126	340	19
3	Halchand	22	7.21	7.8	271	12	64	1.8	7.6	149	0.42	5.9	59	12.4	680	421	78	343	55
4	Gendaibridge	23	7.75	6.2	287	7.4	54	2.1	7.1	175	0.29	10.6	61.6	17	712	659	190	469	46
5	Yar hussain	23	7.87	16	239	90	78	3.2	2.7	127	2.1	3.6	38	8.5	390	318	94	224	32
6	Adina	23.5	8.13	56	228	170	40	2.5	3.2	113	2.3	1.0	29.6	7.4	228	165	65	100	52
7	Umara khan	24	8.38	36	110	98	62	4.0	3.1	117	3.7	1.8	21	2.2	106	219	77	142	15
8	Rashaki	23	8.02	61	115	902	45	3.0	3.7	130	3.4	3.7	57	4.3	290	323	97	226	28
9	Azakhel	23	8.26	92	265	480	125	2.2	2.6	123	1.5	2.6	106	9.1	588	265	86	179	30
10	Pabbi	23.7	8.03	28.8	282	275	58	1.0	2.4	131	0.4	3.3	44	15	360	117	54	63	24
Minimum		22	7.21	6.2	110	7.4	40	1	2.4	113	0.29	1	12.4	2.2	106	117	54	63	15
Maximum		24	8.38	92	287	902	140	4	7.6	175	3.7	10.6	106	17	712	659	190	469	55
Average		23.02	7.938	33.38	232.1	207.44	73.2	2.65	4.18	136.6	1.621	4.5	52.96	8.93	403.8	347.3	100.5	246.8	33.9

Key:

WT	Water temperature (°C)	NaCl	Sodium chloride (mg/L)	PO ₄	Phosphates (mg/L)
pH	H ⁺ concentration	DO	Dissolved oxygen (mg/L)	TA	Total alkalinity (mg/L)
Tu	Turbidity (NTU)	CO ₂	Carbon dioxide (ppm)	TH	Total hardness (mg/L)
TDS	Total dissolved solids (mg/L)	NH ₃ N ₂	Ammonia nitrogen (ppm)	CAH	Calcium hardness (mg/L)
TSS	Total suspended solids (mg/L)	NO ₃	Nitrates (mg/L)	MgH	Magnesium hardness (mg/L)
EC	Electrical conductivity (dS m ⁻¹)	SO ₄	Sulphates (mg/L)	BOD	Biochemical oxygen demand (mg/L)

Table. 13 Distribution of classes/genera/species recorded from 10 sites of winter aspect in Peshawar Valley.

Class / Genera /Species	Sites										Constancy Class
	1	2	3	4	5	6	7	8	9	10	
A. Cyanophyceae											
<i>No of Genera</i>	2	-	1	-	1	2	2	3	1	1	V
<i>No of Species</i>	3	-	1	-	2	3	2	4	3	1	
B. Chlorophyceae											
<i>No of Genera</i>	7	2	2	7	3	7	3	1	2	2	V
<i>No of Species</i>	11	5	3	11	4	8	3	1	2	3	
C. Bacillariophyceae											
<i>No of Genera</i>	5	8	5	7	4	6	4	2	8	5	V
<i>No of Species</i>	6	14	7	13	6	10	4	2	10	6	
D. Euglenophyceae											
<i>No of Genera</i>	-	-	-	-	-	-	1	2	-	1	II
<i>No of Species</i>	-	-	-	-	-	-	1	2	-	2	
<i>Total Genera</i>	14	10	8	14	8	15	10	8	11	9	
<i>Total Species</i>	20	19	11	24	12	21	10	9	15	12	

Key to sites:

1. Jabba Daud Zal, Peshawar
2. Jabba Daud Zal, Peshawar
3. Harichand, Charsadda
4. Gendai Bridge, Charsadda
5. Yar Hussain, Swabi

6. Adina, Swabi
7. Umara Khan, Mardan
8. Rashakai, Mardan
9. Aza Khel, Nowshera
10. Pabbi, Nowshera

Table. 14 Physico-chemical characteristics of water from 10 sites of Peshawar valley in winter aspect, 2004-05.

S.No	Sites	Parameters																	
		WT	pH	Tu	TDS	TSS	EC	NaCl	DO	CO ₂	NH ₃ N ₂	NO ₃	SO ₄	PO ₄	TA	TH	CAH	MgH	BOD
1	Daudzai-1	10	7.4	6.0	265	20	131	3.0	6.2	161	0.35	12.4	47	6.4	292	1530	1360	170	70
2	Daudzai-2	10	7.6	9.0	257	25	89	1.4	4.1	156	0.55	11.2	92	5.8	680	940	780	160	66
3	Harichand	10.2	8.1	12.7	219	40	44	2.8	6.7	126	1.2	2.2	26	1.7	210	750	570	180	65
4	Gendalbridge	10.3	8.2	2.6	276	20	150	1.6	7.1	175	0.22	16.5	31	8.6	266	1480	1360	120	61
5	Yar hussain	10.5	7.7	26.0	225	70	45	2.9	5.6	132	2.3	3.1	29	2.3	197	849	694	155	60
6	Adina	10.5	7.8	18.7	270	198	135	2.5	3.2	167	0.21	13.5	60	6.9	196	1395	1205	190	30
7	Umara khan	10	7.9	11.0	199	53	36	3.4	6.7	117	2.9	1.5	21	1.2	90	701	535	166	55
8	Rashaki	10	7.7	8	180	40.6	31	3.9	5.3	111	1.9	0.3	56	0.7	400	698	418	280	18
9	Azakhel	10	7.8	22.7	244	297	64	2.0	4.8	140	2.0	6.0	103	3.9	174	385	200	185	43
10	Pabbi	10	7.8	12	230	47.2	48	2.8	4.2	124	2.5	3.4	73	2.3	380	573	400	173	58
Minimum		10.0	7.4	2.6	180	20	31	1.4	3.2	111	0.21	0.3	21	0.7	90	385	200	120	18
Maximum		10.5	8.2	26.0	276	297	150	3.9	7.1	175	2.9	16.5	103	8.6	680	1530	1360	280	70
Average		10.15	7.8	12.87	236.5	81.08	77.3	2.63	5.39	140.9	1.41	7.01	53.8	3.98	288.5	930.1	752.2	177.9	52.6

Key:

WT	Water temperature (°C)	NaCl	Sodium chloride (mg/L)	PO ₄	Phosphates (mg/L)
pH	H ⁺ concentration	DO	Dissolved oxygen (mg/L)	TA	Total alkalinity (mg/L)
Tu	Turbidity (NTU)	CO ₂	Carbon dioxide (ppm)	TH	Total hardness (mg/L)
TDS	Total dissolved solids (mg/L)	NH ₃ N ₂	Ammonia nitrogen (ppm)	CAH	Calcium hardness (mg/L)
TSS	Total suspended solids (mg/L)	NO ₃	Nitrates (mg/L)	MgH	Magnesium hardness (mg/L)
EC	Electrical conductivity (dS m ⁻¹)	SO ₄	Sulphates (mg/L)	BOD	Biochemical oxygen demand (mg/L)

Table. 15 Distribution of classes / species in different aspects of Peshawar Valley.
The value noted against each species is the constancy value in various seasons.

S. No	Species	ASPECTION				Average Constancy Value
		Spring	Summer	Autumn	Winter	
	A. Cyanophyceae					
1	<i>Anabaena aequalis</i> Borge				I	2.5
2	<i>A. gelatinicola</i> Ghose			I		2.5
3	<i>A. viguieri</i> Denis & Fremys	I		I		5.0
4	<i>Aphanocapsa elachista</i> G.S. West			I		2.5
5	<i>A. grevillei</i> (Hass) Rabenhorst	I		II		10.13
6	<i>A. richteriana</i> Hieronymus	I				2.5
7	<i>Aphanothece castagnei</i> (Breb) Rabenhorst				I	2.5
8	<i>A. nidulans</i> P. Richter		I			2.5
9	<i>Chroococcus turgidus</i> (Kuetzing) Naegeli	I		I		5
10	<i>Gloeocapsa magma</i> (Breb) Kuetzing			I		2.5
11	<i>Gomphosphacteria aponina</i> Kuetzing	I				2.5
12	<i>G. lacustris</i> Chodat	I		I		5
13	<i>Lyngbya aestuarii</i> (Mertens) Liebmann				I	2.5
14	<i>L. birgei</i> G.M. Smith		I			2.5
15	<i>L. diguetii</i> Gomont	I				2.5
16	<i>L. taylorii</i> Drouet and Strickland			I		2.5
17	<i>L. polysiphoniae</i> Frey			I		2.5
18	<i>L. versicolor</i> (Wartm) Gomont	I		I		5
19	<i>Merismopedia convoluta</i> Brebisson	I	I	I		7.5
20	<i>M. planca</i> (Fehrenberg) Kuetzing		I	I		2.5
21	<i>M. punctata</i> Meyen	I	I	I	I	10
22	<i>Microcystis aeruginosa</i> Kuetzing			I		2.5
23	<i>M. flos-aquae</i> (Witt) Kirchner				I	2.5
24	<i>M. marginata</i> (Menegh) Kuetzing				I	2.5
25	<i>Oscillatoria agardhii</i> Gomont			II		7.63
26	<i>O. animalis</i> C.A. Agardh	I	I	I	I	10
27	<i>O. curvipes</i> Agard	I				2.5
28	<i>O. formosa</i> Bory	II	I	III	I	25.25
29	<i>O. limosa</i> C.A. Agardh				I	2.5
30	<i>O. minnesotensis</i> Tilden				I	2.5
31	<i>O. ornata</i> Kuetzing	I	I			5
32	<i>O. princeps</i> Vaucher	II	I	I	I	15.13

33	<i>O. sancta</i> (Kuetzing) Gomont		I	I	I	7.5
34	<i>O. tenax</i> Agardh	I	I	II	I	15.13
35	<i>Phormidium foveolarum</i> (Montagne) Gomont	I	I			5
36	<i>P. fragile</i> (Menegh) Gomont	I	I			5
37	<i>P. inundatum</i> Kuetzing			I	I	5
38	<i>P. purpurascens</i> (Kuetzing) Gomont	I	I			5
39	<i>P. tenue</i> (Meneghini) Gomont				I	2.5
40	<i>P. uncinatum</i> (Agardh) Gomont	I		II	I	15.13
41	<i>Spirulina laxissima</i> G.S. West	I				2.5
42	<i>S. subtilissima</i> Kuetzing			I		2.5
	Sub Total	20	13	24	16	
B. Chlorophyceae						
43	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	II			I	10.13
44	<i>Asterococcus limneticus</i> G.M. Smith	I		I	I	7.5
45	<i>Basilecladia chelonum</i> (Collins) Hoffman and Tilden	II		I	III	22.75
46	<i>B. crassa</i> Hoffman and Tilden	I	I	I	III	20.13
47	<i>Chaetophora attenuata</i> Hazen	I			I	5
48	<i>C. elegans</i> (Roth) Agardh			I		2.5
49	<i>Chlamydomonas globosa</i> Snow	I	I	I		7.25
50	<i>Characium ambiguum</i> Hermann	I			I	5
51	<i>Chlorococcum humicola</i> (Naeg) Rabenhorst	I		I		5
52	<i>Cladophora crispata</i> (Roth) Kuetzing	I				2.5
53	<i>C. fracta</i> (Dillw) Kuetzing		I		I	5
54	<i>C. glomerata</i> (Linnalus) Kuetzing		I			2.5
55	<i>C. insignis</i> (C.A. Ag) Kuetzing		I			2.5
56	<i>Cladococcus acerosum</i> (Schrank) Ehrenberg	I		I	I	7.50
57	<i>C. cornu</i> Ehrenberg				I	2.5
58	<i>C. diana</i> Ehrenberg			I	I	5
59	<i>C. ehrenbergii</i> Meneghini			I		2.5
60	<i>C. juncidum</i> Ralfs				I	2.5
61	<i>C. lanceolatum</i> Kuetzing	I				2.5
62	<i>C. leibleinii</i> Kuetzing		I	I		5
63	<i>C. littorale</i> Gay			I		2.5
64	<i>C. moniliferum</i> (Bory) Ehrenberg			I		2.5
65	<i>C. turgidum</i> (Bory) Ehrenberg			I		2.5
66	<i>Cosmarium constrictum</i> Delponte				I	2.5
67	<i>C. nitidulum</i> De Notaris	I				2.5
68	<i>C. protractum</i> (Naegeli) Bory			I		2.5
69	<i>C. subimpressulum</i> Borge	I		I		5

70	<i>Cryptogonia rectangularis</i> (Naegeli) Clay			I		2.5
71	<i>Geminella minor</i> (Naegeli) Heering				I	2.5
72	<i>Haematococcus lacustris</i> (Girod) Rostafinski			I		2.5
73	<i>Hydrodictyon reticulatum</i> (Linnaeus) Lagerheim				I	2.5
74	<i>Microspora loeffgrenii</i> (Nordst) Lagerheim	I	I			5
75	<i>M. pachyderma</i> (Wille) Lagerheim	I		I	I	7.5
76	<i>M. quadrata</i> Hazen	I			I	5
77	<i>M. tumidula</i> Hazen				I	2.5
78	<i>M. willeana</i> Lagerheim	I				2.5
79	<i>Mougeotia gracillima</i> (Hassall) Wittrock			I		2.5
80	<i>M. scalaris</i> Hassall	I		I	I	7.5
81	<i>M. spoerocarpa</i> Wille	I	I			5
82	<i>M. virescens</i> (Hassall) Borge		I			2.5
83	<i>M. viridis</i> (Kuetzing) Wittrock			I		2.5
84	<i>Oedogonium illinoense</i> Transeau		I			2.5
85	<i>Oocystis borgei</i> Snow	II				7.63
86	<i>O. crassa</i> Wittrock				I	2.5
87	<i>O. elliptica</i> W. West	I		I		5
88	<i>O. solitaria</i> Wittrock			I	I	5
89	<i>Palmella miniata</i> Leiblein	I		I		5
90	<i>P. mucosa</i> Kuetzing	I				2.5
91	<i>Pediastrum biradiatum</i> Prescott			I		2.5
92	<i>P. duplex</i> Meyen			I		2.5
93	<i>P. simplex</i> Meyen	I		I		5
94	<i>P. tetras</i> (Ehrenberg) Ralfs			I	I	2.5
95	<i>Penium margaritaceum</i> (Ehrenberg) Brebisson			I		2.5
96	<i>Pinophora oedogonia</i> (Montagne) Wittrock				I	2.5
97	<i>Rhizoclonium fontanum</i> Kuetzing	I			I	5
98	<i>Scenedesmus acuminatus</i> (Lay) Chodat			I	I	5
99	<i>S. arcuatus</i> Lemmerman				I	2.5
100	<i>S. dimorphus</i> (Turpin) Kuetzing	I				2.5
101	<i>S. longus</i> Meyen			I		2.5
102	<i>S. obliquus</i> (Turpin) Kuetzing	I				2.5
103	<i>S. quadricauda</i> (Turpin) Brebisson	I				2.5
104	<i>Schroederia setigera</i> (Schroeder) Lemmermann			I		2.5
105	<i>Sphaeroplea annulina</i> (Roth) C.A. Agardh	I				2.5
106	<i>Spirogyra aequinoctialis</i> G. S. West		I	II	I	12.63
107	<i>S. borgeana</i> Transeau		I			2.5
108	<i>S. collinsii</i> (Lewis) Printz				I	2.5

109	<i>S. condensata</i> (Vaucher) Kuetzing	I	I		I	7.5
110	<i>S. crassa</i> Kuetzing		II		I	10.13
111	<i>S. doedaleoides</i> Czurda			I	I	5
112	<i>S. ellipsozona</i> Transeau	I	I	I		7.5
113	<i>S. fluvialis</i> Hilse		I			2.5
114	<i>S. majuscula</i> Kuetzing			I		2.5
115	<i>S. mirabilis</i> (Hass) Kuetzing	I				2.5
116	<i>S. portalis</i> (Muell) Cleve	I	I	I		7.5
117	<i>S. pratensis</i> Transeau	I			I	5
118	<i>S. punctiformis</i> Transeau	I	I	I		7.5
119	<i>S. rectangularis</i> Transeau		I	II		10.13
120	<i>S. scrobiculata</i> (Stockmayer) Czurda	I	I			5
121	<i>S. setiformis</i> (Roth) Kuetzing	I	I	I	II	15.13
122	<i>S. subsalsa</i> Kuetzing		I	I		5
123	<i>Stigeoclonium longipilum</i> Kuetzing	I			I	5
124	<i>S. lubricum</i> (Dillwyn) Kuetzing	I		I	I	7.5
125	<i>S. pachydermum</i> Prescott				I	2.5
126	<i>S. stagnatile</i> (Hazen) Collins	I				2.5
127	<i>S. subsecundum</i> Kuetzing	I			I	5
128	<i>S. tenue</i> (Agardh) Kuetzing	I	I		I	7.5
129	<i>Tetradon muticum</i> (A. Braun) Hansgirg	I		I		5
130	<i>T. trigonum</i> (Naegeli) Rabenhorst	I				2.5
131	<i>Ulothrix subconstricta</i> West				I	2.5
132	<i>U. tenuissima</i> Kuetzing	I	I	I		7.5
133	<i>U. variabilis</i> Kuetzing	I	I			5
134	<i>U. zonata</i> (Weber and Mohr) Kuetzing	II	I	I	I	15.13
135	<i>Uronema elongatum</i> Hodgetts	I		I		5
136	<i>Zygnema sterile</i> Transeau	I				2.5
	Sub Total	49	26	46	39	
C. Bacillariophyceae						
137	<i>Achnanthes exilis</i> Kuetzing				I	2.5
138	<i>A. inflata</i> Kuetzing		I		I	5
139	<i>A. lanceolata</i> (Brebisson) Grunow				I	2.5
140	<i>A. lanceolata</i> Var. <i>rostrata</i> Hustedt	I				2.5
141	<i>A. microcephala</i> (Kuetzing) Cleve			I		2.5
142	<i>A. minutissima</i> (Kuetzing) Cleve	III	II	II	III	40.5
143	<i>Amphora normani</i> Rabenhorst			I	I	5
144	<i>A. ovalis</i> Kuetzing	II	I	I	I	15.13
145	<i>Cocconeis flexella</i> (Kuetzing) Cleve	I		I	I	7.5

146	<i>C. pediculus</i> Ehrenberg	I				2.5
147	<i>C. placentula</i> Ehrenberg	I	I	I	I	10
148	<i>Cyclotella antiqua</i> Smith			I		2.5
149	<i>C. glomerata</i> Bachmann	II				7.63
150	<i>Cymatopleura elliptica</i> (Breb) Wm. Smith			I		2.5
151	<i>C. solea</i> (Breb) Wm. Smith	I	I	I	I	10
152	<i>C. solea</i> Var. <i>subconstricta</i> Mueller	I				2.5
153	<i>Cymbella aequalis</i> Wm. Smith			I		2.5
154	<i>C. amphicephala</i> Nageli				I	2.5
155	<i>C. cistola</i> (Hemprich) Grunow	I				2.5
156	<i>C. cymbiformis</i> (Kuetzing) Brebisson		II			7.63
157	<i>C. leptoceros</i> (Ehr) Grunow				I	2.5
158	<i>C. parva</i> (Wm. Smith) Cleve	I				2.5
159	<i>C. tumidula</i> (Brebisson) Van Heurck			I		2.5
160	<i>C. ventricosa</i> Kuetzing	II	I	I	I	15.13
161	<i>Diatoma anceps</i> (Ehren) Kirchner	I	II	II	IV	35.48
162	<i>D. elongatum</i> Agardh		I			2.5
163	<i>D. hiemale</i> (Lyngbye) Heiberg			I	I	5
164	<i>Epithemia argus</i> (Ehrenberg) Kuetzing	I				2.5
165	<i>Eunotia pectinalis</i> (Kuetzing) Rabenhorst	I			I	5
166	<i>Fragilaria capucina</i> Desmazieres	II	I	I	III	25.3
167	<i>F. construens</i> (Ehrenberg) Grunow				I	2.5
168	<i>F. intermedia</i> Grun	I				2.5
169	<i>F. pinnata</i> Ehrenberg			I		2.5
170	<i>Gomphonema acuminatum</i> Ehrenberg	I		I		7.5
171	<i>G. angustatum</i> (Kuetzing) Grunow			I	I	5
172	<i>G. constrictum</i> Var. <i>capitulum</i> (Ehrenberg) Grunow	I				2.5
173	<i>G. geminatum</i> (Lyngbye) C.A. Agardh			I	I	5
174	<i>G. intricatum</i> Kuetzing	I	III		I	17.63
175	<i>G. olivaceum</i> (Lyngbye) C.A. Agardh		I			2.5
176	<i>G. olivaceum</i> (Lyngbye) Kuetzing	I	I		I	7.5
177	<i>G. olivaceum</i> var. <i>calcareum</i> Cleve	I	I	I	I	10.0
178	<i>G. parvulum</i> (Kuetzing) Grun	I			I	5
179	<i>G. sphaerophorum</i> Ehrenberg		I			2.5
180	<i>Gyrosigma kuetzingii</i> (Grun) Cleve		II	II	II	22.9
181	<i>G. scalproides</i> (Rabenhorst) Cleve	II	I	II	I	20.3
182	<i>G. wormleyi</i> (Sullivant) Boyer			I		2.5
183	<i>Navicula anglica</i> Ralfs			I		2.5
184	<i>N. bacillum</i> Ehrenberg			I		2.5

185	<i>N. confervacea</i> (Kuetzing) Grunow				I	2.5
186	<i>N. cryptocephala</i> Kuetzing	II	III	I	III	35.4
187	<i>N. cuspidata</i> Kuetzing				I	2.5
188	<i>N. dicephala</i> (Ehrenberg) Wm. Smith			I		2.5
189	<i>N. exigua</i> (Gregory) Mueller		I			2.5
190	<i>N. gastrum</i> Ehrenberg	I		I		5
191	<i>N. gracilis</i> Ehrenberg	I	I		I	7.5
192	<i>N. mutica</i> Kuetzing			I		2.5
193	<i>N. protracta</i> (Grun) Cleve	I	II	I	I	15.1
194	<i>N. radiosa</i> Kuetzing	I	II	I	II	20.3
195	<i>N. rhyncephala</i> Kuetzing	I				2.5
196	<i>N. seminum</i> Grunow			I		2.5
197	<i>N. solinarum</i> (Grunow) Cleve			III		12.6
198	<i>N. tuscula</i> (Ehrenberg) Grunow	I		I	II	12.6
199	<i>N. viridula</i> Kuetzing			I		2.5
200	<i>Nitzschia acicularis</i> (Kuetzing) Wm. Smith			I		2.5
201	<i>N. amphibian</i> Grun			I	I	5
202	<i>N. angustata</i> (W. Smith) Grun	I		I	I	7.5
203	<i>N. denticula</i> Grunow	I				2.5
204	<i>N. vermicularis</i> (Kuetzing) Hantzsch	I	I	II	I	15.1
205	<i>Pinnularia major</i> (Kuetzing) Wm. Smith			I		2.5
206	<i>P. parva</i> Gregory	I		I		5
207	<i>Pleurosigma angulatum</i> (Quekett) Wm. Smith	I				2.5
208	<i>Rhopalodia gibba</i> (Fhr) O. Muell				I	2.5
209	<i>Stauroneis anceps</i> Ehrenberg			I		2.5
210	<i>Savirella apiculata</i> Wm. Smith		I			2.5
211	<i>S. elegans</i> Ehrenberg				I	2.5
212	<i>S. oregonica</i> Ehrenberg				I	2.5
213	<i>Synedra acus</i> Var. <i>radians</i> (Kuetzing) Hustedt	I	I		I	7.5
214	<i>S. acus</i> Kuetzing		II	II	I	17.8
215	<i>S. capitata</i> Ehrenberg				I	2.5
216	<i>S. parasitica</i> (Wm. Smith) Hustedt				I	2.5
218	<i>S. pulchella</i> (Ralfs) Kuetzing			I		2.5
219	<i>S. rumpens</i> Kuetzing				I	2.5
220	<i>S. tenera</i> Wm. Smith			I		2.5
221	<i>S. ulna</i> Var. <i>danica</i> (Kuetzing) Grunow				I	2.5
222	<i>S. ulna</i> (Nitzsch) Ehrenberg	I	III	II	II	30.4
223	<i>S. ulna</i> Var. <i>aequalis</i> (Kuetzing) Hustedt		I			2.5
	Sub Total	38	28	46	45	

D. Xanthophyceae						
223	<i>Botryococcus braunii</i> Kuetzing	I				2.5
224	<i>Ophiocytium majus</i> Naegeli		I	I		5
225	<i>Vaucheria aversa</i> Hassal	I				2.5
226	<i>V. hamata</i> (Vaucher) Decandole	I				2.5
227	<i>V. longipes</i> Collins	I				2.5
228	<i>V. sessilis</i> (Vaucher) Decandole	I				2.5
	Sub Total	5	1	1		
E. Euglenophyceae						
229	<i>Euglena acutissima</i> Lemmermann	I	I	I		7.5
230	<i>E. acus</i> Ehrenberg	II	I	I	II	20.3
231	<i>E. deses</i> Ehrenberg		I	II		10.1
232	<i>E. gracilis</i> Klebs			I		2.5
233	<i>E. polymorpha</i> Dangeard	I		I		5
234	<i>E. spirogyra</i> Ehrenberg				I	2.5
235	<i>E. splendor</i> Ehrenberg			I		2.5
236	<i>E. torta</i> Stokes		I			2.5
237	<i>Phacus acuminata</i> Stokes	I		I		5
238	<i>P. logicauda</i> (Ehrenberg) Dujardin		I	I	I	7.5
239	<i>P. triquetra</i> (Ehrenberg) Dujardin			I		2.5
	Sub Total	4	5	9	3	
	Total	116	73	126	103	

Table 16. Seasonal distribution profile of species and genera in different aspects of Peshawar Valley.

Aspect	Species	Genera
Spring	116	54
Summer	73	31
Autumn	126	52
Winter	103	44

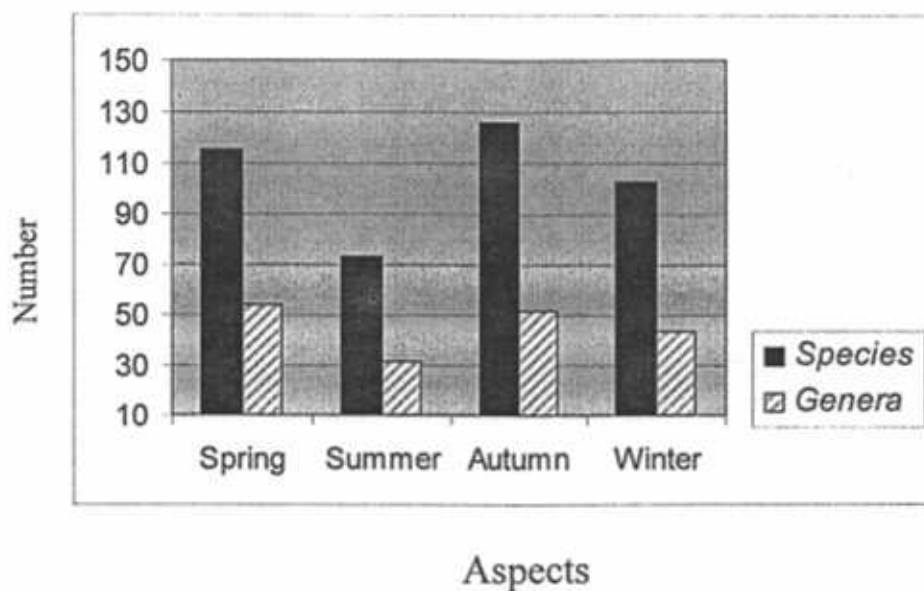


Fig:2 Distribution profile of species and genera in different aspects of Peshawar Valley.

C. Correlation Analysis

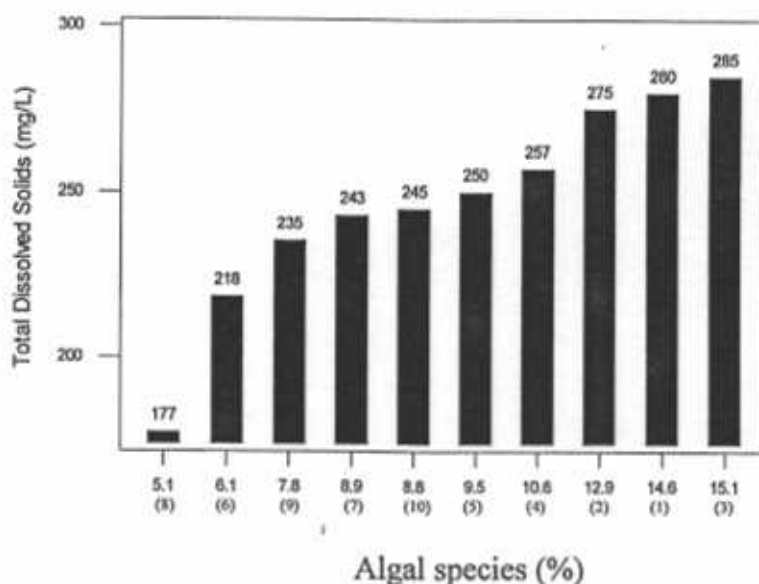


Fig. 3. The algal species (%) as affected by total dissolved solids (TDS) in 10 sites during spring aspect.

Table 17. Regression analysis for algal species (%) and total dissolved solids (TDS).

Model: Algal species (%) = a+b Total Dissolved Solids (TDS)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	109.10	109.10	32.91	0.000
Error	8	26.52	3.32		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	-2.354	2.226	-1.06	0.321
TDS	1	0.052134	0.009263	5.74	0.000

The results of linear regression analysis revealed a highly significant (F-Value 32.91) co-relationship between algal species (%) and total dissolved solids (mg/L). The graphic presentation (Fig. 3) also signifies the same relation between the two parameters (Table 17). It was clear that with increasing TDS the number of species enhanced from 5.1 (177 mg/L TDS) to over 15.1 % in 285 mg/L TDS during the spring season.

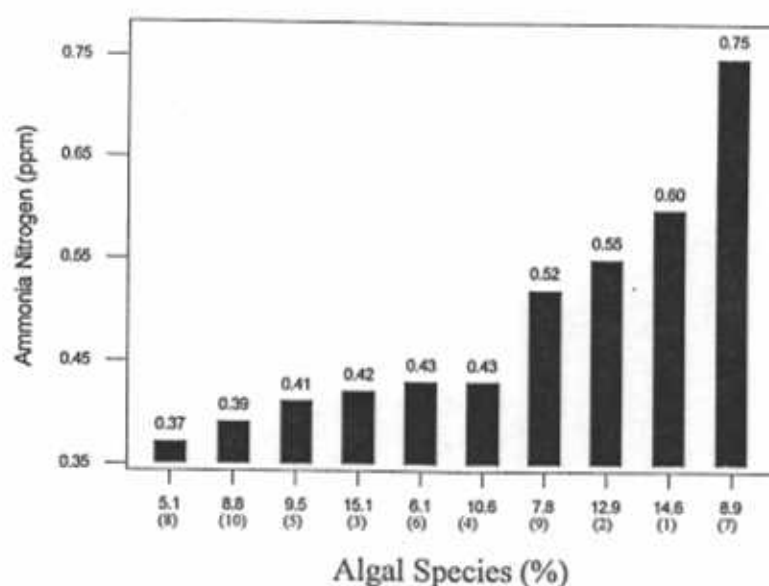


Fig. 4. The algal species (%) as affected by ammonia nitrogen (NH_3N_2) in 10 sites during spring aspect.

Table 18. Regression analysis for algal species (%) and ammonia nitrogen (NH_3N_2).

Model: Algal species (%) = a+b Ammonia Nitrogen (NH_3N_2)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	124.35	124.35	88.19	0.000
Error	8	11.28	1.41		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	14.8806	0.6431	23.14	0.000
NH_3N_2	1	-3.0244	0.3221	-9.39	0.000

The linear regression analysis revealed a highly significant (F-Value 88.19) correlation between algal species (%) and ammonia nitrogen (ppm). The graphic presentation (Fig. 4) also signifies the same relation between the two parameters (Table 18). It was clear that increasing NH_3N_2 also increased the number of species from 5.1 (0.37 ppm NH_3N_2) to over 8.9 % in 0.75 ppm NH_3N_2 during the spring season.

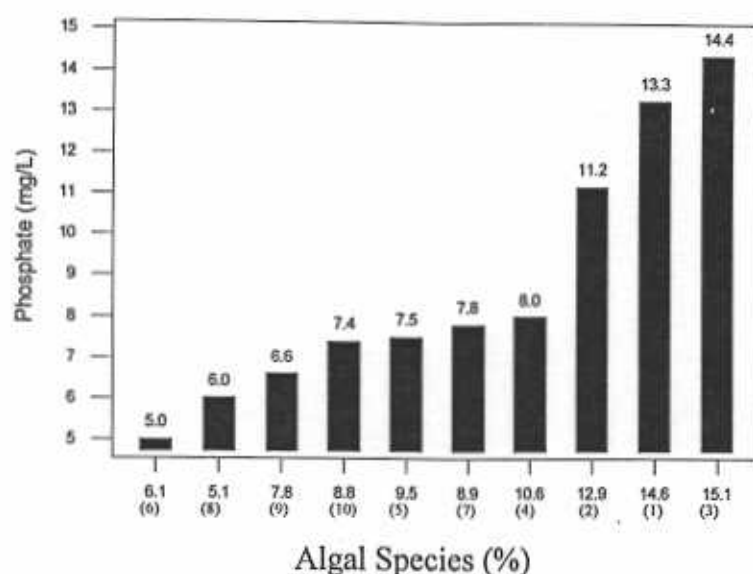


Fig. 5. The algal species (%) as affected by phosphate (PO_4) in 10 sites during spring aspect.

Table 19. Regression analysis for algal species (%) and phosphate (PO_4).

Model: Algal species (%) = a+b Phosphate (PO_4)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	115.86	115.86	46.90	0.000
Error	8	19.76	2.47		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	3.346	1.089	3.07	0.015
PO_4	1	0.7427	0.1084	6.85	0.000

Linear regression analysis showed a highly significant (F-Value 46.90) relationship between algal species (%) and phosphate (mg/L). Fig. 5 also signifies the same relation between the two parameters (Table 19). It was clear that with increasing PO_4 the number of species enhanced from 6.1 (5.0 mg/L PO_4) to over 15.1 % in 14.4 mg/L PO_4 during the spring season.

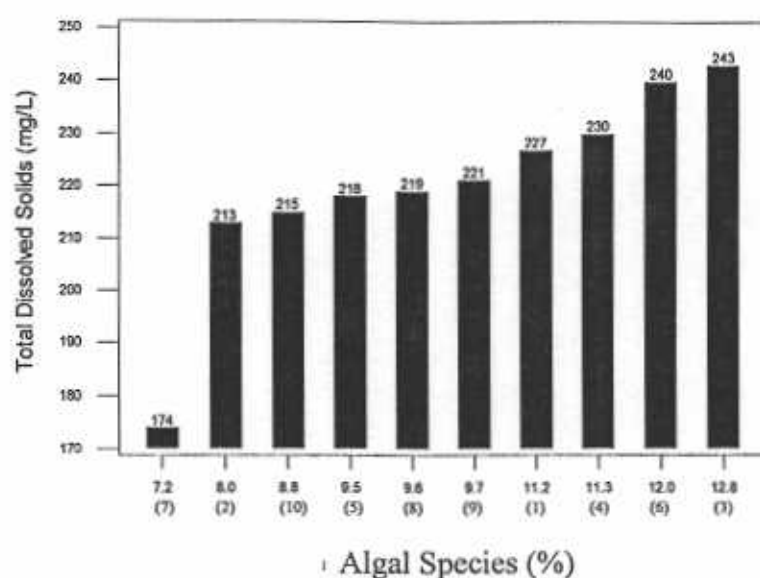


Fig. 6. The algal species (%) as affected by total dissolved solids (TDS) in 10 sites during summer aspect.

Table 20. Regression analysis for algal species (%) and total dissolved solids (TDS).

Model: Algal species (%) = a+b Total Dissolved Solids (TDS)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	23.216	23.216	33.57	0.000
Error	8	5.533	0.692		
Total	9	28.749			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	-8.516	3.208	-2.65	0.029
TDS	1	0.08421	0.01453	5.79	0.000

The results indicated a significant (F-Value 33.57) relationship between algal species (%) and total dissolved solids (mg/L). Fig. 6 also verifies the same relationship (Table. 20) Increasing TDS also increases the number of species 7.2 (174 mg/L TDS) to over 12.8 % in 243 mg/L TDS during the summer season.

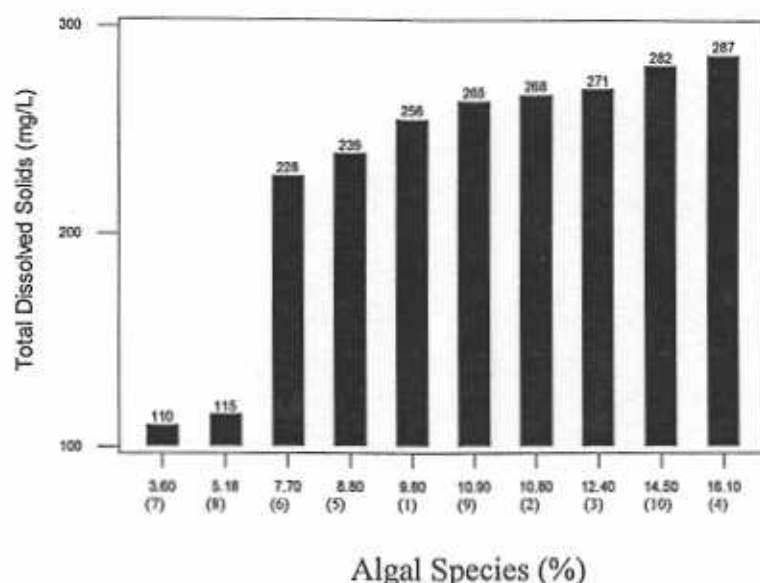


Fig. 7. The algal species (%) as affected by total dissolved solids (TDS) in 10 sites during autumn aspect.

Table 21. Regression analysis for algal species (%) and total dissolved solids (TDS).

Model: Algal species (%) = a+b Total dissolved Solids (TDS)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	109.10	109.10	32.91	0.000
Error	8	26.52	3.32		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	-2.354	2.226	-1.06	0.321
TDS	1	0.053134	0.009263	5.74	0.000

Linear regression revealed a highly significant (F-Value 32.91) co-relation between algal species (%) and total dissolved solids (mg/L). The graphic presentation (Fig 7) also signifies the same relationship between the two parameters (Table 21). It was obvious that with increasing TDS the number of species enhanced from 3.60 (110 mg/L TDS) to over 16.10 % in 287 mg/L TDS during the autumn season.

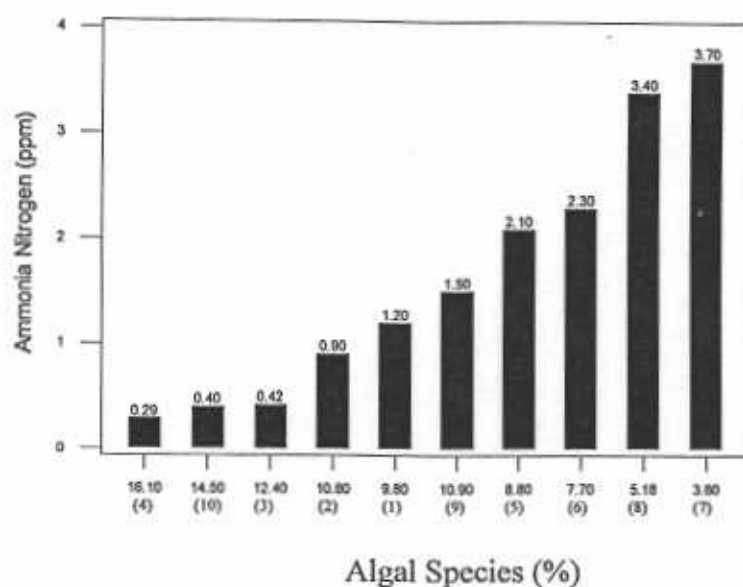


Fig. 8. The algal species (%) as affected by ammonia nitrogen (NH_3N_2) in 10 sites during autumn aspect.

Table 22. Regression analysis for algal species (%) and ammonia nitrogen (NH_3N_2).

Model: Algal species (%) = a+b Ammonia Nitrogen (NH_3N_2)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	124.35	124.35	88.19	0.000
Error	8	11.28	1.41		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	14.8806	0.6431	23.14	0.000
NH_3N_2	1	-3.0244	0.3221	-9.39	0.000

There was a significant (F-Value 88.19) co-relation between algal species (%) and ammonia nitrogen which is also represented by Fig. 8. Increasing NH_3N_2 concentration also enhanced the number of species from 16.10 (0.29 ppm NH_3N_2) to over 3.60 % in 3.70 ppm NH_3N_2 during the autumn season.

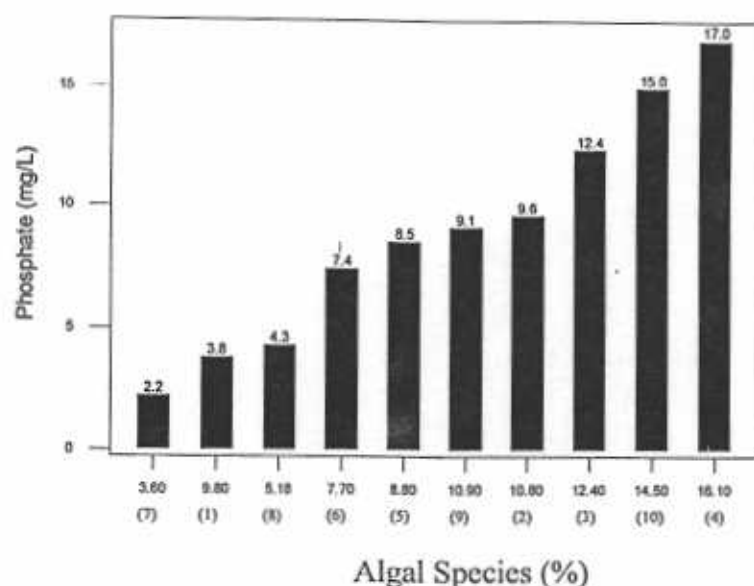


Fig. 9. The algal species (%) as affected by phosphate (PO_4) in 10 sites during autumn aspect.

Table 23. Regression analysis for algal species (%) and phosphate (PO_4).

Model: Algal species (%) = a+b Phosphate (PO_4)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	115.86	115.86	46.90	0.000
Error	8	19.76	2.47		
Total	9	135.63			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	3.346	1.089	3.07	0.015
PO_4	1	0.7427	0.1084	6.85	0.000

The results of linear regression analysis revealed a significant (F-Value 46.90) correlation between algal species (%) and Phosphate (mg/L). Contents was seen the graphic (Fig. 9) also proves the same relationship between the two parameters (Table 23). It was Concluded that with increasing PO_4 the number of species enhanced from 3.60 (2.2 mg/L PO_4) to over 16.10 % in 17.0 mg/L PO_4 during the autumn season.

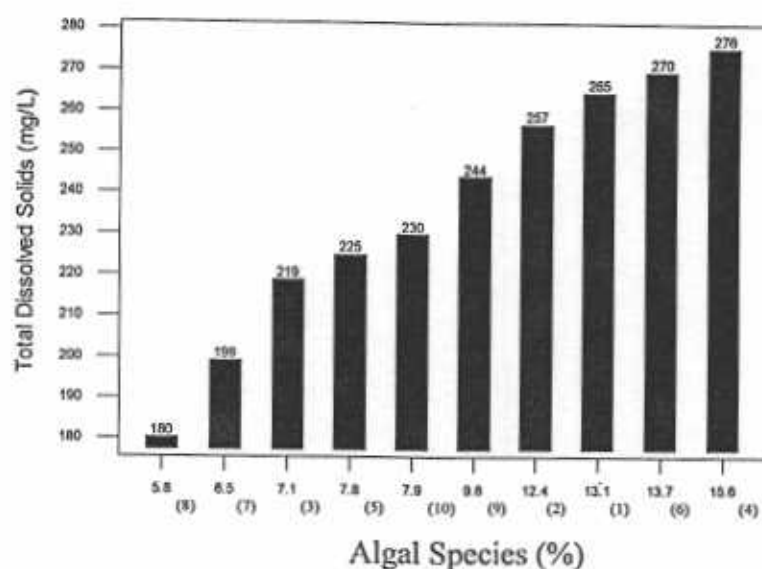


Fig. 10. The algal species (%) as affected by total dissolved solids (TDS) in 10 sites during winter aspect.

Table 24. Regression Analysis for algal species (%) and total dissolved solids (TDS).

Model: Algal species (%) = a+b Total Dissolved Solids (TDS)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	97.516	97.516	74.40	0.000
Error	8	10.485	1.311		
Total	9	108.001			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	-14.579	2.869	-5.08	0.001
TDS	1	0.10380	0.01203	8.63	0.000

A significant (F-Value 74.40) co- relation between species (%) and total dissolved solids (mg/L) was traced statistically which is also depicted by Fig. 10. (Table 24). It was clear that TDS concentration enhanced the species from 5.8 (180 mg/L TDS) to over 15.6 % in 276 mg/L TDS during the winter season.

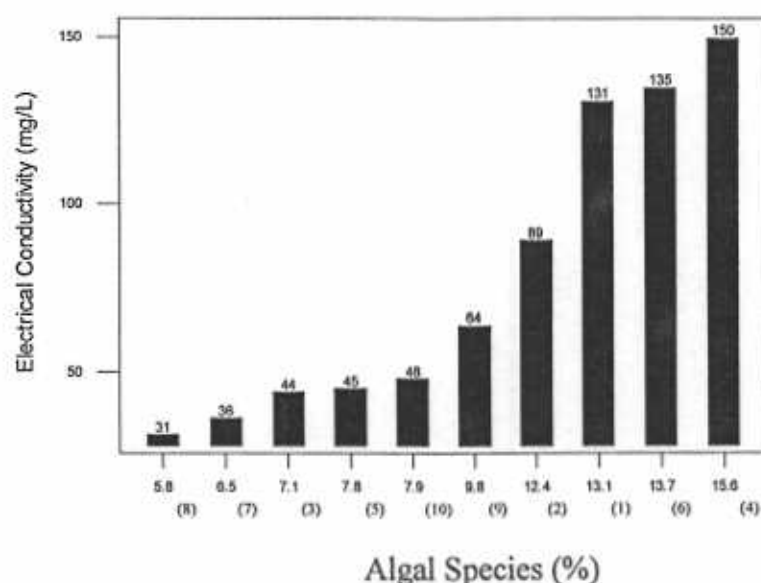


Fig. 11. The algal species (%) as affected by electrical conductivity (EC) in 10 sites during winter aspect.

Table 25. Regression analysis for algal species (%) and electrical conductivity (EC).

Model: Algal species (%) = a+b Electrical Conductivity (EC)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	102.88	102.88	160.69	0.000
Error	8	5.12	0.64		
Total	9	108.00			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	4.2322	0.5186	8.16	0.000
EC	1	0.074228	0.005856	12.68	0.000

The linear regression analysis revealed a significant (F-Value 160.69) co-relation between algal species (%) and electrical conductivity (mg/L). Fig. 11 also signifies the same relation between the two parameters (Table 25). It was clear that with increase in the EC, the number of species also enhanced from 5.8 (31 mg/L EC) to over 15.6 % in 150 mg/L EC during the winter season.

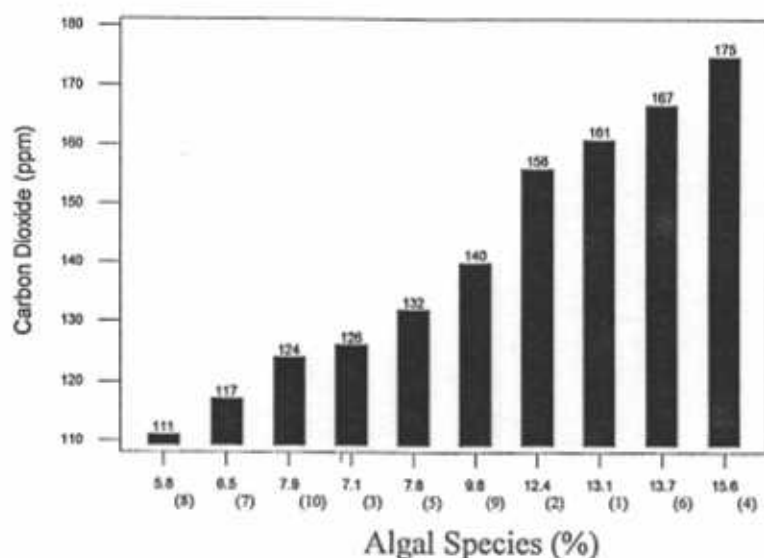


Fig. 12. The algal species (%) as affected by carbon dioxide (CO₂) in 10 sites during winter aspect.

Table 26. Regression analysis for algal species (%) and carbon dioxide (CO₂).

Model: Algal species (%) = a+b Carbon Dioxide (CO ₂)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	106.28	106.28	493.09	0.000
Error	8	1.72	0.22		
Total	9	108.00			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	-11.6141	0.9830	-11.81	0.000
CO ₂	1	0.153187	0.006899	22.21	0.000

The correlation between algal species (%) and carbon dioxide (ppm) proved to be significant (F-Value 493.09), which is also depicted by Fig. 12 (Table 26). It was concluded that increase in the CO₂ enhanced the number of species from 5.8 (111 ppm CO₂) to over 15.6 % in 175 ppm CO₂ during the winter season.

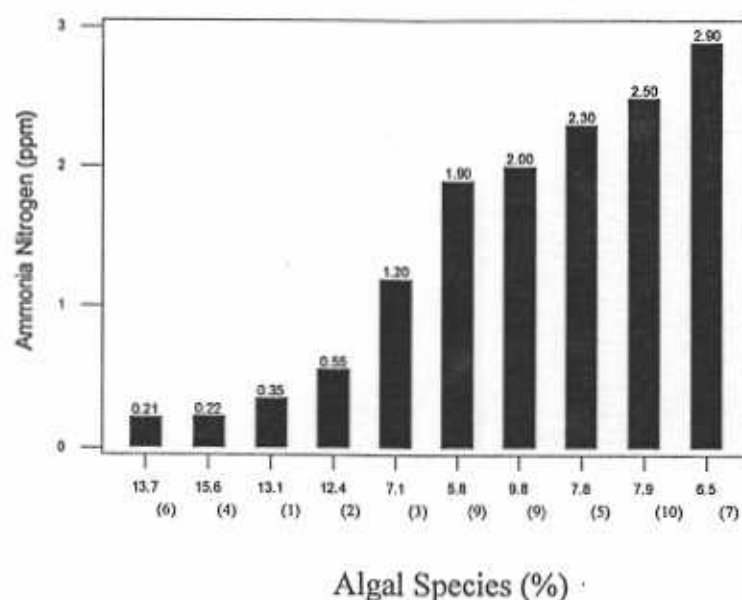


Fig. 13. The algal species (%) as affected by ammonia nitrogen (NH_3N_2) in 10 sites during winter aspect.

Table 27. Regression analysis for algal species (%) and ammonia nitrogen (NH_3N_2).

Model: Algal species (%) = a+b Ammonia Nitrogen (NH_3N_2)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	79.070	79.070	21.86	0.002
Error	8	28.931	3.616		
Total	9	108.001			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	14.035	1.057	13.28	0.000
NH_3N_2	1	-2.8772	0.6153	-4.68	0.002

The co-relationship between algal species (%) and ammonia nitrogen (ppm) appeared to be highly significant (F-Value 21.86). The same is evident from Fig. 13 (Table 27). The number of species enhanced from 13.7 (0.21 ppm NH_3N_2) to over 6.5 % in 2.90 ppm NH_3N_2 during the winter season.

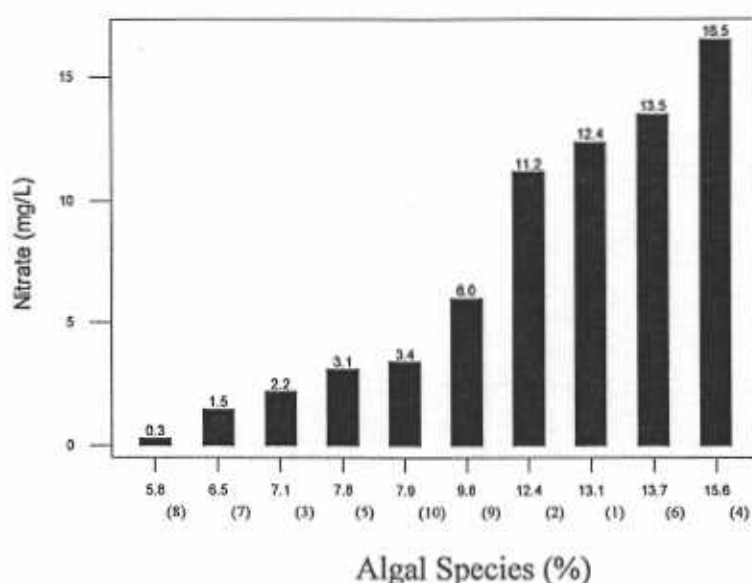


Fig. 14. The algal species (%) as affected by nitrate (NO_3) in 10 sites during winter aspect.

Table 28. Regression analysis for algal species (%) and nitrate (NO_3).

Model: Algal species (%) = a+b Nitrate (NO_3)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	107.69	107.69	2776.52	0.000
Error	8	0.31	0.04		
Total	9	108.00			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	5.8158	0.1005	57.89	0.000
NO_3	1	0.59261	0.001125	52.69	0.000

Algal species (%) and nitrate (mg/L) were significant by (F-Value 2776.52) correlated as is also clear from Fig 14. (Table 28). It was inferred that in increase in NO_3 also enhanced the number of species from 5.8 (0.3 mg/L NO_3) to over 15.6 % in 16.5 mg/L NO_3 during the winter season.

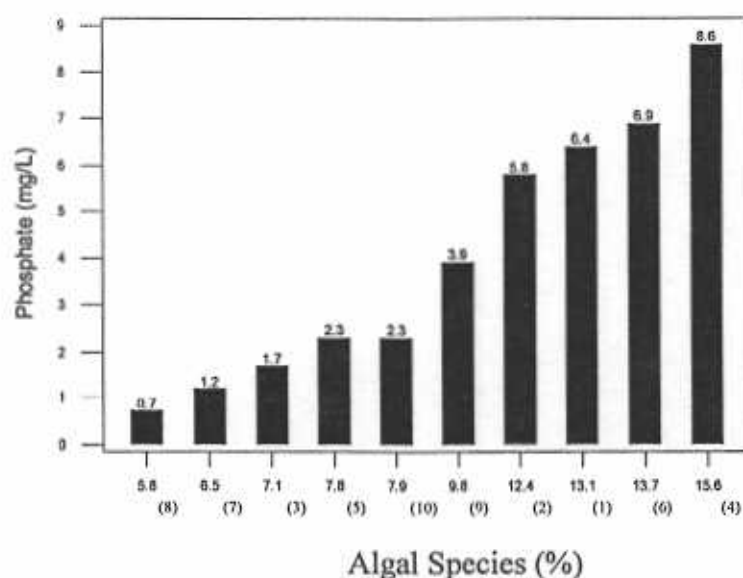


Fig. 15. The algal species (%) as affected by phosphate (PO_4) in 10 sites during winter aspect.

Table 29. Regression analysis for algal species (%) and phosphate (PO_4).

Model: Algal species (%) = a+b Phosphate (PO_4)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	107.93	107.93	11398.76	0.000
Error	8	0.08	0.01		
Total	9	108.00			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H_0	Prob. > t
Constant	1	4.96974	0.056604	88.68	0.000
PO_4	1	1.25635	0.01177	106.76	0.000

The regression analysis showed that correlation between species (%) and phosphate (mg/L) was significant (F-Value 11398.76) same is presented by Fig. 15 (Table 29). The number of species enhanced from 5.8 (0.7 mg/L PO_4) to over 15.6 % in 8.6 mg/L PO_4 during the winter season.

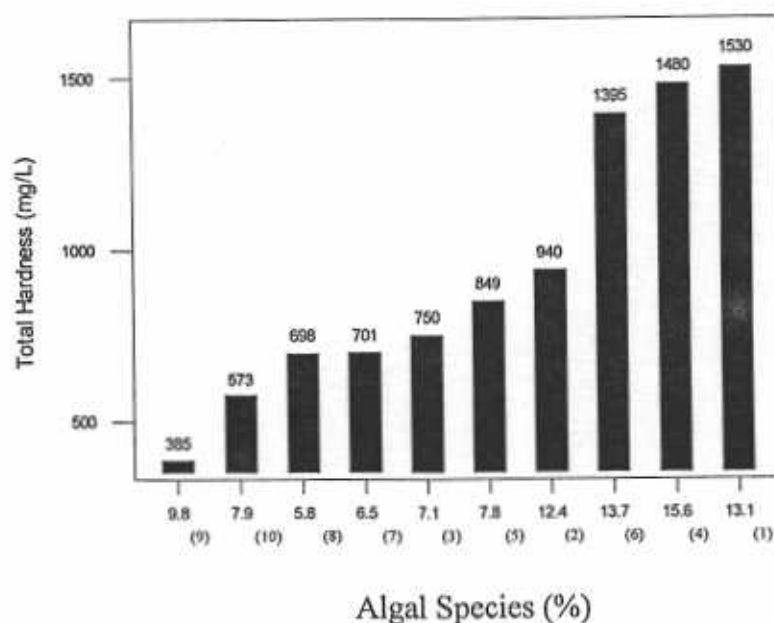


Fig. 16. The algal species (%) as affected by total hardness (TH) in 10 sites during winter aspect.

Table 30. Regression analysis for algal species (%) and total hardness (TH).

Model: Algal species (%) = a+b Total Hardness (TH)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	69.303	69.303	14.33	0.005
Error	8	38.698	4.837		
Total	9	108.001			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	3.537	1.836	1.93	0.090
PO ₄	1	0.006917	0.001827	3.79	0.005

The results of linear regression analysis revealed significant (F-Value 14.33) correlation between species number (%) and total hardness (mg/L) was shown by Fig. 16. (Table 30). The number of species enhanced from 9.8 (335 mg/L TH) to over 13.1 % in 1530 mg/L TH during the winter season.

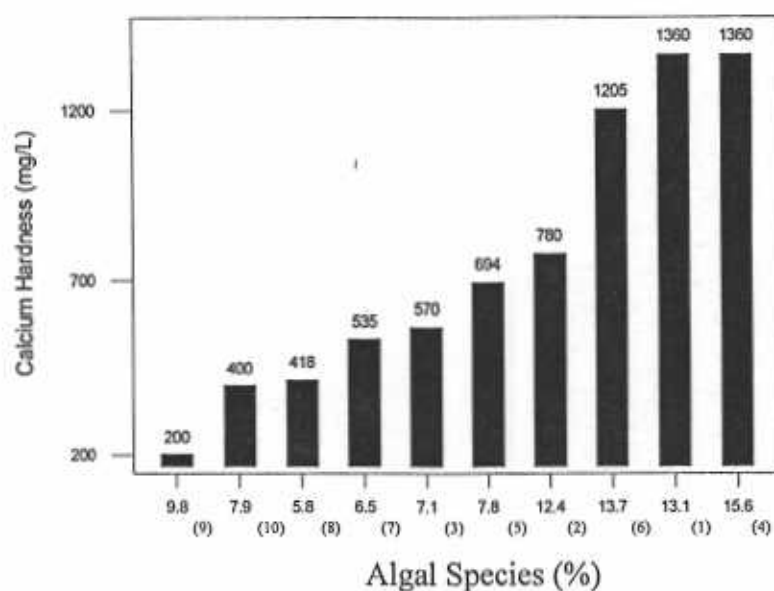


Fig. 17. The algal species (%) as affected by Calcium hardness (CaH) in 10 sites during winter aspect.

Table 31. Regression Analysis for algal species (%) and calcium hardness (CaH).

Model: Algal species (%) = a+b Calcium Hardness (CaH)					
Analysis of Variance					
Source	DF	SS	MS	F-Value	Prob.> F
Model	1	72.971	72.971	16.66	0.004
Error	8	35.030	4.379		
Total	9	108.001			
Parameter Estimates					
Predictor	DF	Estimate	Standard Error	T for H ₀	Prob. > t
Constant	1	4.840	1.420	3.41	0.009
PO ₄	1	0.006820	0.001671	4.08	0.004

The correlation between algal species (%) and calcium hardness (mg/L) was significant (F-Value 16.66). Fig. 17 also signifies the same relation (Table 31). The number of species enhanced from 9.8 (200 mg/L CaH) to over 15.6 % in 1360 mg/L CaH during the winter season.

Regression analysis

Table 32. Regression analysis for season versus site and frequency.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.308	23.654	325.14	0.000
Residual	37	2.692	0.073		
Total	39	50.000			

Regression analysis between season, site and frequency percentage of species were also performed to test the relationship between these parameters. The result (Table 32) of analysis of variance showed highly significant relationship between these parameters ($F = 325.14$).

Table 33. Regression analysis for season versus site and water temperature.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.127	23.563	303.46	0.000
Residual	37	2.873	0.078		
Total	39	50.000			

The analysis of variance (Table 33) carried out between the season, site and water temperature indicated positive relationship ($F = 303.46$) among the three parameters.

Table 34. Regression analysis for season versus site and pH.

Analysis of variance					
Source	DF	SS	MS	F	P
Regression	2	46.947	23.473	284.44	0.000
Residual	37	3.053	0.083		
Total	39	50.000			

Table 34 indicated positive relationship ($F = 284.44$) between the season, site and pH.

Table 35. Regression analysis for season versus site and turbidity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.317	23.658	326.23	0.000
Residual	37	2.683	0.073		
Total	39	50.000			

The statistical analysis indicated a close relationship between turbidity, site and season (Table 35).

Table 36. Regression analysis for season versus site and total dissolved solids.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.263	23.631	319.41	0.000
Residual	37	2.737	0.074		
Total	39	50.000			

Based on the statistical analysis it was found that there was a significant relationship between TDS, site and season (Table 36).

Table 37. Regression analysis for season versus site and total suspended solids.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.440	23.720	342.82	0.000
Residual	37	2.560	0.069		
Total	39	50.000			

Table 37 indicated a positive relationship ($F = 342.82$) among the season, site and TSS.

Table 38. Regression analysis for season versus site and electrical conductivity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.141	23.571	305.08	0.000
Residual	37	2.859	0.077		
Total	39	50.000			

Table 38 indicated a positive relationship ($F = 305.08$) between the season, site and EC.

Table 39. Regression analysis for season versus site and sodium chloride.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	46.926	23.463	282.42	0.000
Residual	37	3.074	0.083		
Total	39	50.000			

A positive relationship ($F = 282.42$) between the season, site and NaCl was obtained (Table 39).

Table 40. Regression analysis for season versus site and dissolved oxygen.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	46.905	23.452	280.33	0.000
Residual	37	3.095	0.084		
Total	39	50.000			

There was a close relationship between DO, site and season (Table 40).

Table 41. Regression analysis for season versus site and carbon dioxide.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.811	23.906	404.16	0.000
Residual	37	2.189	0.059		
Total	39	50.00			

Regression analysis between season, site and CO₂ concentration showed highly significant relationship between these parameters (F – 404.16).

Table 42. Regression analysis for season versus site and ammonia nitrogen.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.112	23.556	301.75	0.000
Residual	37	2.888	0.078		
Total	39	50.000			

Regression analysis between season, site and NH₃N₂ indicated highly significant relationship between these parameters (F – 301.75).

Table 43. Regression analysis for season versus site and nitrate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.408	23.704	338.36	0.000
Residual	37	2.592	0.070		
Total	39	50.000			

There was a close relationship between NO₃, site and season (Table 43).

Table 44. Regression analysis for season versus site and sulphate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	46.966	23.483	286.33	0.000
Residual	37	3.034	0.082		
Total	39	50.000			

A close relationship between SO_4 , site and season (Table 47) was traced statistically.

Table 45. Regression analysis for season versus site and phosphate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.077	23.539	297.99	0.000
Residual	37	2.923	0.079		
Total	39	50.000			

The result of analysis of variance showed highly significant ($F = 297.99$) relationship between season, site and PO_4 percentage of species.

Table 46. Regression analysis for season versus site and total alkalinity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.312	23.656	325.59	0.000
Residual	37	2.688	0.073		
Total	39	50.000			

The analysis of variance (Table 46) carried out between the season, site and TA indicated positive relationship ($F = 325.59$) among the above mentioned parameters.

Table 47. Regression analysis for season versus site and total hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.080	23.540	298.25	0.000
Residual	37	2.920	0.079		
Total	39	50.000			

The analysis of variance (Table 47) between the season, site and TH exhibited positive relationship ($F = 298.25$) among the parameters.

Table 48. Regression analysis for season versus site and calcium hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	46.938	23.469	283.63	0.000
Residual	37	3.062	0.083		
Total	39	50.000			

Table 48 showed highly significant ($F = 283.63$) relationship between season, site and CAH.

Table 49. Regression analysis for season versus site and magnesium hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.447	23.724	343.87	0.000
Residual	37	2.553	0.069		
Total	39	50.000			

Season, site and MgH were significant by relation ($F = 343.87$) to each other (Table 49).

Table 50. Regression analysis for season versus site and biochemical oxygen demand.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	47.259	23.630	319.00	0.000
Residual	37	2.741	0.074		
Total	39	50.000			

The statistical analysis showed that season, site and BOD close relationship (Table 50).

Table 51. Regression analysis for site versus season and frequency.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5039.7	2519.8	321.13	0.000
Residual	37	290.3	7.8		
Total	39	5330.0			

Table 51 indicated that site, season and frequency percentage of species were had significant ($F = 321.13$) relationship among themselves.

Table 52. Regression analysis for site versus season and total dissolved solids.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5046.4	2523.2	329.19	0.000
Residual	37	283.6	7.7		
Total	39	5330.0			

Table 52 depicts a positive relationship ($F = 329.19$) between the site, season and TDS.

Table 53. Regression analysis for site versus season and water temperature.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5000.4	2500.2	280.69	0.000
Residual	37	329.6	8.9		
Total	39	5330.0			

There exists a close relationship between water temperature, site and season (Table 53).

Table 54. Regression analysis for site versus season and pH.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5010.0	2505.0	289.62	0.000
Residual	37	320.0	8.6		
Total	39	5330.0			

The site, season and pH were significant by ($F = 289.62$) relation to each other.

Table 55. Regression analysis for site versus season and turbidity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5067.3	2533.6	356.81	0.000
Residual	37	262.7	7.1		
Total	39	5330.0			

The site, season and Tu positive correlation ($F = 356.81$) among themselves (Table 55).

Table 56. Regression analysis for site versus season and total dissolved solids.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5046.4	2523.2	329.19	0.000
Residual	37	283.6	7.7		
Total	39	5330.0			

A close relationship between TDS, site and season (Table 59) was achieved.

Table 57. Regression analysis for site versus season and total suspended solids.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5078.9	2539.5	374.22	0.000
Residual	37	251.1	6.8		
Total	39	5330.0			

Site, season and TSS were highly significant ($F = 374.22$) relation to each other (Table 57).

Table 58. Regression analysis for site versus season and electrical conductivity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5028.7	2514.3	308.75	0.000
Residual	37	301.3	8.1		
Total	39	5330.0			

The site, season and EC were positively correlated ($F = 308.75$) among themselves (Table 58).

Table 59. Regression analysis for site versus season and sodium chloride.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5003.0	2501.5	283.06	0.000
Residual	37	327.0	8.8		
Total	39	5330.0			

The statistical analysis carried out between the site, season and NaCl gave relation between these parameters (Table 59).

Table 60. Regression analysis for site versus season and dissolved oxygen.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5001.9	2501.0	282.06	0.000
Residual	37	328.1	8.9		
Total	39	5330.0			

Site, season and DO were significantly ($F = 282.06$) relationship correlated among themselves (Table 60).

Table 61. Regression analysis for site versus season and carbon dioxide.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5113.5	2556.7	436.86	0.000
Residual	37	216.5	5.9		
Total	39	5330.0			

The site, season and CO_2 had positive correlation ($F = 436.86$) among themselves (Table 61).

Table 62. Regression analysis for site versus season and ammonia nitrogen.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5026.0	2513.0	305.90	0.000
Residual	37	304.0	8.2		
Total	39	5330.0			

There was a close relationship between NH_3N_2 , site and season (Table 62).

Table 63. Regression analysis for site versus season and nitrate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5075.4	2537.7	368.83	0.000
Residual	37	254.6	6.9		
Total	39	5330.0			

Regression analysis between site, season and NO_3 resulted in highly significant ($F = 368.83$) relationship between these parameters (Table 63).

Table 64. Regression analysis for site versus season and sulphate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5006.3	2503.1	286.09	0.000
Residual	37	323.7	8.7		
Total	39	5330.0			

Table 64 showed that site, season and SO_4 had positive relationship ($F = 286.09$) among themselves.

Table 65. Regression analysis for site versus season and phosphate.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5011.9	2506.0	291.52	0.000
Residual	37	318.1	8.6		
Total	39	5330.0			

The statistical analysis suggested relationship between PO_4 , site and season (Table 65).

Table 66. Regression analysis for site versus season and total alkalinity.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5034.3	2517.2	314.97	0.000
Residual	37	295.7	8.0		
Total	39	5330.0			

The result of analysis of variance (Table 66) points out a significant (F – 314.97) relationship between these parameters.

Table 67. Regression analysis for site versus season and total hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5054.0	2527.0	338.72	0.000
Residual	37	276.0	7.5		
Total	39	5330.0			

Table 67 indicated positive relationship (F – 338.72) among site, season and TH.

Table 68. Regression analysis for site versus season and calcium hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5033.2	2516.6	313.67	0.000
Residual	37	296.8	8.0		
Total	39	5330.0			

There was a statistically sound correlation between site, season and CAH (Table 68).

Table 69. Regression analysis for site versus season and magnesium hardness.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	5050.0	2525.0	333.71	0.000
Residual	37	280.0	7.6		
Total	39	5330.0			

Site, season and MgH were statistically ($F = 333.71$) correlated with each other (Table 69).

Table: 70 Regression analysis site versus season and biochemical oxygen demand.

Analysis of Variance					
Source	DF	SS	MS	F	P
Regression	2	8037.0	2518.5	318.03	0.000
Residual	37	293.0	7.9		
Total	39	5330.0			

Table 70 indicated positive relationship ($F = 318.03$) between the site, season and BOD.

Discussion

A total of 239 species, 68 genera, belonging to Cyanophyceae, Chlorophyceae, Bacillariophyceae, Xanthophyceae and Euglenophyceae were recorded from 10 sites of Peshawar Valley in four seasons i.e. spring, summer, autumn and winter. Chlorophyceae was represented by 94 species and Cyanophyceae by 42 species in the present study. Anjum *et al.* (1985) reported 30 species of Cyanophyceae including those reported by the present study and this agrees with our findings. In our case Chlorophyceae was the most dominant class as the investigated sites were mostly unpolluted. Cyanophyceae was the most dominant class in polluted sites. *Oscillatoria* was the most represented genus in the present case. The present results agree with those of Anjum and Hussain regarding the class Cyanophyceae as the genera and species are the same but this study reported high number of Cyanophyceae than Anjum *et al.* (1982, 1985). Xanthophyceae was represented with only one species. However, Chlorophyceae recorded the highest number of species in investigated sites that disagrees with the findings of Anjum *et al.* (1982, 1985) who mostly worked on polluted habitats. This disparity is primarily due to water quality. The findings also agree with Sarim (1989, 1990) who reported four species of genus *Phacus*: *P. logicauda*, *P. pseudoirenkoe*, *P. anacoelus*, *P. birgei* and 4 species of *Mougeotia* from Peshawar Valley. The same species of *Mougeotia* and *Phacus* were recorded in present study and this agrees with the result of Sarim (1989, 1990). Sarim and Faridi (1976, 1990) described 47 species of *Closterium* from Peshawar valley whereas the present study recorded only 10 species of *Closterium*. The reason for low species number attributed to difference in the selection of sites and quality of water. Sarim (1990) reported more species of *Closterium* from different localities of the valley. He stressed only one genus and in our case we determined the entire algal diversity in four seasons. However species such as *Closterium ehrenbergae*, *C. lanceolatum*, *C. littorale* and *C. turgidum* were not reported by him and this is in addition to the flora. Ara and Faridi (1978) recorded 36 species of genus *Spirogyra* from Peshawar valley and the present study also listed more species compared to them. Siddiqui and Faridi (1964) recorded 102 species of *Chlorococcales* from Peshawar valley but in the investigation recorded only 22 species of *Chlorococcales*.

this observed low species numbers do not correspond with the results of Siddiqui and Faridi (1964) which was specific to *Chlorococcales*. The variation in localities could be one of the reasons for poor number of species. Khan and Faridi (1977) recorted 14 species of *Zygnema* whereas this study reports only species: *Zygnema sterile*. The possible reason could be the nature of water body. *Zygnema* is more favoured by stagnant water while the investigated sites were running water bodies. Salim and Khan (1965) listed 102 species of fresh water diatoms from Peshawar Valley while the present study envisaged 86 species of diatoms which shows close parallelism with them. The present findings also agree with those of Nawaz and Sarim (2004) who reported many genera which were recorded in present case. Ahmed (1988) stated that Chlorophyceae was the dominant class followed by Bacillariophyceae and Cyanophyceae during autumn and this pattern fairly agrees with our findings. Similar results were reported by Begum (1995) who stated that Chlorophyceae was the major class followed by Cyanophyceae, Bacillariophyceae and Xanthophyceae in her studies *Spirogyra* was recorded as the dominant genus represented by 13 species and same is true in our case. The present findings are further strengthened by Mahmood (2001) who observed that Chlorophyceae, represented by 41 species, was the most prevalent class. However Xanthophyceae and Euglenophyceae recorded in this case were not reported by Mahmood (2001). Ghulam (2002) also observed that Chlorophyceae was dominant class from District Charsadda in spring and summer season and our results agree with her in this record. The results regarding distribution of Chlorophyceae and other classes also are in line with Taskeen (2002). In most cases, less number of species have been reported in this case as compared to other researcher who worked on the taxonomy of algae in Peshawar Valley. This could be due to the reasons that different locations of the valley were investigated. The ecology of water body differed in various sites such as Mardan site # 7 or there might by presence of various poisonous chemicals present in the water as in Rashakai Mardan. Mostly, other researchers stressed on the taxonomy of some group while our investigation centered around ecology of water body in relation to algal distribution.

In spring, there were 54 genera with 116 species (Table 3). The class Chlorophyceae was dominant, followed by Bacillariophyceae, Cyanophyceae,

Xanthophyceae and Euglenophyceae. The Results are similar to Ali and Quershi (1979), who observed 31 genera with 73 species were recorded from Rawalpindi district whereas Bacillariophyceae were more than the other algae. These results agree with Hussain *et al.* (1984) who reported 39 genera and 89 species from Hanna-Urak Valley, near Quetta, Baluchistan where Bacillariophyceae was dominant including 36 species. In autumn, 52 genera with 126 species were recorded (Table 9). The species of Chlorophyceae and Bacillariophyceae were equal in number. Results agree with those of Leghari *et al.* (2003) who reported similar species both for Chlorophyceae and Bacillariophyceae from Kallar Kahar, Chakwal. It appears that the difference in number of species and genera were mainly due to changing climatic factors such as temperature, rain fall, humidity and light etc. The number of species of various classes increased or decreased with the increasing or decreasing of temperature. The number of species of Chlorophyceae increased during the spring and autumn season because of suitable temperature while in summer season due to high temperature and low temperature in winter was seems to be favorable for the growth of Bacillariophyceae and Chlorophyceae. The findings are in line with Zaman and Sarim (2005) who reported 89 species of fresh water algae from district Charsadda.

In the present study, the physical and chemical characteristics of water bodies in four seasons were investigated. The range of water temperature varied from 10 °C (cold) - 31 °C (hottest) in various seasons. Temperature usually controls the distribution of algae. High temperature of water surface helps in dissolving the organic and inorganic minerals. Results are similar to that of Leghari (2003) who stated that photosynthetic rate of algae increases with increase of temperature. Increase in pH indicates increase in inorganic matter. The pH of water samples varied from 7.21 – 8.55 and was more or less alkaline in nature. In the present study, the investigated sites such as Jabba Daud Zai sites 1 and 2, Harichand, Gendai Bridge, Adina, Aza Khel and Pabbi which had pH value between 7.8 to 8.5 and these sites had high number of species as compared to other sites. Nishat (1998) similarly reported the effect of pH on some algae. She observed that suitable pH favour the growth and also stated that cell division get retarded in low pH. The results also

strengthened Moss (1973) who observed that low pH is harmful for the growth of desmids while high level of pH accelerates their growth. The present findings are further supported by Gough (1977) who observed that *Closterium* and *Cosmarium* were favoured by suitable pH.

Total dissolved solids of water affects the growth and distribution of algae. The present investigation indicated that the level of TDS was quite suitable for the growth and distribution of algae. In the present study, the same relationship was observed as with increase in TDS, algal species increased. TSS shows the ratio of total suspended solids in water. The higher value of total suspended solids indicates the high concentration of non living particulates originate as catchments, derived salts, clay, mud, organic matter etc are present in the water. It increase turbidity of water. Rashakai Mardan had lesser number of species in present study in autumn season which might be attributed to presence of high total suspended solids value (902 mg/L). High turbidity decreases light penetration and oxygenation. This causes decreased species growth and population. EC (15 – 155 ds m^{-1}) shows soluble salts in water body. The optimum amount of EC favours the growth and distribution of algal species. In summer season, the high value of EC along with high temperature might have been harmful for many species. Although, in the study there was positive correlation between EC and algal species %age in winter while in spring and autumn there were weak correlation between EC and number of species whereas EC in spring and autumn was nearly equal to the EC of winter season. Results correspond with those of Leghari *et al.* (2005) who studied and compared conductivity of fresh water with marine water in relation with algal flora. It was observed that fresh water had 45 species with optimum conductivity in comparison to marine water which has 9 species with high conductivity. The salinity (NaCl) of summer season was high which varied from (1.3 – 4.5 mg/L) as compared to other seasons which was not suitable for the number of species. That is why, there were lesser number of species in the summer than other seasons. The results are similar to those of Heimanns (1969) who observed that small amount of NaCl promote the growth of algae while high value cause growth retardation. The result was further supported by Lealand *et al.* (2001) who concluded that interaction between salinity and nitrogen affected the structure of

benthic algae communities and same was true in the present case. The increasing CO_2 (110 – 186 ppm), NH_3N_2 (0.17 – 3.7 ppm), nitrate (0.2 – 16.5 mg/L), phosphate (0.4 – 17 mg/L) and calcium hardness (42 – 1360) increased the number of algal species. Leghari (2002, 2005) also concluded that high CO_2 content, nitrates, phosphates and calcium hardness generally enhanced the algal species and support the present findings. Goldman and Horn (1983) and Reynolds (1984) also stated that the presence of calcium, carbon, oxygen, nitrogen and phosphorus were essential in fresh water for the growth of plants. All those sites which had optimum level of nutrients supported high number of species. Generally, the results are also similar to those of Bolas and Lund (1974) who observed that there was a relationship between high phosphate contents and algal growth. The present findings also are inline with Kalin *et al.* (2001) who observed that there was direct relation between water variables and phytoplankton community structure and that of total phosphorus and arsenic contents. Bernhart *et al.* (2004) further give support to the present findings that algal biomass rarely responded positively to enrichment with nitrogen and phosphorus. In the present study, the amount of SO_4 were higher in spring (162 mg/L), in autumn (106 mg/L) and winter (103 mg/L) as compared to summer season which is low (68 mg/L). The number of species were generally affected due to the presence of high content of SO_4 . The cause of less number of species in summer season was perhaps may be due to the low value of sulphates and high temperature. Similarly, Sarim and Ali (1986) observed the low sulphates promoted the growth of algae. A negative correlation between BOD and algal species was achieved in present study. The BOD value in all the investigated sites during spring, summer, autumn and winter seasons were varied from 20 – 71 NTU, 14 – 93 NTU, 15 – 55 NTU and 18 – 70 NTU respectively. The number of species were in high in autumn because of low level of BOD while the number of species in summer season were in low because of high level of BOD. High BOD indicates poor oxygen in the water. Similarly oxygen decreases with high temperature.

The present study showed the water quality differed among the sites and seasons. The water bodies located at Jabba Daud Zai 1, Harichand, Jendai Bridge, Adina, Rashakai and Pabbi were deep with fast running and perennial water which

had supported more species of Chlorophyceae than sites like Jabba Daud Zai 2, Yar Hussain, Umara Khan and Aza Khel sites had shallow slow running and seasonal water. Some sites such as Jabba Daud Zai 1, Harichand, Adina and Pabbi were located near to settlements that were polluted because they received domestic refuses. In such sites Cyanophyceae and Bacillariophyceae were more prevalent. In sites like Umara Khan and Rashakai Mardan had less number of species probably due to the cemented floor of the water body. All water body that received polluted and poisonous influents discharges from industries were high polluted and had high number of Cyanophyceae with generally low species diversity.

Chlorophyceae was the most dominant class in the study because it the largest class of algae, generally found in a fresh water, widely distributed and occur practically every where provided found light and moisture are available. The main reason of the dominancy of green algae could be the optimum temperature, high CO_2 value, NO_3 , total hardness and calcium hardness that agree with findings of Leghari *et al.* (2002, 2003). Bacillariophyceae was next well represented class. The majority of species reported in this class are capable of growing in variety of habitats, both in fresh and salt waters and even on damp surface to planktonic conditions. The results also similar with Leghari *et. al* (2004) who stated that low salinity and low temperature provide the chances for the growth of Bacillariophyceae. The findings were further strengthened by Pandey (1969) having the same results like me. Cyanophyceae was next to Bacillariophyceae in the present findings and generally found in polluted water. The results agree with Legahri *et. al* (2005) and Pandey (1969) who stated that blue green algae were dominant in summer and polluted water. The findings further strengthened by Anjum and Hussain (1985) who reported 30 species of Cyanophyceae from polluted ponds of Yar Hussain. Xanthophyceae was the least represented class of my study and even absent in winter season which agree with Allore (1930) proposed that unlike other classes, Xanthophyceae was not well studied and therefore, the class is characterized only on the basis of chromoplast pigmentation, flagellation and reserve food material. Like Xanthophyceae, Euglenophyceae was generally the least class of my present study because it is usually found in fresh water forms often producing water bloom in ponds, pools and

lakes. The species like *Oscillatoria animalis*, *Oscillatoria formosa*, *Oscillatoria princeps*, *Oscillatoria tenuis*, *Achnanthes minutissima*, *Fragilaria capucina*, *Navicula cryptocephala* and *Synedra ulna* present in the water body indicate that the water is polluted and can not be used for drinking purposes.

General Conclusions

The present study spread over 2 years sampling of algae and water samples in four different seasons in Peshawar Valley. Based on the present findings following general conclusions and recommendations could be drawn:

1. There were 239 species in all that belonged to Cyanophyceae (42 species, 12 genera), Chlorophyceae (94 species, 32 genera), Bacillariophyceae (86 species, 19 genera), Xanthophyceae (6 species, 3 genera) and Euglenophyceae (11 species, 2 genera).
2. Seasonal distribution showed that autumn season had the maximum number of species while summer the least.
3. Chlorophyceae appeared to be the most represented class and Xanthophyceae as the least represented.
4. Genera *Spirogyra* (12 species) and *Navicula* (12 species) were the most recorded during summer and autumn seasons respectively.
5. All the classes were present in all the investigated seasons except Xanthophyceae which was absent during winter season.
6. Majority of species like *Oscillatoria animalis*, *Oscillatoria formosa*, *Oscillatoria princeps*, *Oscillatoria tenuis*, *Merismopedia punctata*, *Basicladia crassa*, *Spirogyra setiformis*, *Ulothrix zonata*, *Achnanthes minutissima*, *Amphora ovalis*, *Cocconeis placentula*, *Cymatopleura solea*, *Cymbella ventricosa*, *Diatoma anceps*, *Fragilaria capucina*, *Gomphonema olivaceum*, *Gyrosigma scalproides*, *Navicula cryptocephala*, *Navicula protracta*, *Navicula radiosa*, *Nitzschia vermicularis*, *Synedra ulna* and *Euglena acus* were highly distributed as they were placed in constancy class V and IV.
7. Water analysis indicated that there were significant differences in species and some parameters such as temperature, turbidity, total suspended solids and magnesium hardness etc in different seasons.
8. pH, almost remained similar through out the year.
9. TDS, DO, PO₄, TSS, NH₃N₂, magnesium hardness parameters had high concentration in autumn season than other seasons.

10. Correlation analysis indicated that there was positive relationship of algal species % with increasing levels of TDS, NH_3N_2 , EC, CO_2 , NO_3 , PO_4 , total hardness and calcium hardness.
11. There was negative correlation between BOD and NaCl with algal species.
12. The type of water body i.e. running, polluted and depth affected the algal flora and quality of water.
13. The over all water quality appeared to be basic, nutrient rich at Jabba Daud Zai -1, Jabba Daud Zai -2, Harichand -3, Gendai Bridge -4, Yar Hussain -5, Adina -6, Aza Khel -9, Pabbi -10 and nutrient poor at Umara Khan -7 & Rashakai Mardan.
14. The type of species varied with the seasonal aspect with in the valley. Secondly, the chemical physical features influenced the quality of water that in governed the distribution of species.

General Recommendations

1. Further study is needed to explore the autecology of some algae that could be used a food for fishes, nitrogen fixer or having some ecological importance.
2. Although frequency distribution of species was determined, yet there is need to determine productivity of algae of these water bodies at primary and secondary level.
3. There is need to explore algal food chain for better understanding of energy flow in these aquatic ecosystem.
4. Similar study are needed to be expanded to other water bodies in the Valley that could not envisaged due to shortage of time.
5. Soil around the water bodies be analyzed for further explanation as these factors affect the quality of water bodies that affect algae.
6. Some important algae should be analyzed for there chemical nature.
7. Relationship of algal species community among one another should be worked out.

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APPENDIX

Systematic Account of plants

Genus: *Oscillatoria* Vaucher 1803

Trichomes unbranched, cylindric, without evident sheaths or amorphous jelly, solitary or in floccose masses, straight or variously curved and contorted, sometimes apically narrowed, terminal cell rounded or calyptrate; cell contents homogeneous or granular, color variable; plants often exhibiting oscillating or gliding movements; end cells often obscure in fragmented material.

Key to the Species

1. Diameter of cells 4-6 μm -----*O. agardhii*
1. Diameter of cells 9-10 μm -----*O. ornata*
1. Diameter of cells 10-20 μm -----*O. sancta*
 2. Cell diameter 10-17 μm -----*O. curviceps*
 2. Cells diameter 16-60 μm -----*O. princeps*
3. Trichomes 4-10 μm broad- ----- *O. tenuis*
3. Trichomes 3-4 μm broad -----*O. animalis*
 4. Apical cell with thickened outermembrane-----*O. limosa*
5. End cell conical -----*O. formosa*

Description of the Species

Oscillatoria animalis C.A. Agardh

Tiffany and Britton. 1952, P. 346, Pl 93, Fig. 1079.

Cells 3-4 $\times$ 1.5-5.0 μm , not granulate at cross-walls; trichomes straight, not constricted at cross-walls, tapering and somewhat bent at the apex, end cell acutely rounded, forming blue-green aggregates.

Local Distribution.

Sites – 2, 4, 8, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

O. curviceps Agard

Prescott, 1951, P. 487, Pl. 108, Figs. 17, 18.

Cells 10-17 μm in diameter, 3-5 μm long; trichomes forming an expanded

blue-green plant mass; straight for at last a portion of their length, twisted and much entangled, scarcely tapering to the apex, apical cells broadly rounded, not capitate, without a calyptra.

Local Distribution.

Sites – 1, 5, 6, 8, Spring, 2004.

***O. formosa* Boy**

Tiffany and Britton, 1952, P. 346, Pl. 94, Fig. 1084.

Desikachary, 1959, P. 232, Pl. 40, Fig. 15

Prescott, 1951, P. 487, Pl. 109, Fig. 10, 11.

Cells nearly quadrate, upto $\frac{1}{2}$ as long as broad, 2.5-5 μm long; thallus blue-green; trichome straight, slightly constricted at the across walls, 4-6 μm broad, bright blue-green, attenuated at the ends and bent; sometimes slightly granulated; end cells nearly obtuse, calyptra absent not capitate.

Local Distribution.

Sites – 2, 3, 5, 6, 7, 8, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

***O. sancta* (Kuetzing) Gomont**

Tiffany and Britton. 1952, P. 342, Pl. 93, Fig. 1078.

Cells 10-20 x 2.5-6.0 μm , granulate at cross-wall, with half-rounded, slight capitate end cells with thick outer membrane; trichomes straight or twisted, slightly constricted at cross-walls, slightly narrowed apically, deep blue-green to dirty olive-green; masses steel-blue, shiny, thin, slimy.

Local Distribution.

Sites – 2, 4, 5, 9, 10, Summer, Autumn, Winter 2004 – 2005.

***O. agardhii* Gomont**

Tiffany and Britton. 1952, P. 346, Pl. 94, Fig. 1082.

Cells 4-6 x 2.5 -4.9 μm , coarsely granulate, with pseudovacuoles; trichomes straight or somewhat bent, not constricted at cross-walls, gradually tapering at the apex, free-floating or forming blue-green masses in water or on very moist soil; cross-

wall granulate; end cell convex to broadly rounded, sometimes acute, often capitate, with convex calyptra.

Local Distribution.

Site – 10, Autumn 2004.

***O. limosa* C.A. Agard**

Tiffany and Britton, 1952, P. 342, Pl. 93, Fig. 1076.

Desikachary, 1959, P. 206, Pl. 42, Fig. 11

Anjum, 1981, P. 83, 84, Pl. 12, Fig. 30.

Cells 11-22 x 2-5 μ m, granulate at cross-walls; trichomes usually straight, dark blue-green to brown or olive-green, not constricted at cross-walls, with broadly rounded end cells, with slightly thickened outer membrane, becoming blackish blue-green to brown in aggregates.

Local Distribution.

Site – 6, Winter 2005.

***O. minnesotensis* Tilden**

Desikachary, 1959 P. 225, Pl. 40, Fig. 19

Cells 2-4 μ m in length; thallus thin, dark blue-green; trichome 2-5 μ m broad, more or less curvedl especially constricted at the joints, apex of the trichome straight, or slightly bent, neither tapering nor capitate; apical cell round and calyptra none.

Local Distribution.

Site – 7, Winter 2005.

***O. ornata* Kuetzing**

Tiffany and Britton. 1952, P. 342, Pl. 93, Fig. 1077.

Cells 9-11 x 2-5 μ m, end cell rounded, not capitate and without calyptra; trichomes apically twisted, constricted at cross-walls, deeply blue-green, becoming very dark blue-green to blackish green in aggregahates.

Local Distribution

Site – 1, 2, 10, Spring, Summer 2004.

***O. tenuis* Agardh**

Desikachary, 1959, P. 222, Pl. 42, Fig. 15.

Anjum, 1981, P. 90, Pl. 19, Fig. 225.

Cells 4-10 x 2.5-5 μ m; constricted at the cross-walls; sometimes only slightly of which are granular, trichomes aggregated to form a blue-green mass, sometimes becoming scattered and appearing singly among other algae; apical cell convex, smooth and not capitate; outer membrane sometimes slightly thickened.

Local Distribution.

Sites – 1, 2, 5, 8, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

***O. princeps* Vaucher**

Tiffany and Britton, 1952, P. 334, Pl. 93, Fig. 1080.

Desikachary, 1959, P. 210, Pl. 37, Figs. 1, 10.

Cells 332-80 μ m in diameter; 4-8.7 μ m long, not constricted at the cross-walls, which are not granular; cell contents densely granular; trichomes solitary or loosely entangled to form small floating plant masses, black green in colour, trichomes very slightly and briefly tapering at the apex; apical cell usually not capitate sometimes very slightly so, the outer membrane broadly and smooth.

Local Distribution.

Sites – 1, 3, 5, 6, 8, 9, Spring, Summer, Autumn, Winter, 2004 – 2005.

Genus: *Gomphospharia* Kuetzing 1836

A globose or ovate colony of globular or pyriform cells arranged singly or in pairs at the ends of gelatinous strands which radiate from a common center, the cells at the periphery of a colorless, mucilaginous envelope; individual sheaths of the cells usually confluent. Cells lie side by side in pairs for some time. The division is accompanied by a forking of the stalk at base of cell, which thus forms the radiating branched stalks of the colony. The cells, especially in some species, appear heart-shaped because fission begins at the outer, free pole of the cell, whereas division of the attached end of the cell is delayed.

Key to the Species

1. Cells 4-12 μm in diameter pyriform or cordate -----*G. aponina*
1. Cells 1.5-2.4 μm in diameter, spherical or somewhat reniform -----*G. lacustris*

Description of the Species

Gomphospharia aponina Kuetzing

Prescott, 1951, P. 472, Pl. 106, Fig. 5.

Cells 4-5 μm in diameter, 8-12 μm long; cells pyriform, or cordate in stages of division, arranged at the periphery of a globular and usually wide gelatinous sheath, and at the ends of stout radiating, gelatinous strands.

Local Distribution.

Site – 7, Spring 2004.

G. lacustris Chodat

Prescott, 1951, P. 473. Pl. 106, Fig. 9.

Cells 1.5-2.4 μm in diameter; cells spherical or sometimes reniform, arranged in clusters of 4-8 individuals at the ends of fine gelatinous strands, clusters at some distance from one another in copious gelatinous envelopes.

Local Distribution.

Sites – 1, 5, Spring, Autumn 2004.

Genus: *Aphanocapsa* Naegeli 1848

A globular, ovate, or sometimes an amorphous mass, gelatinous and free-floating, in which spherical cells are usually widely and evenly distributed through yellowish or hyaline, homogenous colonial mucilage; individual cell sheaths not evident, cells often in pairs as a result of recent division; contents homogenous or finely granular, pale-green to bright blue-green.

Key to the Species

1. Cells mostly 2-3 μm in diameter -----*A. richteriana*
1. Cells mostly 1.5-2.5 μm in diameter -----*A. elachista*
1. Cells 4 – 5 μm in diameter -----*A. grevillei*

Description of the Species

Aphonocapsa richteriana Hieronymus

Tiffany and Britton. 1952, P. 331. Pl. 90, Fig. 1046.

Cells 2-3 μm in diameter, spherical, scattered or closely aggregated, blue-green or yellow-green, homogeneous or slightly matrix hyaline, homogeneous, forming indefinite blue-green strata on submerged sub-states.

Local Distribution.

Site – 10, Winter 2005.

A. elachista G.S. West

Prescott, 1951, P. 453, Pl. 101, Figs. 10,11.

Cells 1.6-2.0 μm in diameter; colonies ovate or globose, frequently irregular in shape up to 150 μm in diameter; cells spherical, crowded within a hyaline colonial mucilage, often with many cells in pairs,

Local Distribution.

Site – 8, Autumn 2004.

A. grevillei Rabenhorst

Prescott, 1951, P. 454, Pl. 101, Figs. 15,16.

Desikachary, 1959, P. 100, Pl. 21 Fig. 9.

Whitford and Schumacher, 1973, P. 128, Pl. 60, Fig. 23.

Shaheem, 1995, P. 18, Pl. 1, Fig. 1.

Cells 3.8 – 5.5 μm in diameter; free-floating colonies, sometimes on moist soils, spherical, irregularly shaped; cells in pairs, in groups of four and crowded, or solitary, evenly dispersed through colourless mucilage, blue-green, with pseudovacuoles; rare in the tychoplankton of several lobes.

Local Distribution.

Sites – 3, 9, Spring, Autumn 2004.

Genus: *Lyngbya* C.A. Agardh 1824

Filamentous, composed of a uniseriate, unbranched trichome of cells enclosed by a non-gelatinous, more or less firm sheath; planktonic and solitary, or aggregated, forming entangled masses on substrates or intermingled among other algae; some species spirally coiled; trichomes mostly cylindrical throughout and tapering very slightly, if at all, toward the apices, which are usually not capitate.

Key to the Species

- 1. Filaments 20-24 μm broad ----- *L. birgei*
- 1. Filaments 8-28 μm and solitary ----- *L. aestuarii*
- 1. Filaments lying parallel, forming tufts ----- *L. taylorii*
 - 2. Trichomes 2.8-3.2 x 2.0-6.5 μm ----- *L. versicolor*
 - 2. Trichomes 2-3 x 1.0-3.5 μm ----- *L. diguetii*
 - 2. Trichomes up to 200 μm long ----- *L. polysiphoniae*

Description of the Species

Lyngbya aestuarii Liebman

Prescott, 1951, P. 499, Pl. 111, Fig. 8.

Cells 2.5-5 μm in length, not constricted at the cross walls; plants aggregated, entangled, forming extensive layers on submerged substrates or upon moist earth and stones; sometimes becoming free-floating. Filaments varying greatly in diameter, 10-26 μm wide. Trichomes 8-28 μm in diameter, tapering a little at the apices, vary in shape, conical, truncate, or somewhat capitate. Sheaths firm, becoming thickened, lamellose, and discolored with age.

Local Distribution.

Site - 1, Winter 2005.

L. birgei G.M. Smith

Prescott, 1951, P. 499, Pl. 111, Fig. 9.

Cells very short and disciform, 3-7 μm long; plants solitary, planktonic, scattered among water bloom organisms; filaments straight, 18-25 μm in diameter,

with many hormogonia when aged; sheaths thick and firm, not lamellated, extending far beyond the apices of the trichomes, which are broadly rounded; trichome 20-24 μm in diameter, not constricted at the cross walls.

Local Distribution.

Site – 5, Summer 2004.

***L. taylrii* Drouet and Strickland**

Tiffany and Britton. 1952, P. 339, Pl. 92, Figs. 1063, 1069.

Cells 4-7 x 2-7 μm ; granulate; trichomes, blue-green, not apically attenuated, not constricted at cross-walls, obscurely lamellose, colorless, becoming blue with Chlorzinciodide; filaments elongate, parallel, forming extensive blue-green, penicillate and radiate tufts; generally attached, sometimes floating.

Local Distribution.

Site – 4, Autumn 2004.

***L. diguetii* Gomont**

Prescott, 1951, P. 500, Pl. 112, Fig. 8.

Cells 1.5-3.5 μm long; apical cell convex, smooth; plants solitary or entangled, sometimes forming bundles, frequently adhering to and growing out from filamentous algae which have non-mucilaginous walls; filaments up to 3.2 μm in diameter, sheaths thin; trichomes 2.5-3 μm in diameter.

Local Distribution.

Site – 1, Spring 2004.

***L. polysiphoniae* Frey**

Desikachary, 1959, P. 287, Pl. 53, Figs. 4,5.

Cells $\frac{1}{2}$ - $\frac{1}{3}$ as long as broad, cross-walls visible, not granulated; end cells convex, not capitate; filaments straight or curved, single or in bundle, epiphytic, up to 200 μm long; sheath very thin, delicate, colourless, trichome pale blue-green or violet, constricted at the cross-walls, about 2 μm broad, apices not attenuated.

Local Distribution.

Site – 5, Autumn 2004.

***L. versicolor* Gomont**

Prescott, 1951, P. 504, Pl. 113, Fig. 4.

Cells 2.8-3.4 μm in diameter; filaments 3-5 μm in diameter; plants forming a mucous expansion on submerged objects, becoming detached and floating; filaments much entangled; trichomes not tapering toward the apices and not constricted at the cross walls, which are not granular.

Local Distribution.

Sites – 2, 8, Spring, Autumn 2004.

Genus: *Phormidium* Kuetzing 1843

Trichomes unbranched, cylindric, enclosed by watery gelatinous sheathes, partially or wholly confluent, carbonate, not enclosed at the apices; plant mass aquatic, subaerial, composed of nearly parallel or densely interwoven trichomes, generally forming an extensive stratum, rarely solitary; apex various, sometimes capitate, often with calyptra.

Key to the Species

1. Cell length more than 2 μm -----*P. tenue*
1. Cell length less than 2 μm -----*P. foveolarum*
1. Cells length more than 5 μm -----*P. inundatum*
 2. Cells 5.5 -9.0 μm broad, generally aquatic -----*P. uncinatum*
 2. Cells more or less conical -----*P. fragile*
3. Trichomes 1.5-2.5 μm broad-----*P. purpurascens*

Description of the Species

Phormidium foveolarum Gomont

Tiffany and Britton. 1952, P. 348, Pl. 95, Fig. 1095.

Cells 0.8 - 2.0 μm long about, 1.5 μm broad; not granulate at cross-walls; trichomes bent or twisted, constricted, not apically narrowed, end cells rounded without calyptra; sheaths soft. Diffluent into an amorphous mucous, colorless, not blue with Chlorzinciodide; plant mass thin, dark green.

Local Distribution.

Site – 8, Spring, Summer 2004.

P. fragile (Menegh) Gomont

Desikachary, 1959, P. 253, Pl. 44, Figs. 1-30.

Fremy, 1933, P. 86, Pl. 22, Fig. 6.

Askar, 1990, P. 25, Pl. 3, Fig. 10

Akhlaq, 1994, P. 20, Pl.3, Fig. 5.

Cell 1.2 – 2.3 μm broad, cells nearly quadrate, 1.2-3 μm long; thallus mucilaginous; lamellated, yellowish or brownish blue-green, sheath diffluent trichomes more or less flexuous, entangled or nearly parallel, distinctly constricted at the cross-walls, septa not granulated at the ends, end cell acute-conical, without calyptra.

Local Distribution.

Sites – 7, 8, Spring, Summer 2004.

P. inundatum Kuetzing

Tiffany and Britton, 1952, P. 348, Pl. 95, Fig. 1100.

Naheed, 1992, P. 20, Pl. 3, Fig. 7.

Cells 3-5 $\times$ 4-8 μm ; thallus blue-green; granulate at cross walls; trichomes generally straight, not capitate, blue-green; and cells broadly conical; sheaths thin and diffluent, blue with Chlorzinciodide; plant mass membranous, blue green to blackish or brownish green.

Local Distribution.

Site – 2, 6, 8, Autumn, Winter 2004 – 2005.

P. purpurascens Gomont

Desikachary, 1959 P. 262, Pl. 44, Fig. 4 and Pl. 45, Figs. 1.4.

Cells 2-4.5 μm long; nearly quadrate or up to nearly two times longer than broad, thallus compact, leathery, purple to brownish violet; trichome strongly bent, entangled, not constricted at the cross-walls, ends not attenuated, 1.5-2.5 μm broad, dark violet; sheath more or less diffuent, not coloured violet by chloro-zinc-iodide; cross-walls marked by two granules on either side; end-cell rounded, calyptra absent.

Local Distribution.

Sites – 1, 10, Spring, Summer 2004.

P. tenue Gomont

Tiffany and Britton, 1952, P. 347, Pl. 95, Fig. 1088.

Desikachary, 1959, P. 259, pl. 43, Figs. 13-15 and Pl. 44, Figs. 7-9.

Fremy, 1972, P. 88, Pl. 23, Fig. 4.

Idris, 1982, P. 102, Pl. 3, Fig. 5.

Akhalq, 1994, P. 23, Pl. 3, Fig. 3.

Cells 2.5-5.4 μm long; up to 3 times longer than broad, thallus pale blue-green, thin, membranous, expanded; trichome, straight or slightly bent, densely entangled, slightly constricted at the cross-walls, attenuated at the ends, 1-2 μm broad, pale blue-green; sheath thin, diffuent, coloured violet by chlor-zinciodide; septa not granulated, cross-walls not commonly visible; endcell acute-conical, calyptra absent.

Local Distribution.

Site – 10, Winter 2005.

P. uncinatum Gomont

Prescott, 1951, P. 496, Pl. 107, Fig. 18.

Cells 6-9 μm in diameter, 2-6 μm long; filaments forming an expanded, thin but firm plant mass, either floating or adherent to a substrate, dark green or brownish;

trichomes straight or curved, briefly tapered at the apex which is curved; sheaths sticky, distinct finally but becoming confluent with the mucilage of the plant mass; apical cell capitate, with a round or conical calyptra; granular at the cross walls; cell contents blue-green.

Local Distribution.

Sites – 1, 2, 3, 4, 6, 8, Spring, Autumn, Winter 2004 – 2005.

Genus: *Spirulina* Turpin 1827

Trichomes unicellular or multicellular cylindrical sheath absent; loosely or tightly coiled into a more or less regular spiral; apex of trichome usually not attenuated; cross-walls if obscured; terminal cell rounded, without calyptra.

Key to the Species

1. Spirals loose 17-22 μm distant ----- *S. laxissima*
1. Spirals 1.25-2 μm away from each other ----- *S. subtilissima*

Description of the species

S. laxissima West

Prescott, 1951, P. 875, pl. 107, Fig. 17.

Desikachary, 1959, p. 196, pl. 36, Fig. 5.

Trichome 0.7 – 0.8 μm broad, blue-green, spirals very loose but regular, 4.5 – 5.3 μm broad; 17- 22 μm distant from each other, end cells rounded, obtuse.

Local Distribution

Site – 2, Spring 2004.

S. subtilissima Kuetzing

Desikachary, 1959, P. 196, Pl. 36, Fig. 10.

Trichome 0.6-0.9 μm broad, regularly spirally coiled, bright blue-green or yellowish, spirals 1.5 -2.8 μm broad, distance between the spirals 1.25 -2 μm .

Local Distribution.

Site – 2, Autumn 2004.

Genus: *Microcystis* Kuetzing 1833

Cells spherical or elongated, spherical, ellipsoidal or irregularly overlapping or not like colony, free-swimming, often with attached daughter colonies; cells in homogenous colourless, often diffuent, mucilage, individual envelopes absent; cells mostly very densely arranged, cell-division in all directions, generally transverse in elongate cells; gas-vacuoles often present.

Key to the Species

- 1. Colonies clathrate ----- *M. aeruginosa*
- 1. Colonies not clathrate ----- *M. flos-aquae*
- 1. Colonies simple ----- *M. marginata*

Description of the Species.

Microcystis aeruginosa Kuetzing

Prescott, 1951, P. 456, pl. 102, Fig. 4.

Tiffany and Britton, 1952, P. 336, Pl. 91, Fig. 1052.

Desikachary, 1959, P. 93, Pl. 17, Figs. 1,2,6.

Shaheen, 1995, P. 21, Pl. 4, Fig. 7.

Cells 3-54. 5 μ m in diameter, an ovate spherical or irregularly lobed clathrate colony of numerous spherical cells; much crowded within a gelatinous matrix; colonial mucilage hyaline and homogenous retaining a definite shape; cell-contents blue-green, highly granular and with conspicuous pseudovacuoles.

Local Distribution.

Site - 7, Autumn 2004.

M. flos-aquae (Wittrock) Kirchner

Desikachary, 1959, P. 94, Pl 17, Fig. 11.

Cells 3-7 μ m in diameter; colonies roughly spherical, ellipsoidal or somewhat elongate or often squarish in optical section, not clathrate, with indistinct colonial mucilage; spherical, with gas-vacuoles; annnocytes present.

Local Distribution.

Site – 1, Winter 2005.

M. marginata (Menegh) Kuetzing

Desikachary, 1959, p. 87, Pl. 17, Figs. 3 – 5.

Anjum, 1981, P. 46, Pl. 1, Fig. 9.

Zada, 1989, p. 32, Pl. 2, Fig. 6.

Cells 3-6 μm in diameter; colonies spherical or irregularly flattened, more or less lenticular, simple, margins of colonial mucilage very distinct, refractive, sometimes stratified; cells spherical, closely arranged; gasvacoules present, colonies not clathrate.

Local Distribution.

Site – 1, Winter 2005.

Genus: *Merismopedia* Meyen 1839

Cells 4-16 μm in diameter or more in tubular colonies arranged in a homogenous mucilage, generally in fours, arranged in single plane, free-floating, cells globose, oblong before cell division, subspherical after division, contents blue-green rarely violaceous or reddish; multiplication by division in two directions perpendicular to the plane of the colony.

Key to the Species

1. Cells 3-6 μm broad ----- *M. glauca*
1. Cells 2.5-3.5 μm broad ----- *M. punctata*
2. Thallus convolute ----- *M. convoluta*

Description of the Species.

Merismopedia convoluta Brebisson

Prescott 1951 P. 458, Pl. 103, Fig. 13.

Cells 4-5 μm in diameter, 4-8 μm long, spherical or oblong, arranged in

multiple families of 64 individuals; colony irregularly quadrangular, forming extensive sheets with convolute margins, 1-4 mm. in width and usually visible to the unaided eye.

Local Distribution.

Sites – 7, 10, Spring, Summer, Autumn 2004.

***M. glauca* (Ehrenberg) Naegeli**

Prescott 1951, P. 459. Pl. 101, Figs. 2.4.

Cells 3-7 μm in diameter; 30-celled colony 30 μm wide; colony of 16-64 ovate or hemispherical cells, very regularly arranged to form quadrangular colonies; cell contents bright blue-green, homogeneous.

Local Distribution.

Site – 7, Autumn 2004.

***M. punctata* Meyen**

Prescott 1951. P. 459, Pl. 100, Fig. 17.

Cells 2.5-4 μm in diameter; cell contents homogeneous, blue-green; a rectangular plate of 32-128 ovate cells, usually loosely arranged, sometimes in compact groups of 4-8 individuals, the groups widely separated within a broad gelatinous envelopes.

Local Distribution.

Sites – 2, 3, 4, 6, 7, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

Genus: *Anabaena* Bory 1822

Filamentous, mostly gregarious, much entangled and enclosed in amorphous mucilage, solitary and planktonic in a few species, sometimes attached and forming films and gelatinous expansions on moist substrates; trichomes straight, flexuous, or spirally coiled, either with or without a sheath; barrel-shaped, or cylindrical; heterocysts usually numerous and scattered in the trichome, spherical, ovate, or cylindrical; gonidia round, ovate, or cylindrical (sometimes elongate-ovate), either adjacent to or remote from the heterocysts.

Key to the Species

1. Gonidial 1 or 2 together, elongate to subcylindric-----*A. aequalis*
2. Vegetative cells barrel-shaped to short-cylindric-----*A. viguieri*
3. Trichomes 6-7.5 μ m broad, end wall pointed -----*A. gelatinicola*

Description of the Species

Anabaena aequalis Borge

Prescott, 1951, P. 512, Pl. 115, Figs. 1,2.

Cells 4.5--7.5 μ m in diameter, 7.6-8.5 μ m long; somewhat quadrate or barrel-shaped, trichomes straight, forming a small plant mass, or scattered among other algae; heterocysts ovate to sub-cylindric, 5.5-8 μ m in diameter; 10-15.20 μ m long; gonidia cylindrical, remote from the heterocysts.

Local Distribution.

Site - 3, Winter 2005.

A. gelatinicola Ghose

Desikachary, 1959, P. 398, Pl. 76, Fig. 6.

Cells 6-7.5 μ m broad, subspherical, apex acute; heterocysts 7-8 μ m broad, spherical; spores in series, away from the heterocyst, spherical, about 14 μ m in diameter; thallus thick, gelatinous; trichome mostly solitary, spirals densely arranged and coiled, not screw like, sometimes straight;

Local Distribution.

Site - 5, Autumn 2004.

A. viguieri Denis and Fremys

Prescott, 1951, P. 519, Pl. 119, Figs. 1-3,

Cells 7-7.8 μ m in diameter, 4-10 μ m long; barrel-shaped to short-cylindric; with pseudovacuoles. Heterocysts globose to subglobose; 7.6 μ m in diameter and up to 9 μ m long; smaller than the vegetative cells. Gonidia broadly ovate; 12-150 μ m in diameter.

Local Distribution.

Sites – 2, 9, Spring, Autumn 2004.

Genus: *Chroococcus* Naegeli 1849

Cells spherical or sub spherical, hemispherical, after division in small groups of 2-4 individuals, some times 8 – 16, rarely single, in a gelatinous or mucous matrix; sheath of individual cells distinct, firm, generally lamellated, in some homogeneous, persistently or irregularly broken; reproduction by cell division and fragmentation of colonies; division of cells in three directions, nannocytes occasionally seen.

Key to the Species

1. Maximum diameter of cell, including sheath, 50 μ m ----- *C. turgidus*

Description of the Species

***Chroococcus turgidus* Naegeli**

Prescott, 1951, P. 450. Pl. 100, Fig. 19.

Cells 8-32 μ m in diameter without sheath, 15-50 μ m wide including sheath; a free-floating colony of 2-4 ovoid or hemispherical cells enclosed by a very wide, hyaline, and lamellate colonial sheath; cells bright blue-green, contents sometimes coarsely granular, enclosed by individual sheaths.

Local Distribution.

Site – 7, Spring, Autumn 2004.

Genus: *Aphanothece* Naegeli 1849

Cell ovate, oblong or subcylindrical, densely but evenly arranged and scattered throughout firm and copious mucilage, forming masses which are often macroscopic and either amorphous or definite in shape, free-floating or sedentary, sometimes subaerial; cell contents either gray, olive, or bright blue-green, granular but not vacuolated; cell sheaths indistinct and confluent with the homogeneous colonial mucilage.

Key to the Species

1. Cells 2-3.5 μm in diameter-----*A. castagnei*
 1. Cells 1-1.5 μm in diameter -----*A. nidulans*

Description of the Species

Aphanothece richteriana hieronymus

Prescott, 1951, P. 467, Pl. 105, Figs. 5.6.

Cells 2-3.5 μm in diameter, 4-8 μm long; ellipsoid or ovate to subcylindric, densely arranged within a gelatinous, amorphous mass which is olive-green or brownish; cells of various shapes and size within the same colony, oblong or polygonal when compressed.

Local Distribution.

Site - 8, Winter 2005.

A. nidulans P. Richter

Prescott, 1951, P. 468, Pl. 104, Figs. 2,3.

Cells 1-1.5 μm in diameter, 3-3.5 μm long; cell contents pale blue-green; cells short-cylindric, broadly rounded at the apices, densely and evenly distributed in small ovate or spherical colonies, enclosed by a colorless mucilage in which individual cell sheaths are not distinct;

Local Distribution.

Site - 1, Summer 2004.

Genus: *Gloeocapsa* Kuetzing 1849

Cells spherical, 2-8 in colonies, seldom many, with a number of concentric special envelops, colonies single or many together forming an expanded mass, individual sheaths lamellated or unlamellated, cell division very regularly in three directions, cells in large colonies often with secondary colonies, arranged irregularly; occasionally with nannocytes, resembling *Aphanocapsa* stage; spores with firm thick walls often formed in a number of species.

Key to the Species

1. Cells up to 300 μm long ----- *G. magma*

Gloeocapsa magma Kuetzing

Prescott. 1951, P. 120, Pl. 24, Fig. 13.

Cells 30-70 μm ; mostly 45 μm diameter., seldom larger, and up to 300 μm diameter; colonies spherical or irregularly arranged, colorless or red or brown with 2.5 μm thick cuticle like sheath.

Local Distribution.

Sites – 7, 10, Autumn 2004.

Spirogyra Link, 1820

Filaments long and unbranched, usually without basal-distal differentiation but sometime with rhizoidal branches developing laterally where the filament come in contact with substrate, cells cylindrical, short, to very long in some species, with plane, and smooth, replicate or colligate end walls, chromatophores 1-16 straight or spirally arranged, parietal, ribbon like bodies embedded in the cytoplasm, each with several to many, more or less distinct pyrenoids, nucleus centrally placed supported by several stands of cytoplasm which terminate near pyrenoid.

Reproduction by zygote, aplanospores, parthenospores, akinetes and fragmentation, conjugation, usually scalariform, sometimes lateral; tubes formed by both gametangia or by the male gametangium before movement of gametes, zygote walls layered, with chitinous median layer, variously coloured, smooth or ornamented.

Spirogyra is the largest genus in number of species and the most common of Zygnemataceae. It is identifiable in the field; by its bright, green cottony growth, and its slippery mucilaginous texture.

Key to the Species

1. Vegetative cells 23 -25 μm in diameter ----- *S. aequinoctialis*
 1. Vegetative cells 15-24 μm diameter----- *S. collinsii*

2. The one chromatophore making 2 turns -----*S. daedaleoides*
2. The one chromatophore making 0.5 – 4.0 turns-----*S. condensata*
3. Zygosporangium compressed -----*S. crassa*
3. Inflation of gametangia cylindric -----*S. rectangularis*
4. Vegetative cells short -----*S. scrobiculata*
4. Vegetative cell long ----- *S. majuscula*
5. Chloroplast solitary -----*S. porticalis*
5. Conjugation scalariform-----*S. fuellebornei*
6. Conjugation lateral -----*S. gratiana*
6. Conjugation scalariform ----- *S. subsalsa*
7. Median spore wall yellow -----*S. borgeana*
7. Median spore evidently polymorphic-----*S. pratensis*
8. Fertile cells cylindrical up to 70 μ m diameter -----*S. fluviatilis*
8. Fertile cell inflated 44 – 50 μ m in diameter -----*S. micropunctata*
9. Vegetative cell 32 – 37 μ m in diameter ----- *S. irregularis*
9. Vegetative cell 60-80 μ m in diameter -----*S. nitida*
10. Spores more than 29 μ m in diameter -----*S. mirabilis*
11. Vegetative cell 70-80 μ m in diameter -----*S. setiformis*
11. Vegetative cell 90-115 μ m in diameter -----*S. ellipsospora*
12. Vegetative cells 24-26 μ m in diameter ----- *S. mirabilis*
12. Vegetative cells 27-30 μ m in diameter----- *S. punctiformis*

Description of the Species

S. aequinoctialis G.S West

Prescott, 1951, P. 311, Pl. 72. Figs. 3.4

Hena 2000, P. 21, Pl. 1, Fig. 1

Cells long cylindric, 23 – 29 x 60-150 μ m; with plane end walls; chloroplast 2 – 3, with crenate margins and large pyrenoids, making 1 to 1 ½ turns, conjugation by tubes from both gametangia; the receiving cell becoming symmetrically inflated,

zygospores elongate ellipsoid to ovate, with broadly rounded poles; median spore wall with deep pits.

Local distribution

Sites – 1, 2, 3, 4, 5, 9. Summer, Autumn, Winter. 2004 – 2005.

***S. boregeana* Transeau**

Prescott, 1951, P. 311, Pl. 77, Fig. 7.

Tiffany and Britton, 1952, P. 146, Pl. 44, Fig. 467.

Cells 30 – 35 x 50-200 μm , with plane end walls and chromatophore making $\frac{1}{2}$ turns; conjugation scalariform, tubes formed by both gametangia; zygote ellipsoidal, 30-40 x 54-70 μm ; median spore wall smooth and yellow.

Local Distribution:

Site – 2, Summer 2004.

***S. collinssi* (Lewis) Printz**

Prescott, 1951, P. 312, Pl. 77, Fig. 6.

Transeau, 1951, P. 198, Pl. 33, Figs. 12.13.

Hadi, 1985, P. 9, 8, Pl. 1, Fig. 1.

Cells 18-22 x 100-200 μm ; with plane end walls; chloroplast one, rarely 2 in some cells, making from 3 to 9 turns in the cells; conjugation usually lateral, sometimes scalariform; conjugation tubes formed mostly by the male gametangia; sporangia inflated, 25-39 x 45 – 110 μm ; zygospores ellipsoidal or some times ovoid, 26- 37 x 52-62 μm ; median spore wall coarsely punctuate, yellow.

Local Distribution.

Site – 2, Winter 2005.

***S. condensata* Vauch Kuetzing**

Prescott. 1951, P.312, Pl.72, Fig. 5,6,

Tiffany and Britton. 1952, P.146, Pl.44, Fig.458.

Bibi. 2001, P.12, Pl.1, Fig.3.

Cells 45-60 x 45-120 μm ; with plane end walls and one slender chromatophores making 0.5 – 4.0 turns in the cells, conjugation scalariform and lateral tubes formed by both gametangia cylindrical or slightly enlarged, zygote, ellipsoidal, 34 -38 x 50-75 μm , median spore wall yellow, smooth, sterile cells sometimes inflated.

Local Distribution.

Site – 5, Spring, Summer, Winter 2004 - 2005.

***S. crassa* Kuetzing**

Prescott, 1951, P. 312, Pl. 72, Figs. 7, 8

Cells 133 – 160 μm ; with plane and walls, chloroplasts 6 – 12 slender, making $\frac{1}{2}$ to 1 turn; conjugation by tubes from both gametangia; fertile cells cylindric, zygospores ovate or laterally flattened, the poles broadly rounded; median wall finely reticulate and brown, 80 – 140 μm in diameter 166 – 175 μm long.

Local Distribution.

Site – 2, 4, 6, 9, Summer, Winter 2004- 2005.

***S. daedaleoides* Czurda**

Prescott. 1951, P. 313, Pl. 72, Fig. 9 – 11.

Tiffany and Britton. 1952, P. 148, Pl. 45, Fig. 473 – 474.

Nishat. 1998, P. 34, Pl. 1, Fig. 4.

Cells 30 – 44 μm , with plane end walls and one chromatophore, making 2 – 8 turns, conjugation scalariform by tubes form both gametangia, fertile cells enlarged or slightly inflated, zygote ellipsoidal with irregular reticulate ridges.

Local Distribution.

Site – 2, 3, Autumn, Winter 2004 - 2005.

***S. ellipsozona* Transeau**

Prescott, 1951, P. 313, Pl. 72, Fig. 12.

Tiffany and Britton, 1952, P. 152, Pl. 46, Fig. 484.

Begum, 1996, P. 121, Pl. 1, Fig. 12.

Cells 125-150 x 125-500 μm ; with plane end walls; chloroplast 3-8, narrow bands, making $\frac{1}{2}$ -5 turns conjugation scalariform; tubes formed by both gametangia; fertile cells cylindric, zygospore ellipsoid or cylindric-eloipsoid; not compressed; spore wall smooth, yellow-brown, 100-140 x 160-255 μm .

Local Distribution.

Sites – 3, 5, Spring, Summer, Autumn 2004.

S. fluvialilis Hilse

Prescott, 1951, P. 314, Pl. 73, Figs. 4,5.

Transeau, 1951, P. 184, Pl. 3, Fig. 5.

Tiffany and Britton, 1952, P. 154, pl. 46, Fig. 493.

Hadi, Sarim and Akhtar, 1988, p. 1, P. 678, Fig. 8.

Cells 30 – 45 x 70 – 240 μm , with plane end walls 3-4 chromatophores making 1.5-3.5 turns, conjugation scalariform by tubes from both gametangia, fertile cells becoming inflated, zygospore ovate, median spore wall wrinkled and irregularly pitted.

Local Distribution.

Sites – 5, 6, Summer 2004.

S. majuscula Kuetzing

Prescott, 1951, Pl. 74, Fig. 10.

Tiffany and Britton, 1952, P. 150, Pl. 45, Fig. 474.

Cells 50-80 x 80-500 μm ; with plane end walls; chloroplast 3-8, straight conjugation by tubes from both gametangia; zygospore lenticular or spheroidal, laterally compressed, median spore wall smooth and brown; 52-72 μm in diameter, 45-60 μm .

Local Distribution.

Site – 4, Autumn. 2005.

***S. mirabilis* (Hass) Kuetzing**

Prescott. 1951, P. 77, Fig. 1.

Cells, 24-27 μm ; with plane end walls; chloroplast solitary, making 4-7 turns.

Conjugation by tubes from both gametangia; fertile cells inflated.

Local Distribution.

Site – 2, Spring 2004.

***S. porticalis* (Muell) Cleve 1868:**

Prescott. 1951, P. 318, Pl. 75, Fig. 10.

Tiffany and Britton. 1952, P. 147, Pl. 44, Fig. 468.

Bibi, 2001, P. 15, Pl. 2, Fig. 3.

Cells 40 – 50 μm ; 68 – 200 μm long, with plane end walls; chloroplast solitary, making 3 to 4 turns, conjugation scalariform by tubes from both gametangia; fertile cells sometimes inflated; zygospores ovate 38–50 μm in diameter, 50 – 83 μm long.

Local Distribution.

Sites – 2, 3, 5, Spring, Summer, Autumn 2004.

***S. pratensis* Transeau:**

Prescott. 1951, P. 319, Pl. 75, Fig. 5.

Tiffany and Britton. 1952, P. 144, Pl 43, Fig. 457.

Cells 17 – 20 x 80 – 240 μm , with plane end walls and 1 (rarely 2) chromatophores making 1 – 8 turns; conjugation scalariform and lateral, tubes formed by both gametangia; receptive gametangia inflated up to 55 μm sterile cells cylindric, Zygote polymorphic (ovoid, ellipsoid or cylindric) with pointed ends, 24 – 36 x 50 – 70 μm , with yellow, smooth median walls; aplanospores similar to zygotes.

Local Distribution.

Sites – 1, 2, Spring, Winter 2004 – 2005.

***S. punctiformis* Transeau**

Tiffany and Britton, 1952, p. 154, pl. 47, Fig. 496.

Cells 2-30 x 120-390 μm ; with plane end walls and two narrow chromatophores making 3-6 turns in the cells conjugation scalariform; fertile cells inflated to 45-50 μm in diameter, receptive gametangia 100-250 μm long, male gametangia 90-140 μm long occurring singly or in pairs alternating with vegetative cells; zygote ovoid, 40-48 x 60-110 μm , median spore wall punctuate, yellow.

Local Distribution.

Sites - 2, 3, 5, Spring, Summer, Autumn 2004.

***S. rectangularis* Transeau**

Tiffany and Britton, 1952, P. 161, Pl. 49, Fig. 522.

Nishat, 1992, P. 10, Pl. 1, Fig. 4.

Cells 35-40 x 150-320 μm , with replicate end walls and 2-4 chromatophores making 2-5 turns in the cell, conjugation lateral and scalariform, middle upto 48-70 μm , zygote ovoid to cylindrical ovoid, 45-65 x 75 - 140 μm , median spore wall yellow brown smooth.

Local Distribution.

Sites - 4, 5, 6, 10, Summer, Autumn 2004.

***S. scorbiculata* Czurda**

Prescott, 1951, P. 320, Pl. 76, Figs. 3, 4

Cells short 30 - 40 μm ; in diameter, making 1 to 5 turns, conjugation by tubes from both gametangia, the fertile cell inflated on the conjugating side, zygosporos ellipsoid, median spore wall deeply pitted and brown; 33 - 38 μm long.

Local Distribution.

Sites - 2, 3, Spring, Summer 2004.

***S. setiformis* (Roth) Kuetzing**

Tiffany and Britton, 1952, p. 152, Pl. 45, Fig. 480.

Whitford and Schumacher, 1973, P. 62, Pl. 16, Fig. 15.

Cells 19-115 x 100-225 μm ; with plane end wall, chromatophores 4, making 0.5-10 turns in the cell; conjugation scalariform; tubes formed by both gametangia; fertile cells cylindrical; zygote ellipsoidal; 85-100 x 115 - 160 μm , with smooth, black median spore wall.

Local Distribution.

Sites - 1, 2, 3, 4, Spring, Summer, Autumn, Winter 2004 - 2005.

S. subsala Kuetzing

Prescott, 1951, P. 321, Pl. 73, Figs. 1-3

Cells of filaments 26 - 28 μm ; long with plane end wall; chloroplast solitary, making 1 ½ to 3 turns, conjugation by tubes form both gametangia; fertile cells becoming slightly swollen, zygosporos ellipsoid; median spore wall wrinkled irregularity reticulate, and brown 18 - 35 μm long.

Local Distribution.

Sites - 5, 9, 10, Summer, Autumn 2004.

GENUS: *Stigeoclonium* Kuetzing 1843

Filament branched arising from a prostrate portion of a thallus which many be reduced to a pseudo-parenchymatous mass of cells; in some species the major portion of the plant spreads in loosely branched, horizontal filaments; plant covered by a thin, scarcely evident, film of mucilage; branches of first and second order either alternate or opposite, and composed of cells scarcely smaller than those of the main axis, ending in bluntly pointed or setiferous cells; chloroplast a parietal plate covering most of the cell wall, especially in the cells of branches; one or several pyrenoids.

Key to the Species

1. Vegetative cell 14-17 μm in diameters -----*S. longipilum*
1. Vegetative cell 3-10 μm in diameters -----*S. subsecundum*
1. Vegetative cell 5-10 μm in diameters -----*S. tenue*

- 2. Branching ending in blunt point -----*S. lubricum*
- 2. Branching very irregular with long & tapering -----*S. pachydermum*
- 2. Branching few celled and thorn like -----*S. stagnatile*

Description of the Species

Stigeoclonium longipilum Kuetzing

Tiffany and Britton, 1952, P. 36, Pl. 8, Fig. 65.

Cell 11-14 x 11-30 μ m, opposite branching predominating; end cells generally setiferous.

Local Distribution

Sites – 1, 9, Spring, Winter 2004 – 2005.

S. lubricum (Dillw) Kuetzing

Prescott. 1951, P. 115, Pl. 10, Fig. 1-2.

Tiffany and Britton. 1952, P. 65, Fig. 6 – 7.

Nishat. 1998, P. 83, Pl. 5, Fig. 14.

Cells in the main filament 17 x 12 – 30 μ m; branch cells 6 – 7 μ m wide, filaments elongate; branches mostly opposite or whorled, developed from barrel shaped axil cells.

Local Distribution

Sites – 1, 10, Spring, Autumn, Winter, 2004 – 2005.

S. pachydermum Prescott

Prescott. 1951, p. 116, Pl. 12, Fig. 1.

Cells in the main axis 19-21 μ m in diameter, in the branches 15-16 μ m in diameter; cylindrical and several times longer than wide, short and barrel shaped in the same filament; filaments much branches, erect, with numerous basal, downward, projecting rhizoidal branches; branches in the upper portion irregularly disposed.

Local Distribution.

Site – 1, Winter 2005.

***S. stagnatile* (Hazen) Collins**

Prescott. 1951, P. 117, Pl. 11, Fig. 3.

Tiffany and Britton. 1952, P. 34, Pl. 10, Fig. 72.

Cells 7 – 11 x 8 – 32 μm ; filaments sparsely branched, solitary or opposite; forming floccose masses.

Local distribution

Site – 1, Spring 2004.

***S. subsecundum* Kuetzing**

Prescott, 1951, P. 117, Pl. 10, Fig. 3.

Cells 12-18 x 13-150 μm in diameter, filament elongate and sparsely branched; the branches gradually and gracefully tapering to fine points, alternate in origin, sometimes short and composed of only 2 or 3 cells; cells elongate and cylindrical.

Local Distribution

Site – 1, Spring, Winter 2004 - 2005.

***S. tenue* (Agardh) Kuetzing**

Tiffany and Britton. 1952, P. 34, Pl. 10, Fig. 70.

Cells 5 – 10 x 7 – 30 μm ; branches more often opposite, though some always solitary; tufts bright green.

Local Distribution

Sites – 1, 7, Spring, Summer, Winter 2004 – 2005.

Genus: *Cladophora* Kuetzing 1843

Filaments usually with profuse lateral branching attached by well defined rhizoidal cells or free floating as entangled masses of indefinite shape; vegetative cells with thick stratified walls, multinucleate, much longer than broad; chromatophores single and reticulate, or numerous and discoid, pyrenoids several; quadriflagellate zoospores; biflagellate gametes.

Key to the Species

- 1. Wall lamillate ----- *C. crispata*
- 1. Branches glomerata ----- *C. glomerata*
- 2. Cells swollen ----- *C. fracta*
- 2. Cells cylindrical ----- *C. insignis*

Description of the Species.

Cladophora crispata Kuetzing

Prescott, 1951, P. 137, Pl. 19, Figs. 9-11.

Tiffany and Britton 1952, P. 45, Pl. 13, Fig. 92.

Shaheen, 1996, P. 40, Pl. 3. Fig. 9.

Cells 40-75 μ m in diameter; filaments mostly long, slender and entangled; free floating; main axis composed of short cells with thick lamellose walls and quite dense chromatophores; branches long slender with relatively thinner walls and more defuse chromatophore, sparingly distributed along main axis; plant mass dark green or yellow-green.

Local Distribution.

Sites - 3, 10, Spring 2004.

C. insignis Kuetzing

Prescott 1951, P. 139, Pl. 21, Figs. 4,5.

Cells cylindrical or swollen; branches 40-70 μ m in diameter; 4-6 times the diameter in length; thallus composed of straight, coarse, and sparsely branched filaments, the branches often arising at right angles to the main axis and very slightly smaller. Main filament 75-120 μ m in diameter.

Local Distribution.

Site - 4, Summer 2004.

C. fracta Kuetzing

Prescott. 1951, P.137, Pl.20, Fig. 1 - 6.

Anjum. 1986, P.30, Pl. 3, Fig. 1.

Hadi, Sarim and Akhtar. 1988, P.678, Pl.3, Fig. 1.

Khan . 1998, P. 61, Pl. 3, Fig. 10.

Cells 60 – 120 μm wide in the main axis; 1 – 3 times their diameter in length; 20 – 40 μm wide in the ultimate branches, cells irregularly swollen, cylindrical, forming coarse, light green masses of irregularly branched filaments, the branches often curving.

Local Distribution

Sites - 1, 4, Summer, Winter 2004 – 2005.

C. glomerata (Linnaeus) Kuetzing

Prescott. 1951, P.138, Pl.20, Figs.8,9.

Tiffany and Britton. 1952, P.45, Pl.13, Fig.93.

Hadi, Sarim and Akhtar. 1988, P. 678, Pl. 3, Fig. 2.

Nishat. 1998, P.63, Pl. 3, Fig. 12.

Cells of the main axis 45 – 150 x 300 – 1,000 μm ; of ten branches 35 – 60 x 150 – 360 μm ; branches often in glomerate clusters. Plants attaining lengths of 5 – 10 cm. or sometimes up to nearly 1 meter; transition from thick walls of main axis and primary branches to thin walls of branch clusters distinct; branching of main filament often Y-shaped; plant mass light green to dark green.

Local Distribution

Site – 4, Summer 2004.

GENUS: *Closterium* Nitzsch 1817

Cells elongate, usually markedly attenuated, rarely straight, in most cases curved, often strongly arcuate or lunate, without a median constriction; poles obtuse, truncate, rostrate, or attenuate to firm needle like points; cell wall smooth, costate or straight, colorless or yellow to brown, often with one or more transverse lines either at middle of cell or at different points along cell; chromatophores entire or with variable number of longitudinal ridges, one in each semicell; pyrenoids few or many, usually in a single axial row or more rarely scattered through chromatophore; with

terminal vacuole between cell apex at the end of chromatophore; conjugation between recently divided cells or mature cell.

Key to the Species

1. Apices rounded truncate ----- *C. acerosum*
1. Apices acutely rounded ----- *C. lanceolatum*
 2. Cells apices acutely rounded ----- *C. leibleinii*
 2. Cells obtusely rounded ----- *C. moniliferum*
3. Cells cylindrical ----- *C. cornu*
3. Cells strongly curved ----- *C. diana*
3. Cells slightly curved ----- *C. turgidum*
 4. Cells less than 15 μm in width ----- *C. juncidum*
 4. Cells pyrenoids not in a single median series ----- *C. ehernbergii*
 4. Cells inner margin concave ----- *C. littorale*

Description of the Species

Closterium acerosum Nitzsch

Thompson, 1936, P. 41, Pl. 9, Fig. 11

Tiffany and Britton 1952, P. 169, Pl. 52, fig. 550

Whitford and Schumacher, 1973, P. 200, Pl. 18. Fig. 8

Sarim, 1980, P. 83, Pl. 8. Fig. 7

Cells $19 - 53 \times 288 - 530 \mu\text{m}$; with apices $4 - 5 \mu\text{m}$ wide, $8 - 16$ times longer than wide, very slightly curved or almost straight, narrowly fusiform, outer margin slightly curved, about $30 - 38$ degree of arc, inner margin, almost straight or slightly convex gradually tapering to the narrow end, often slightly thickened, rounded truncate apices, cell wall smooth, colourless, becoming delicately striate and yellowish brown in colour with age, with or without a median girdle, chromatophores ridged, pyrenoids $7 - 12$ in a median series; terminal vacuoles with a number of moving granules; zygote spherical, smooth, $50 - 87 \mu\text{m}$ in diameter.

Local Distribution

Site - 4, 8, 9, Spring, Autumn, Winter 2004 - 2005.

***C. diana* Ehrenberg**

Tiffany and Britton, 1952, P. 169, Pl. 52, Fig. 548.

Compere, 1977, P. 87, Pl. 22, Fig. 327.

Sarim, 1976, P. 227, Pl. 2, Fig. 27.

Cells 16-36 x 103-380 μ m; with apices 4-7 μ m wide, usually 10-12 times longer than wide, strongly curved, outer margin about 107-130 degrees of arc, inner margin very slightly tumid, cell wall smooth, reddish brown, usually without a median girdle; chromatophores obscurely ridged; pyrenoids 3-6 in a single series; terminal vacuoles with many moving granules.

Local Distribution:

Sites - 3, 4, 10, Autumn, Winter 2004 - 2005.

***C. ehrenbergii* Meneghini**

Tiffany and Britton 1952, P. 172, Pl. 52, Fig. 558.

Cells 60-145 x 285-720 μ m; stout, 4.0-5.5 times longer than wide, moderately curved, outer margin 92-140 degrees of arc; inner margin concave but inflated in the middle, gradually attenuated to the obtusely rounded apices.

Local Distribution.

Sites - 9, 10, Autumn 2004.

***C. lanceolatum* Kuetzing**

Tiffany and Britton, 1952, P. 173, Pl. 52, Fig. 552

Cells 32 - 72 x 2345 - 550 μ m 5 - 10 times longer than wide sub-lanceolate almost straight, outer margin slightly curved, 30 - 55 degree of arc, inner margin straight or slightly convex, gradually narrowed toward the acutely rounded apices; cell wall smooth, colourless, chromatophores with 7 - 8 ridges, pyrenoid 6 - 7 in a median series, terminal vacuoles with a number of moving granules; zygote subglobose or oblong, ellipsoid smooth, 81- 104 μ m in diameter.

Local distribution

Site - 1, Spring 2004.

***C. leibleinii* Kuetzing**

Tiffany and Britton 1952, P. 172, Pl. 52, Fig. 547.

Cells 17-42 x 105-250 μm , 6-8 times longer than wide, strongly curved, outer margin 124-190 degrees of arc, inner margin strongly concave, tumid in the middle, gradually attenuated to the acutely rounded apices.

Local Distribution.

Sites – 4, 9, Summer, Autumn 2004.

***C. littorale* Gay**

Tiffany and Britton, 1952, Pl. 51, Fig. 544.

Cells 17.5-22.5 x 150-220 μm ; apices 3.5 -5.5 μm wide, ten times longer than wide, slightly curved, outer margin 35-55 degrees of arc, inner margin little concave and slightly but widely tumid in the middle, gradually attenuated to the acute to obtusely rounded apices; cell wall smooth; chromatophores with 7-8 ridges; pyrenoids 4-5 in median series; terminal vacuoles, with a number of moving granules; zygote spherical, smooth.

Local Distribution.

Site – 3, Autumn 2004.

***C. juncidum* Ralfs**

Sarim 1976, P. 229, Pl. 2, Fig. 23.

Cells 188-310 μm long; 10-12 μm wide apex 4.5-5 μm ; 9-17 striae in 10 μm ; with or without girdle bands; apical wall unthickened; terminal granules present; cell slightly curved.

Local Distribution.

Site – 3, Winter 2005.

***C. moniliferum* (Bory) Ehrenberg**

Tiffany and Britton 1952, P. 172, Pl. 52, Fig. 549.

Cells 30-68 x 188-420 μm ; stout, 6-8 times longer than wide, moderately curved; outer margin 100-130 degrees of arc, inner margin inflated in the middle;

uniformly narrowed to the obtusely rounded apices.

Local Distribution.

Sites – 2, 4, Autumn 2004.

C. cornu Ehrenberg

Sarim 1976, P. 226, Pl. 1, Fig. 11.

Cells 160-200 μm long; 7.2-11 μm lateral; about 20° of arc; pyrenoids 4; cell wall smooth; older semicell brown in colour; cell cylinder and about straight; cell showing considerable range in size.

Local Distribution.

Site -3, Winter 2005.

C. turgidum (Bory) Ehrenberg

Tiffany and Britton 1952. P. 170, Pl. 52, Fig. 553.

Cells 50-75 x 616-791 μm ; slightly curved, 11-12 times longer than wide, outer margin 47-55 degrees of arc inner margin not tumid, gradually attenuated to subtruncate, recurved apices.

Local Distribution

Site – 2, Autumn 2004.

Genus: *Asterococcus* Scherffel 1908

Cells globose or subglobose, either solitary or in colonies of from 4 to 16, in colorless homogeneous envelopes of mucilage. Chloroplast a stellate mass with radiate arms from a central core, which contains a pyrenoid.

Key to the Species

1. Cells in colonies of 8 or 16, 10-25 μm in diameter ----- *A. limneticus*

Description of the Species

Asterococcus limneticus G.M. Smith

Presscot. 1951, P. 86, Pl. 4, Fig. 11.

Cells spherical, arranged at some distance from one another in free-floating colonies of 4-16 within a colorless homogeneous investing mucilage.

Local Distribution.

Sites – 1, 4, 6, Spring, Autumn, Winter 2004 – 2005.

Genus: *Chlamydomonas* Ehrenberg 1835

Cells ovoid, ellipsoid, or spherical, sometimes with 1 or 2 apical papillae, from which the 2 flagella arise; often with a narrow or wide mucilaginous sheath. Chloroplast a dense, padded body occupying the entire cell, or a thin parietal cup (in a few species H-shaped or stellate); pyrenoids 1 to many, basal or bilateral and scattered; pigment-spot lateral and anteriors, rarely median; 2-4 apical contractile vacuoles usually discernible.

Key to the Species

1. Cells without an apical papilla ----- *C. globosa*

Description of the Species

Chlamydomonas globosa Snow

Prescott. 1951, P. 69, Pl. 1, Figs. 8,9.

Cells broadly ovoid to globose, enclosed in a hyaline, gelatinous sheath; anterior papilla absent.

Local Distribution.

Sites – 1, 4, 7, Spring, Summer, Autumn 2004.

Genus: *Characium* A. Braun 1849

Cells solitary or aggregate, epiphytic or epizootic; generally stipitate or sometimes nearly sessile, pyriform, ovoid, subspherical, cylindric or fusiform; chromatophore 1 or several, parietal and laminate to cup-shaped, with 1 or more pyrenoids; uninucleate or multinucleate.

Key to the Species

1. Cell 4-8 μm in diameter ----- *C. ambiguum*

Description of the Species

Characium ambiguum Hermann

Tiffany and Britton. 1952, P. 108, Pl. 29, Fig. 286.

Cells 4-8 x 24-32 μm , straight, asymmetric, oblique or somewhat lanceolate, with pointed, somewhat bent apex; stipe short, without basal thickening; epiphytic on other algae.

Local Distribution.

Sites - 5, 7, Spring, Winter 2004 - 2005.

Genus: *Cosmarium* Corda 1834

Cells variable in size, a little longer than wide, rarely twice as long as wide, a few species wider than long, generally compressed, symmetrical in 3 planes at right angles to each other; constricted in the middle to variable depths, semicells elliptic, subcircular, semicircular, subquadrate, or truncate-pyramidal, apex rounded, truncate or subtruncate, without an apical incision, center sometimes protuberant; vertical view elliptic, sub-elliptic, oblong, or rarely circular, often having 1 or more central protuberances on either side; chromatophores usually axial, 1 in each semicell, with 4 curved longitudinal plates and 1-2 large pyrenoids, parietal in a few species, 4-8 in each semicell, with 1 or more pyrenoids in each; cell-wall smooth, punctate, scrobiculate, granulate, papillate, with the markings arranged in a definite pattern.

Key to the Species

1. Apex dilated ----- *C. constrictum*
 1. Apex truncate ----- *C. nitidulum*
 2. Longer than wide ----- *C. subimpressulum*
 2. Longer slightly than wide ----- *C. protractum*

Description of the Species

Cosmarium constrictum Delponte

Tiffany and Britton, 1952, P. 185, Pl. 54, Fig. 594.

Gronblad, 1960, P. 60, Pl. 2, Figs. 25-28.

Whitford and Shumacher, 1973, P. 72, Pl. 30, Fig. 10.

Cells 21-38 μm broad; broadly elliptical, longer than wide deeply constricted; wall smooth, semicells semielliptical, basal angles rounded, lateral view of semicell broadly elliptic; vertical view elliptical; single pyrenoid in each semicell.

Local Distribution.

Site - 4, Winter 2005.

C. nitidulum De. Notaris

Tiffany and Britton, 1952, P. 185, Pl. 53, Fig. 572.

Khan, 1994, P. 12, Pl. 1, Fig. 5.

Cells 8-10 μm wide, little longer than wide, deeply constricted; sinus narrowly linear, the apex slightly dilated; semicell truncate, subsemicircular, basal angle broadly rounded, upper angle slightly converging upward, apex small, truncate convex, straight or slightly retuse; vertical view elliptical; lateral view of semicell subcircular; cell wall minutely and often obscurely punctate; pyrenoid single, central.

Local Distribution.

Site - 7, Spring 2004.

C. protractum Bory

Tiffany and Britton 1952, P. 190, Pl. 53, Fig. 570.

Cells 33-47 x 34-45 μm and 17.5-24.0 μm thick (isthmus 8.5-12.0 μm , apex 13-20 μm wide), about as long as wide or slightly longer, very deeply constricted, sinus linear, the apex slightly dilated and outer portion somewhat open, isthmus narrow; semicells pyramidal, lateral margins deeply incised.

Local Distribution.

Site - 3, Autumn 2004.

***C. subimpressulum* Borge**

Tiffany and Britton 1952, P. 186, Pl 54. Fig. 588.

Cells 21-27 x 27-38 μm and 15.5 μm thick (isthmus 6.5-9.0 μm wide, longer than wide, constriction deep, pyramide-truncate above, apex prominent, sides parallel below, attenuated upward, crenate, 4 crenations on each side, in part acute and nearly forming right angles.

Local Distribution.

Sites - 7, 9, Spring, Autumn 2004.

Genus: *Oocystis* Naegeli 1855

Cells ovoid, ellipsoid or cylindric, with smooth walls and sometimes polar nodules, solitary or in colonies of 2-16(or more) surrounded by the greatly swollen and partially gelatinized old mother-cell wall; chromatophores 1 to many, parietal, disciform, stellate or reticulate; with or without pyrenoids.

Key to the Species

1. Chromatophore 1-4 in number ----- *O. borgei*
1. Chromatophore 10-20 in number ----- *O. elliptica*
2. Cells 7-10 μm in diameter ----- *O. solitaria*
2. Cells 10-20 μm in diameter ----- *O. crassa*

Description of the Species***Oocystis borgei* Snow**

Prescott. 1951, P. 243. Pl. 51, Fig. 10.

Tiffany and Britton. 1952, P. 117, Pl. 32, Fig. 322.

Cells 9-13 μm in diameter; 9-19 μm long; colony of 8 cells, up to 31 μm in diameter, 46 μm long; unicellular or crowded in groups of 2-8, enclosed by the old mother cell wall; ellipsoid or ovate cells with the poles broadly rounded and smooth; chloroplasts 1 or as many as 4 parietal plates, each with a pyrenoid.

Local Distribution.

Sites - 4, 5, 6, Spring 2004.

***O. crassa* Wittrock**

Prescott. 1951, P. 243. Pl. 51, Fig. 9.

Tiffany and Britton. 1952, P. 117, Pl. 32, Fig. 323.

Cells 10-20 μm in diameter; cells ovate, the poles broadly rounded and furnished with a nodular thickening; chloroplasts several (as many as 10) large parietal discs, with pyrenoids usually present.

Local Distribution.

Site - 7, Winter 2005.

***O. elliptica* W. West**

Prescott. 1951, P. 244. Pl. 51, Fig. 11.

Tiffany and Britton. 1952, P. 117, Pl. 32, Fig. 318.

Cells 11-15.6 μm in diameter; 20-25 μm long; poles of the cells broadly rounded and without polar thickenings; chloroplasts numerous (as many as 20) parietal discs, apparently without pyrenoids.

Local Distribution.

Sites - 4, 10, Spring, Autumn 2004.

***O. solitaria* Wittrock**

Prescott. 1951, P. 247, Pl. 54, Fig. 10.

Tiffany and Britton. 1952, P. 116, Pl. 32, Fig. 319.

Cells 3-9 μm diameter, 7-20 μm long; often solitary, or in a family of 2-8 cells enclosed by the old mother cell wall; cells ovate or ellipsoid; poles with nodular thickenings; chloroplasts numerous parietal plates, each with a pyrenoid.

Local Distribution.

Sites - 2, 10, Autumn, Winter 2004 - 2005.

Genus: *Pediastrum* Meyen 1829

Coenobium a free-floating, circular, monostromatic disc of cells which may be continuous or perforate; peripheral cells of the disc with 1 or 2 lobes or processes, or merely emarginated without processes; interior cells either the same shape as the

marginal ones or different; chloroplast a parietal reticulum, covering the walls, with 1 pyrenoid; cells multinucleate.

Key to the Species

- 1. Lobes of the peripheral cells bifurcate at their apices -----*P. biradiatum*
- 1. Lobes of the peripheral cells not bifurcate at their apices -----*P. duplex*
- 2. Cells with a single projection -----*P. simplex*
- 2. Cells with projections emarginated-----*P. tetras*

Description of the Species

Pediastrum biradiatum Prescott

Prescott 1951, P. 222, Pl 47, Figs. 7, 8.

Cells up to 11.7 μm in diameter; 9.7 -10 μm long; 16-celled colony; cells bilobed at the periphery, the lobes bifurcate, the inner margin of the lobules convex; peripheral cells adjoined along the lower part of their lateral margins only; lobes of inner cells merely emarginated.

Local Distribution.

Site - 4, Autumn 2004.

P. duplex Meyen

Prescott, 1951, P. 223, Pl. 48, Fig. 2.

Cells 15.6 μm in diameter; 36-celled colony 105 μm in diameter; with smooth cell wall; lens-shaped spaces between the inner cells, which are quadrate, the outer margin concave; peripheral cells quadrate, the outer margin extended into 2 tapering, blunt-tipped processes, distance between processes of one cell about one-half the distance between processes of adjacent cells.

Local Distribution.

Site - 7, Autumn 2004.

***P. simplex* Meyen**

Tiffany and Britton 1952, P. 110, Pl 30, Figs. 290, 291.

Cells 7-20 x 15-30 μm , walls smooth or punctuate, projections of marginal cells single; coenobia 8-64 celled, compact or perforate.

Local Distribution.

Site – 7, Spring, Autumn 2004.

***P. tetras* Ralfs**

Prescott, 1951, P. 227, Pl. 50, Figs. 3.6.

Cells 8-16 μm in diameter; cells with 4-6 straight sides but with one margin deeply incised; peripheral cells crenate, with a deep incision in the outer free margin, their lateral margins adjoined along $\frac{2}{3}$ of their length.

Local Distribution.

Sites – 4, 7, Autumn, Winter 2004 – 2005.

Genus: *Rhizoclonium* Kuetzing 1843

Filaments cylindric, slightly or not at all constricted at the cross-walls, with short, irregularly twisted and curved rhizoidal branches, 1-2-celled, or unbranched; vegetative cells with wall up to 4 μm in thickness and generally lamellose, multinucleate; chromatophores parietal, reticulate, with several pyrenoids.

Key to the Species

1. Rhizoidal branches multicellular, abundant. -----*R. fontanum*

Description of the Species***Rhizoclonium fontanum* Kuetzing**

Tiffany and Britton. 1952, P.46, Pl. 13. Fig. 90.

Cells 22-27 x 55-310 μm , with thin walls and 2- or 3-celled rhizoidal branches, each separated from the parent cells by a cross-wall; filaments light-green or yellow-green, much entangled.

Local Distribution.

Sites – 1, 4, Spring, Winter 2004 – 2005.

Genus: *Scenedesmus* Meyen 1829

Coenobia generally flat plates of ellipsoid, oblong, fusiform, acicular or ovoid cells in multiples of 2; cells laterally in contact or rarely connected by short processes, in 1 or 2 rows (sometimes with quadrate arrangement); cells-wall smooth or variously ornamented, with or without terminal or lateral spines or teeth; chromatophore single, parietal. Often occupying the whole cells, pyrenoid generally single.

Key to the Species

1. Cells definitely arranged in a double series -----*S. arcuatus*
1. Cells fusiform, all the same shape in the colony -----*S. obliquus*
 2. Cells cylindric-ovoid to ellipsoid -----*S. quadricauda*
 2. Cells oblong or cylindrical um long -----*S. longus*
3. Cells adjoined along their longitudinal walls -----*S. acuminatus*
3. Cells both fusiform and crescent shaped -----*S. dimorphus*

Description of the Species

Scenedesmus acuminatus Chodat

Prescott, 1951, P. 275, Pl 62, Fig. 16

Cells 3-7um in diameter, 30-40um long; cells strongly lunate, with sharply pointed apices, the convex wall adjoined in-wardly, the concave faces directed outward.

Local Distribution

Site – 4, Autumn, Winter 2004 - 2005.

S. arcuatus Lemmerman

Prescott, 1951, P. 275, Pl 62, Fig. 8.

Cells 4-9 um in diameter, 10-17 um long; Cells arranged to form a curved

(usually double) series of 4-16 oblong-ovate individuals with lateral walls in contact along $\frac{1}{3}$ to $\frac{1}{2}$ their length; cell wall without spines or teeth; poles of the cell broadly rounded.

Local Distribution.

Site – 4, Winter 2005.

S. longus Meyen

Prescott, 1951, P. 278, Pl 63, Fig. 16

Cells 4-6 μ m in diameter, 8-12 μ m long; cells arranged in a single series; apices of both inner and outer cells with 1 or 2 sharp spines which are longer on the outer cells.

Local Distribution.

Site – 4, Autumn 2004.

S. obliquus (Turpin) Kuetzing

Tiffany and Britton. 1952, P. 123, Pl. 35, Fig. 369.

Cells 3-9 x 10-21 μ m, fusiform, with acute apices, in a linear or sublinear series; cells sides in contact straight, free sides of terminal cells various; cells-wall smooth, without teeth or spines.

Local Distribution.

Sites– 1, 4, 7, Spring 2004

S. quadricauda Brebisson

Prescott, 1951, P. 280, Pl 64, Fig. 2

Cells 9-35 μ m long; 3-18 μ m in diameter; usually in 1 series (sometimes in 2 alternating series). Outer cells with a long curved spine at each pole; inner cells without spines or with mere papillae at the apices; cells variable in size.

Local Distribution.

Site – 7, Spring 2004.

***S. dimorphus* (Turpin) Kuetzing**

Tiffany and Britton. 1952, P. 123, Pl. 35, Fig. 370.

Cells 2-5x 18-23 μm ; fusiform with delicately pointed apices, in a linear or alternating series; inner cells asymmetric, outer cells lunate or symmetric; cell-wall smooth, without teeth or spines.

Local Distribution.

Site - 7, Spring 2004.

Genus: *Sphaeroplea* C.A. Agardh 1824

Free-floating filaments of long cylindrical multinucleate units with thickened cross walls. Chloroplast numerous, ovate, and so grouped as to form up to 30 parietal bands or zones within each 'cell' sexual reproduction oogamous; non-motile eggs and anthrizoids produced in unmodified vegetative 'cells' in the same or in separate filaments.

Key to the Species

1. Cells 27-72 μm in diameter 20 times longer than wide-----*S. annulina*

Description of the Species***Sphaeroplea annulina* (Roth) C.A. Agardh**

Prescott. 1951, P. 111, Pl. 12, Figs. 5,8.

Cells 27-72 μm in diameter; 20 times longer than wide; spherical female gametes arranged in a double series with in unspecialized vegetative cells.

Local Distribution.

Site - 5, Spring 2004.

Genus: *Basiacladia* Hoffman and Tilden 1930

Filaments branched; sometimes only in the region of the basal cells; attached to freshwater turtles by rhizoidal outgrowths or by a coralloidal apex; vegetative cells multinucleate, chromatophore somewhat massive or scarcely reticulate, with pyrenoids.

Key to the Species

1. Cells 12-20 μm in diameter-----*B. chelonum*
1. Cells 50 μm in diameter -----*B. crassa*

Description of the Species

Basicladia chelonum (Collins) Hoffman and Tilden

Tiffany and Britton. 1952, P. 48, Pl. 13, Fig. 89.

Cells 30-65 (-120) $\times$ 40-500 μm ; sporangia 30-50 $\times$ 30-200 μm ; basal coenocyte 12-20 μm in diameter and up to 1,000 μm in length; branches usually in the vicinity of holdfast cells; filaments form dark-green matted tufts, 1-8 cm. in length; growing on carapaces of turtles.

Local Distribution.

Sites - 1, 3, 5, 6, 10, Spring, Autumn, Winter 2004 - 2005.

B. crassa Hoffman and Tilden

Tiffany and Britton. 1952, P. 144, Pl. 77, Figs. 11. 13.

Cells 50-120 μm in diameter; thallus composed of tangled prostrate filaments giving rise to up-right filaments as much as 2 cm long; upright branches rigid.

Local Distribution.

Sites - 3, 4, 5, 6, 9, Spring, Summer, Autumn, Winter 2004 - 2005.

Genus: *Ulothrix* Kuetzing 1833

Filament unbranched, not apically attenuated, frequently attached basally; vegetative cell uninucleate, cylindrical or sometimes barrel-shaped; chromatophores band shaped, occupying part or the whole of cell circumference, with one or more pyrenoids; formation of quadrigellate and biflagellate zoospores occurred; sexual reproduction by biflagellate gametes; zygotes germinating into daughter protoplast producing aplanospores or zoospores; haploid filaments producing either gametes only, gametes and zoospores or zoospores only.

Key to the Species

1. Chromatophore median band ----- *U. zonata*
1. Chromatophore otherwise ----- *U. subconstricta*
 2. Cells 16 – 20µm wide ----- *U. tenuissima*
 2. Cells 4.5 – 7µm wide ----- *U. variabilis*

Description of the species

Ulothrix subconstricta West

Prescott, 1951, P. 96, Pl. 6, Fig. 11.

Cells 5.7-9 µm in diameter; 10-36µm long; cells slightly inflated arranged in form of filaments; sometimes enclosed in a gelatinous sheath. Chloroplast a parietal plate extending through about 2/3 of the median region of the cell, sometimes with a pyrenoid.

Local Distribution.

Site – 5, Winter 2005.

U. tenuissima Kuetzing

Prescott, 1951, P. 97, Pl. 67, Fig. 11.

Ramnathan, 1964, P. 34, Pl. 9, Fig. 10.

Butt, 1996, P. 31, Pl. 3, Fig. 6.

Cells 4.5 - 6 µm in diameter and up to 15 µm long. cells cylindrical with out constrictions at the cross walls. chloroplast folded, parietal plate, $\frac{1}{2}$ to $\frac{2}{3}$ the length of the cell, with one pyrenoid.

Local Distribution.

Sites – 1, 9, Spring, Summer, Autumn 2004.

U. variabilis Kuetzing

Prescott, 1951, Pl 6, P. 97, Fig. 1.

Tiffany and Britton, 1952, P. 26, Pl. 4, Fig. 37.

Whitford and Schumacher, 1973, p. 18, Pl. 4, Fig. 7.

Filaments attached or free floating, holdfast somewhat pointed; filaments not constricted; cells 4.5-7 µm thick $\frac{1}{2}$ -1 time as long as broad cylindrical; cell wall thin; plastid parietal, folded plate covering $\frac{1}{2}$ to $\frac{2}{3}$ of cells; pyrenoid one.

Local Distribution.

Sites – 1, 8, Spring, Summer 2004.

U. zonata Kuetzing:

Prescott. 1951, P. 97, Pl. 6, Fig. 14.

Tiffany and Britton. 1952, P. 26, Pl. 4, Figs. 35,36.

Whiftord and Schumacher. 1973, P. 18, Pl. 4, Fig. 7.

Nishat. 1998, P. 74, Pl. 5, Fig. 4.

Cells 11 – 45 x 10 – 100um, cylindrical or swollen, cell wall thick at maturity; chromatophores usually a median band with several large pyrenoids.

Local Distribution

Sites – 1, 2, 3, 4, 5, 6, Spring, Summer, Autumn, Winter 2004 – 2005.

Genus: *Uronema* Lagerheim 1887

Simple, unbranched filaments which are always attached. Cells cylindrical, the basal cell forming an organ of attachment, the terminal cell tapering unsymmetrically to a blunt point. Chloroplast a parietal plate, $\frac{1}{2}$ to $\frac{2}{3}$ the length of the cell; with 1 or 2 pyrenoids.

Key to the Species

1. Cells 5-10 um wide with a parietal chloroplast -----*U. elongatum*

Description of the Species

Uronema elongatum Hodgetts

Prescott. 1951, P. 98, Pl. 5, Fig. 5.

Cells cylindrical, as much as 13 times their diameter in length, and 5-10 um wide. Chloroplast a parietal folded plate extending for $\frac{2}{3}$ of the circumference and $\frac{1}{2}$ to $\frac{2}{3}$ the length of the cells; with 2 pyrenoids. Terminal cell unsymmetrically tapering to a blunt point and often slightly curved.

Local Distribution.

Site – 1, Spring, Autumn 2004.

Genus: Zygnema C.A. Agardh 1824

Filaments simple, with cells 1-9 diameters long, usually with 2 distinctly stellate chromatophores (rarely in some cells 1-4), each with a prominent central pyrenoid, connected by a cytoplasmic isthmus containing the nucleus.

Key to the Species

1. Reproduction mostly by akinetes ----- *Z. sterile*

Description of the Species

***Zygnema sterile* Transeau**

Tiffany and Britton 1952, P. 137, Pl. 40, Fig. 426

Cells 44-54 x 22-69 μ m, with heavy cell-walls, often with an outer pectic layer 6-15 μ m in thickness; usually passing the dormant season as heavy-walled akinetes; rarely reproducing by aplanospores; median spore-wall brown and often distinctly colligate; zygotes not known.

Local Distribution.

Site - 4, Spring 2004.

Genus Microspora Thuret 1850

Filament unbranched, unattached filaments of uniseriately arranged cylindrical or slightly swollen cells; cell walls thin in some species, in other thick and lamellate, composed of 2 sections overlapping in the mid region; filaments fragmenting readily when mature by the separation of the walls at their point of juncture so that H-shaped section and fragments are formed; chloroplast either a dense and irregularly padded parietal plate or net, or an open mesh work form a reticulum; pyrenoids lacking 1 cells frequently forming aplanospores or akinetes; the later globose, with much-thickened walls.

Key to the Species

1. Chloroplast a loose net ----- *M. loefgrenii*
 1. Chloroplast a folded plate ----- *M. pachyderma*

- 2. Cells not constricted at the cross walls -----*M. willeana*
- 2. Cells constricted at the cross walls -----2
- 3. Cell walls thick -----*M. tumidula*
- 3. Cell wall thin -----*M. quadrata*

Description of the Species.

Microspora loefgrenii Lagerheim

Prescott, 1951, P. 107, Pl. 8, Fig.2.

Cells 18-20 um long; short-cylindric; rectangular, as long as broad or a little longer; 15-20um in diameter, Chloroplast a loose net, covering nearly all of the cell wall.

Local Distribution

Sites- 3, 10, Spring, Summer 2004.

M. pachyderma Lagerheim

Prescott, 1951, P. 108, Pl. 8, Fig.3.

Cells cylindrical; 8-12 um in diameter, 14.8 -16 um long. Chloroplast a folded plate, covering most of the cell wall.

Local Distribution

Sites - 1, 3, Spring, Autumn, Winter 2004 - 2005.

M. quadrata Hazen

Tiffany and Britton, 1952, P. 29, Pl. 5, Fig. 52.

Whitford and Schumacher, 1973, P. 20, Pl. 4, Fig. 18.

Cells 5-7 x 3-7 um; wall thin; chromatophore are internally covering entire cell wall; akinete rounded 5-7 um in diameter.

Local Distribution.

Sites - 1, 3, Spring, Winter 2004 - 2005.

***M. tumidula* Hazen 1902**

Prescott. 1951, P.108, Pl.8, Fig.9.

Tiffany and Briton. 1952, P.29, Pl.5, Fig.53.

Whitford and Schumacher.1973, P.19, Pl.4, Fig.21.

Cells 10-14.8 um long; 7.4 um in diameter; walls relatively thick, lamellate, the sections of the wall very evident in the mid region of the cell. Cells cylindrical, slightly constricted at the cross walls; 7.4 um in diameter, 10-14.8um long. Chloroplast densely granular.

Local Distribution

Site – 6, Winter 2005.

***M. willeana* Lagerheim**

Prescott, 1951, P. 108, Pl. 8, Fig. 5.

Tiffany and Britton, 1952, P. 29 Pl. 5, Figs. 48-49.

Whitford and Schumacher, 1973, P. 20, Pl. 4, Fig. 21.

Cells 11-14 x11-22 um; walls thin, section scarcely discernible, cell cylindrical, slightly or not at all constricted at the cross wall; filaments very long, chloroplast usually a dense parietal plate, sometime perforate.

Local Distribution

Site – 3, Spring 2004.

Genus: Mougeotia (C.A. Agardh) Wittrock 1872

Unattached filaments of cylindrical cells without basal-distal differentiation, forming entangled cottony masses, floating or caught among aquatic plants, sometimes attached and epiphytic on submerged calms of scriptures; chloroplast occasionally rod like, usually a broad axial plate, sometime 2 plates connected by a bridge; with either an axial row of pyrenoids or with pyrenoids scattered over the surface; sometimes twisted in the mid region of the cell; conjugation usually scalariform, the zygospore formed in the tube between the gametangias.

Key to the Species

1. Zygotc ovoid to subglobose -----*M. sphaerocarpa*
1. Zygotc ovoid to globose -----*M. scalaris*
 2. Spore-wall smooth -----*M. viridis*
 2. Spore-wall verrucose-----*M. gracillima*
3. Cells sap purplish -----*M. capucina*
3. Cells sap not purplish -----*M. virescens*

Description of the Species

Mogeotia gracillima Wittrock

Tiffany and Britton. 1952, P. 130, Pl. 39, Figs. 415-416.

Cells 5-7 um in diameter, 55-140 um long. Zygosporcs dividing both gametangia; quadrate with concave margins to retuse angles, the wall finely verrucose; 20-25 um in diameter.

Local Distribution.

Site - 3, Autumn 2004.

M. scalaris Hassall

Tiffany and Britton, 1952, P. 130, Pl. 38, Figs. 397,

Fayyaz, 1989, P. 42, Pl. 3, Figs. 2.

Cells 20 - 27 um; in diameter, 40 - 180 um long, chloroplast broad plate with 4 pyrenoids; zygosporcs formed in the tube by scalariform conjugation, and dividing gametangia, globose or broadly ovate; walls smooth and golden brown; 25 - 31 um in diameter, 27 - 40 um long.

Local Distribution

Sites - 1, 2, Spring, Autumn, Winter 2004 - 2005.

M. sphaerocarpa Wille

Tiffany and Britton. 1952, P. 132, Pl. 38, Fig. 389.

Cells 26 - 35um in diameter and 60 - 90um long chloroplast a broad band filing the length of the cells, with several pyrenoids, conjugation scalariform or

lateral, spore wall smooth or yellow.

Local Distribution

Sites – 1, 2, Spring, Summer 2004.

***M. virescens* Borge**

Prescott, 1951, P. 43, Pl. 72, Figs. 1, 2.

Cells 8-11 um in diameter; 30-130 um; long. Zygosporangia formed in the tube, dividing both gametangia; quadrate with concave margins and rounded angles; wall smooth and colorless; 29-34.5 um in diameter.

Local Distribution.

Site – 1, Summer 2004.

***M. viridis* Wittrock**

Prescott. 1951, P.306, Pl.71, Fig.8-10

Tiffany, 1952, P.129, Pl.39, Fig.409-410

Whitford and Schumacher, 1973, P.57, Pl.15,

Cells 6-8 um in diameter; 24-80 um long; chloroplast a broad plate extending the full length of the cell with 4-6 pyrenoids. Zygosporangia formed in the tube, dividing both gametangia; quadrate, the sides concave, corners retuse; median spore wall smooth and colorless; 24-32um in diameter.

Local Distribution

Site – 3, Autumn 2004.

Genus: *Oedogonium* Link 1820

Filaments single, unbranched; vegetative cells uninucleate, cylindrical or sometimes capitellate, nodulate or undulate; chromatophore reticulate, with numerous pyrenoids at larger intersections of reticulum basal cell with holdfast; terminal cell obtuse, apiculate, or hyaline; vegetative cells, except the basal one, capable of division; oogonia and antheridia produced by direct division of vegetative cells.

Key to the Species

1. Cell 13-18 um long and curved ----- *O. illinosense*

Description of the Species***Oedogonium illinoisense* Transeau**

Tiffany and Britton. 1952, P. 86, P. 25, Figs. 241. 243.

Cell 13-18 x 80-140 um; suffultory cell 32-40 x 50-80 um; cells of the filament enlarged; androsporangia 1-5; basal cell elongate; dwarf male slightly curved, on suffultory cell.

Local Distribution.

Site - 7, Summer 2004.

Genus: *Schroederia* Lemmerman 1899

Cells solitary, acicular to fusiform, straight or slightly curved; apices produced into setae which may be fine and tapering or slightly broader, occasionally bifurcate, and sometimes ending in disc; chromatophore single with 1-3 pyrenoids; eyespot present in one species.

Key to the Species

1. Cells acicular to fusiform ----- *S. setigera*

Description of the Species***Schroederia setigera* (Schroeder) Lemmermann**

Tiffany and Britton. 1952, P. 109, Pl 32, Fig. 324.

Cells 2.5 -10.0 x 22.5-52.5 um (without spines); spines 13-45 um long.

Local Distribution.

Site - 1, Autumn 2004.

Genus: *Penium* Brebisson 1844

Cells of medium size, about 10 times longer than wide, cylindric, sub-cylindric, ellipsoidal, or fusiform, with or without a slight median constriction, very

slightly attenuated to the broadly rounded or truncate apices; cellwall colorless or older portions brownish, smooth to punctuate semicell, axial, with longitudinal plates extending to the cell-wall; pyrenoids one or more in a median series.

Key to the Species

1. Cell 10 time longer than ovoid -----*P. margaritaceum*

Description of the Species

Penium margaritaceum (Ehrenberg) Brebisson

Tiffany and Britton. 1952, P. 176, Pl. 51. Fig. 540.

Cells 12.5-26.0 x 73-170 um, 6-12 times longer than wide, cylindric or subfusiform, very slightly attenuated to the truncately rounded apices.

Local Distribution.

Site -10, Autumn 2004.

Genus: *Geminella* Turpin 1828

Filaments unbranched and uniseriate, composed of spheroidal, broadly ovoid, or short cylindrical cells enclosed by a wide gelatinous sheath and usually separated from each other; daughter cells approximated for some time after division to give a paired arrangement.

Key to the Species

1. Cells adjoined to form continuous filaments -----*G. minor*

Description of the Species

Geminella minor (Naegeli) Heering

Tiffany and Britton. 1951, P. 100. Pl. 6, Fig. 17.

Cells adjoined without interruption within a wide gelatinous; homogeneous sheath.

Local Distribution.

Site - 4, Winter 2005.

Genus: *Ankistrodesmus* 1848

Cells acicular to fusiform (sometimes with acute apices and considerably attenuate), straight, curved or sigmoid, solitary or loosely aggregate; chromatophore single, parietal, often without pyrenoids.

Key to the Species

1. Cells fusiform or lunate ----- *A. falcatus*

Description of the Species

Ankistrodesmus falcatus (Corda) Ralfs

Tiffany and Britton. 1952, P. 114, Pl. 31, Fig. 307.

Cells 1.5-4.0 x 20-80 μ m; curved, with acute apices, solitary or in loose fasciculate bundles.

Local Distribution.

Sites - 1, 4, 6, 7, Spring, Winter 2004 - 2005.

Genus: *Chaetophora* Schrank 1789

Filament branched, enclosed in a macroscopic, tough envelop that may be spherical, hemispherical, elongate, or irregularly tuberculate and fasciculate.

Key to the Species

1. Branches not fasciculated at the top ----- *C. attenuata*
 1. Branches lax and spreading ----- *C. elegans*

Description of the Species

C. elegans (Roth) Agardh

Tiffany and Britton. 1952, P. 32, Pl 6, Fig. 62.

cells of main filaments 6-11 x 20-100 μ m; gelatinous colonies globose or subglobose; filaments with lax branching, radiating from center of colony;

Local Distribution.

Site - 4, Autumn 2004.

***Chaetophora attenuata* Hazen**

Tiffany and Britton. 1952, P. 32. Pl 7, Fig. 64.

Cells of main filaments 5-6 x 25-60 μm ; gelatinous colony globose or nearly so; filaments branched, very erect, not apically fasciculate.

Local Distribution.

Sites – 4, 6, Spring, Winter 2004 – 2005.

Genus: *Hydrodictyon* Roth 1800

Cells macroscopic, usually elongate-cylindric (occasionally branched), united into a free-floating, saccate, reticulate coenobium; cells coenocytic with parietal chromatophores, reticulate at first and later diffuse, with pyrenoids; mesh of nets 3-12 sided.

Key to the Species.

1. Cells coenocytic with parietal chromatophores -----*H. reticulatum*

Description of the Species

***Hydrodictyon reticulatum* (Linnaeus) Lagerheim**

Tiffany and Britton. 1952, P.110, Pl. 29, Fig. 289.

Cells 5-250 μm in diameter and up to 1.5 cm. long.

Local Distribution.

Site – 6, Winter 2005.

Genus: *Chlorococcum* Fries 1820

Cells spherical, or angular in masses; terrestrial or aquatic; chromatophore parietal, bell-shaped or spherical, with one pyrenoid when young, diffuse with several pyrenoids when older; cells uninucleate; later multinucleate.

Key to the Species

1. Cell 3-25 μm in diameter-----*C. humicola*

Description of the Species

Chlorococcum humicola (Naeg) Rabenhorst

Tiffany and Britton. 1952, P. 102, Pl. 29, Figs. 277, 278.

Cell 3-25 μm in diameter; solitary or in small aggregates; forming thin coatings on moist places, especially on damp soil.

Local Distribution

Sites – 1, 2, 4, Spring, Autumn 2004.

Genus: *Crucigenia* Morren 1830

Coenobia of 4 cells, or multiples of 4 by daughter coenobial aggregates in a more or less conspicuous gelatinous envelope, forming a flate or slightly curved plate; cells flat, appearing ovoid, angular or semicircular in front view, quadrately arranged with a quadrate or rhomboidal space in the center; cell-wall smooth; chromatophores 1-4, cup-shaped, with or without a pyrenoid.

Key to the Species

1. Coenobium generally regular ----- *C. rectangularis*

Description of the Species

Crucigenia rectangularis (Naegeli) Gay

Tiffany and Britton. 1952, P. 121. Pl. 33, Fig. 333.

Cells 4-7 x 5-10 μm , ovoid to elongate-ovoid, in mutual contact at the poles and sides with a small rectangular opening at the center of the coenobium; chromatophores 1-4 each with a single pyrenoid; multiple coenobia common.

Local Distribution.

Site –9, Autumn 2004.

Genus: *Tetraedron* Kuetzing 1845

Cells solitary (or rarely in temporary aggregates when young), flat and angular (triangular, quadrangular or polygonal) or polyhedral, with angles simple or produced

into simple or furcated spines; wall smooth or not; chromatophores 1 to many; parietal or filling the cells, with or without pyrenoids.

Key to the Species

1. Cells triangular in flat view ----- *T. muticum*
2. Cell triangular (sometimes quadrate) ----- *T. trigonum*

Description of the Species

Tetraedron muticum (A. Braun) Hansgirg

Tiffany and Britton. 1952, P. 118, Pl. 34, Fig. 335.

Cells 5-8 μm thick and 6-20 μm long, flat view square or oblong with concave sides and slightly rounded corners, side view fusiform-elliptic, wall smooth or granulate.

Local Distribution.

Sites - 2, 4, Spring, Autumn 2004.

T. trigonum (Naegeli) Rabenhorst

Tiffany and Britton. 1952, P. 118, Pl. 34, Fig. 340.

Cells without spines 20-40 μm in diameter; 6-16 μm thick; triangular or sometimes 4-sided; angles rounded with mucronate tip, or stout spine 8-10 μm long.

Local Distribution.

Site - 4, Spring 2004.

Genus: *Pithophora* Wittrock 1877

Filaments irregularly branched, with smaller branches toward the apex; cells up to 30 diameters long, with thin walls and bright-green or pale-green chromatophores; plants forming light-green to grass-green masses; akinetes terminal or intercalary, solitary or in series.

Key to the Species

1. Akinetes generally more than 250 μm long ----- *P. oedogonia*

Description of the Species

Pithophora oedogonia (Montagne) Wittrock

Tiffany and Britton. 1952, P.48. Pl. 12, Fig. 86.

Cells 40-120 x 200-3000 μm ; akinetes 80-160 x 232-375 μm ; if intercalary, cask-shaped or lobed and variously distorted when formed at bases of branches, if terminal, ovoid to subconic.

Local Distribution.

Site – 6, Winter 2005.

Genus: *Palmella* Lyngbye 1819

A shapeless, gelatinous mass, containing many spherical cells with out any order of arrangement; individual cell sheaths usually distinct at first, becoming confluent with the colonial mucilage. Chloroplast cup-shaped or bell-shaped, with one pyrenoid. Plants aquatic or terrestrial.

Key to the Species

1. Cells colored by hematochrome, solitary or in group-----*P. miniata*
1. Cells sheath evident 6-14 μm in diameter -----*P. mucosa*

Description of the Species

Palmella miniata Leiblein

Tiffany and Britton. 1951, P. 21, Pl. 3, Figs. 28,29.

Cells 3-40 μm in diameter, colored by hematochrome, solitary or in groups of 2-8 in irregular gelatinous masses; on damp soil.

Local Distribution.

Sites – 1, 10, Spring, Autumn 2004.

P. mucosa Kuetzing

Tiffany and Britton. 1951, P. 83, Pl 3, Figs. 8, 9.

Cells 6-14 μm in diameter; plant mass densely green, forming gelatinous expansions on the substrate; individual cell sheaths evident at first but becoming indistinct;

chloroplast parietal, covering nearly the entire wall.

Local Distribution

Site – 5, Spring 2004.

Genus: Haematococcus C. A. Agardh 1828

Cell solitary, ovoid, sometimes beaked between the 2 flagella; cell-wall peripherally firm and internally often wide and gelatinous, transversed by strands from the protoplast; chromatophore more or less reticulate, with one eyespot, 2-8 pyrenoids; bright red haematochrome often abundant.

Key to the Species

1. Cells 8-30 um in diameter, often brick-red in color-----*H. lacustris*

Description of the Species

Haematococcus lacustris (Girod) Rostafinski

Tiffany and Britton. 1951, P. 20, Pl 2, Fig. 22.

Cells 8-30 um in diameter, often brick-red in color.

Local Distribution.

Site – 2, Autumn 2004.

Genus: Achnanthes Bory 1822

Cells somewhat rectangular and longitudinally bent or curved in girdle view, generally attached by gelatinous stalks, or sessile and united into bundles at the valves, rarely into filaments, sometimes free-floating, solitary; valves generally linear-lanceolate or somewhat elliptic; hypovalve usually concave, with raphe, a distinct central nodule, rather inconspicuous polar nodules, central area sometimes transversely widened into a stauros; epivalve generally convex, with a pseudoraphe; transverse striations, often somewhat radiate, and in some species prominent costae; chromatophores one, two, or numerous and discoid.

Key to the Species

1. Striations pronounced, 13-17 in 10 μm ----- *A. lanceolata*
1. Striations tranverse 20-22 in 10 μm ----- *A. exilis*
 2. Valves constricted toward capitate poles ----- *A. microcephala*
 2. Valves gradually tapering toward poles ----- *A. minutissima*
3. Cells valves broad thick striation ----- *A. inflata*
3. Cells valves broad elliptic ----- *A. lanceolata* Var. *rostrata*

Description of the Species

Achnanthes lanceolata Var. *rostrata* Hustedt

Tiffany and Britton 1952, P. 241, Pl. 64, Fig. 725

Cells 4-10 x 8-40 μm ; valves broad elliptic, abruptly narrowed toward the poles.

Local Distribution.

Site -- 3, Spring 2004.

A. exilis Kuetzing

Tiffany and Britton 1952, P. 242, Pl. 64, Fig. 723.

Cells 4-6 x 13-30 μm ; valves linear-lanceolate gradually narrowed to rounded poles; transverse striations about 20-22 in 10 μm .

Local Distribution.

Site -- 3, Winter 2005.

A. inflata Kuetzing

Leghari MK. 2000, Pl. 14, Fig. 1.

Cells 6-12 x 10-40 μm ; valves broad with thick vertical striations; broad meses equal to all sides; with rectangular shape.

Local Distribution.

Sites -- 1, 6, 10, Summer, Winter 2004 -- 2005.

***A. lanceolata* (Brebisson) Grunow**

Tiffany and Britton 1952, P. 241, Pl. 64, Fig. 724.

Cells 4-10 x 8-40 μm ; valves elliptic-lanceolate, with transverse striations 13-17 in 10 μm ; hypovalve with pronounced thread-like raphe, with central area broad, some shaped spot on one side.

Local Distribution.

Sites – 3, 8, Winter 2005.

***A. microcephala* (Kuetzing) Cleve**

Tiffany and Britton 1952, P. 278, Pl 64, Fig. 726.

Cells 2-3 x 8-26 μm ; valves linear-lanceolate, constricted toward the rounded, capitate poles, with transverse striations 26-36 in 10 μm ; hypovalve with very slender raphe, central area small.

Local Distribution.

Site – 5, Autumn 2004.

***A. minutissima* (Kuetzing) Cleve**

Tiffany and Britton 1952, P. 242. Pl 64, Fig 727.

Cells 2-4 x 5-40 μm ; valves linear-elliptic, slightly narrowed to rounded poles; transverse striations 33-35 in 10 μm ; hypovalve with delicate thread-like raphe, central area small; epivalve with very narrow pseudoraphe, central area absent.

Local Distribution.

Sites – 1, 2, 4, 5, 6, 7, 8, 9, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

Genus: *Amphora* Ehrenberg 1840

Cells usually sessile with concave faces attached in girdle view, broadly elliptic in outline, with truncate ends, girdles usually separated by several punctuate or striate intercalary bands; valves lunate, longitudinally asymmetric, transversely striate; axial field strongly excentric, nearer the concave margin; chromatophores single or 2-4.

Key to the Species

1. Cells without intercalary bands, in girdle view 17-63 μm broad ----- *A. ovalis*
1. Cells with intercalary bands, in girdle view 10-14 μm broad ----- *A. normani*

Description of the Species

Amphora normani Rabenhorst

Tiffany and Britton. 1951, P. 274, Pl.73, Fig. 854.

Cells in girdle view long-elliptic with broadly rounded ends, 10-14 x 16-40 μm ; intercalary bands numerous, about 12 to 10 μm .

Local Distribution

Sites – 1, 3, Autumn, Winter 2004 – 2005.

A. ovalis Kuetzing

Tiffany and Britton. 1951, P. 274, Pl 73, Fig. 855.

Cells in girdle view broadly elliptic with truncate ends, 17-63 x 20-25 μm ; valve lunate, with rather blunt poles.

Local Distribution.

Sites – 1, 2, 3, 4, 6, 9, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

Genus: *Cocconeis* Ehrenberg 1835

Cells transversely curved in girdle view, solitary, epiphytic upon submerged aquatics, especially upon slow-growing filamentsous algae; septa incomplete, intercalary bands absent; valves elliptic, epivalve with axial pseudoraphe, hypovalve with median raphe, straight or sigmoid, with central and polar nodules, with transverse striac or punctuate rows; chromatophore single, laminate, usually with one or two pyrenoids, and adjoining the epivalve.

Key to the Species

1. Raphe sigmoid----- *C. flexella*
2. Hyaline intramarginal ring in hypovalve ----- *C. placentula*
2. No hyaline intramarginal ring in hypovalve ----- *C. pediculus*

Description of the Species

Cocconeis flexella (Kuetzing) Cleve

Tiffany and Britton. 1952, P. 240, Pl. 64, Fig. 737.

Cells 10-26 x 20-80 μm ; irregularly rectangular in girdle view; valves elliptic-lanceolate with blunt ends; striae strictly transverse to somewhat radial 22-30 in 10 μm ; raphe sigmoid, with large rectangular central.

Local Distribution.

Site – 10, Spring, Autumn, Winter 2004 - 2005.

C. placentula Ehrenberg

Tiffany and Britton 1952, P. 241, Pl. 64, Fig. 734.

Cells 8-40 x 11-70 μm ; flat or lightly curved; valves elliptic, transverse striae, 23-25 in 10 μm ; hypovalve with filamentous, straight raphe and intramarginal hyaline ring, central area round, small epivalve with narrow linear pseudoraphe.

Local Distribution.

Sites – 3, 4, 6, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

C. pediculus Ehrenberg

Tiffany and Britton. 1952, P. 241, Pl. 64, Fig. 733.

Cells 10-37 x 15-56 μm , curved; valves broadly elliptic; hypovalve with radially arranged transverse striae, 16-18 in 10 μm ; with round punctae 18-20 in 10 μm ; raphe thread-like, straight with small rounded central area; epivalve with striations 15-17 in 10 μm crossed by irregularly longitudinal rows of large punctae, with narrow linear pseudoraphe scarcely medianly widened.

Local Distribution.

Site – 3, Spring 2004.

Genus: *Cymatopleura* Wm. Smith 1851

Cells generally solitary and free-floating, linear in girdle view with undulate margins, symmetric, valves linear, naviculoid or elliptic, sometimes, medianly

concave, transversely and longitudinally symmetric, transversely undulate on the face with a marginal keel containing a raphe; broadly costate at the periphery, sometimes very short; transverse striations interrupted by longitudinal pseudoraphe, sometimes obscure; chromatophore single, appearing as two expanded lobes, one next each valve, connected by a cytoplasmic bridge; a single auxospore formed by the juncture of the two cells; or a single auxospore from each of the cells without conjugation.

Key to the Species.

1. Valves with out constriction ----- *C. elliptica*
1. Valves with broad median constriction ----- *C. solea*

Description of the Species

Cymatopleura elliptica (Breb) Wm. Smith

Tiffany and Britton 1952, P. 290, Pl. 77, Fig. 909.

Whitford and Schumacher 1973, P. 119, Pl. 58. Fig. 1.

Cells 40-90 x 50-220 μm ; valves broadly elliptic with rounded poles; costae 2-5 in 10 μm and striations, irregularly interrupted, 15-20 in 10 μm .

Local Distribution.

Site - 10, Spring, Autumn 2004.

C. solea (Breb) Wm. Smith

Tiffany and Britton 1952, P. 290, Pl. 77, Fig. 905.

Cells 12-40 x 30-300 μm ; valves broadly linear with very wide median constriction and somewhat cuneate ends; costae 6-9 in 10 μm , with transverse striations perpendicular to the margin.

Local Distribution.

Sites - 3, 7, 10, Spring, Summer, Autumn, Winter 2004 - 2005.

Genus: *Cymbella* 1830

Cells solitary and free-floating or attached at the ends of gelatinous stalks or confined within little branched gelatinous tubes, with parallel sides in girdle view and

smooth girdles, without intercalary bands; valves asymmetric, lunate or nearly elliptic or rhombic or naviculoid, dorsally convex, ventrally concave, straight to somewhat convex; axial field wide or narrow, nearer the ventral margin, with central area with or without dots; raphe curved, with well-defined nodules; transverse striations radiate, sometimes cross-lined; chromatophore a single expanded plate; auxospores formed in pairs between conjugating cells.

Key to the Species

1. Transverse striations not cross-lined -----*C. aequalis*
2. poles not rostrate-capitate -----*C. leptoceros*
3. Central area large, rhombic -----*C. amphicephala*
4. Dost two or more (sometimes lacking) -----*C. cistula*
5. Dot isolated, on ventral side -----*C. tumida*
6. Striatins with about 20 cross-lines in 10 μ m -----*C. cymbiformis*
7. Ventral margin slightly convex-----*C. ventricosa*
8. Transverse striations strongly crossed-lined -----*C. parva*

Description of the Species

Cymbella aequalis Wm. Smith

Tiffany and Britton 1952, P. 276, Pl. 74, Fig. 866.

Cells 4-12 x 15-54 μ m; valves linear-elliptic to linear-lanceolate, somewhat asymmetric, with convex sides, slightly attenuated to rounded poles; axial area narrow; central area not well developed, angular to round; raphe slightly excentric, outwardly cleft; transverse striations radiate, 11-16 in 10 μ m; finely punctuate.

Local Distribution.

Site – 3, Autumn 2004.

C. amphicephala Nageli

Tiffany and Britton, 1952, P. 278, Pl. 74, Fig. 870.

Anjum and Hussain 1983, P. 2, Pl. 1, Fig. 2.

Cells 9-10 x 25-40 μ m; valves lanceolate, somewhat asymmetric, with convex

sides and evident constrictions below the rostrate-capitate poles; raphe straight, slightly excentric; axial area narrow, not enlarged medianly; transverse striations radiate, 12-16 in 10 μ m.

Local Distribution.

Site – 2, Winter 2005.

***C. cistola* (Hemprich) Grunow**

Tiffany and Britton 1952, P. 278, Pl. 74, Fig. 861.

Cells 15-36 x 35-180 μ m; valves strongly symmetric, naviculoid in shape with dorsal sides convex, ventral sided concave with a median expansion; raphe excentric, broad, dorsally convex; axial area narrow, somewhat widened at the middle; transverse striations radiate, 6-9 in 10 μ m.

Local Distribution.

Site – 4, Spring 2004.

***C. cymbiformis* (Kuetzing) Brebisson**

Tiffany and Britton 1952, P. 278, P. 74, Fig. 873.

Cells 9-14 x 30-100 μ m; valves naviculoid, strongly curved, dorsally convex, ventrally nearly straight, with slight median expansion; raphe excentric, broad; axial area narrow, somewhat medianly widened, with ventral median striation ending in an isolated dot; transverse striations radiate, 8-10 in 10 μ m.

Local Distribution.

Sites – 3, 6, 8, Summer 2004.

***C. leptoceros* (Ehr) Grunow**

Tiffany and Britton 1952, P. 278, Pl 74, Fig. 868.

Cells 7-13 x 17-60 μ m; valves lanceolate, with somewhat asymmetric and evidently convex sides, poles sharply rounded; raphe slightly excentric, a little curved; central nodule prominent; axial area narrow, sharply limited; central area not evident; transverse striations very pronounced, 9-12 in 10 μ m, with evident cross lines.

Local Distribution.

Site – 9, Winter 2005.

***C. parva* (Wm. Smith) Cleve**

Tiffany and Britton 1952, P. 279, Pl. 74, Fig. 874.

Cells 8-12 x 25-70 μm ; valves semilanceolate, generally convex dorsally and straight or slightly convex ventrally, gradually attenuated to round poles; raphe excentric, curved; axial area narrow, more or less centrally expanded, transverse striations radiate, 9-13 in 10 μm .

Local Distribution.

Site – 4, Spring 2004.

***C. tumidula* (Brebisson) Van Heurck**

Tiffany and Britton 1952, P. 278, Pl. 74, Fig. 860.

Cells 15-23 x 40-105 μm ; valves asymmetric and curved, broadly naviculoid, with rostrate poles, convex dorsal sides and straight or slightly convex ventral sides having a median expansion; raphe excentric; axial area narrow; central area large, round, with a ventrally placed prominent isolated to transverse striations 8-10 in 10 μm .

Local Distribution.

Site – 3, Autumn 2004.

***C. ventricosa* Kuetzing**

Tiffany and Britton 1952, P. 279, Pl. 74, Fig. 871.

Cells 5-12 x 10-40 μm ; valves somewhat semielliptic, dorsally convex, ventrally straight to slightly convex, with sharply rounded poles; raphe straight, closer to the ventral side except at the poles; axial area narrow, slightly expanded medianly, without isolated dots; transverse striations 12-18 in 10 μm , generally radiate, punctuate, with punctae about 35 in 10 μm .

Local Distribution.

Sites – 4, 9, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

Genus: Eunotia Ehrenberg 1837

Cells rectangular to linear to tabular in girdle view, both girdles and valves strongly ornamented, usually with intercalary bands, free-floating or epiphytic.

Key to the Species

1. Cells 5-10 x 10-50 μm -----*E. pectinalis*

Description of the Species

***Eunotia pectinalis* Rabenhorst**

Tiffany and Britton 1952, P. 240. Pl. 64, Fig. 729.

Cells 5-10 x 10-50 μm , rectangular in girdle view; valve linear, slightly to broadly curved, with nearly parallel sides and rounded poles; transverse striations about 12 in 10 μm .

Local Distribution.

Site – 2, Spring, Winter 2004 – 2005.

Genus: Fragilaria Lyngbye 1819

Cells rectangular in girdle view, symmetric, with 1 or 2 sometimes none intercalary bands, without septa and costae, united into free-floating or sessile colonies; mostly zigzag chains, sometimes flat, stellate colonies; valves linear to fusiform, bilaterally symmetric, usually attenuated at the poles, sometimes capitate, often medianly inflated, rarely constricted; transverse striae usually fine, sometimes coarse; pseudoraphe narrow and indistinct or broad and prominent; chromatophores numerous small discoid bodies or one to four laminate plates with pyrenoids; auxospores formed singly with in the cells.

Key to the Species.

1. Cells medianly constricted -----*F. capucina*
 1. Cells apically constricted -----*F. intermedia*

2. Cell Valves greatly expanded medianly-----*F. construens*
 2. Cell valves broadly to narrowly elliptica -----*F. pinnata*

Description of the Species

Fragilaria capucina Desmazieres

Tiffany and Britton 1952, P. 234, Pl. 62, Fig. 698.

Cells 12-4.5 x 25-100 μ m; united into long chains; valves linear with pseudoraphe and rectangular to elliptic central area; transverse striations fine, about 15 in 10 μ m.

Local Distribution.

Sites – 1, 2, 4, 5, 6, 9, 10, Spring, Summer, Autumn, Winter, 2004 – 2005.

F. construens (Ehrenberg) Grunow

Tiffany and Britton 1952, P. 234, Pl. 62, Fig. 696.

Cells 5-12 x 7-25 μ m; united into rather long compact chains; valves greatly expanded medianly, almost cruciform, with lance-like pseudoraphe; transverse striations 14-17 in 10 μ m, slightly radial.

Local Distribution.

Site – 2, Winter 2005.

F. pinnata Ehrenberg

Tiffany and Britton 1952, P. 234, Pl. 62, Fig. 700.

Cells 2-6 x 3-30 μ m, united into flat chains; valves broadly to narrowly elliptica, with evident linear pseudoraphe; transverse striations prominent, almost rib-like, sometimes radial, 10-12 in 10 μ m, with finer cross lines.

Local Distribution.

Sites – 9, 10, Autumn 2004.

F. intermedia Grun

Hirano 1977, P. 182, Pl. 4, Fig. 2.

Cells 6-6 x 50-77 μ m; valves near with constricted, slightly capitate ends,

central area unilateral; striae 9-11 in 10 μm .

Local Distribution.

Sites – 1, 5, Spring 2004.

Genus: *Gomphonema* C.A Agardh 1984

Cells usually epiphytic on the ends of dichotomously branched gelatinous stalks, sometimes sessile, sometimes solitary and free-floating, transversely asymmetric in both girdle and valve views, girdles smooth without intercalary bands or septa; valves cuneate, clavate, lanceolate, or nearly straight, with one pole capitate or broader than the other, longitudinally symmetric; axial field narrow, straight, with a straight raphe and conspicuous central and polar nodules, striations strictly transverse or somewhat radial, striate composed of a single row of punctate; central area, sometimes extending to the margins, with an asymmetrically placed dot, sometimes several dots; chromatophore a single, lobed plate, usually with a single pyrenoid; auxospores formed in pairs between two conjugating cells.

Key to the Species.

1. Apex acute ----- *G. acuminatum*
1. Apex broad flat ----- *G. acuminatum* var. *coronatum*
2. Length of cells less than 41 μm ----- *G. olivaceum*
2. Length of cells more than 41 μm ----- *G. olivaceum* Var. *calcareum*
3. Cells valves linear-clavate ----- *G. intricatum*
3. Cells valves biconstricted ----- *G. geminatum*
3. Cells valves clavate-lanceolate ----- *G. parvulum*
4. Central area narrowed ----- *G. sphaerophorum*
4. Central area broad ----- *G. constrictum*

Description of the Species

Gomphonema acuminatum Ehrenberg

Tiffany and Britton, 1952, P. 272, Pl. 72, Fig. 830.

Cells 5-11 x 20-70 μm ; valves generally cuneate, expanded near the apex and less so medianly, with cuneate and acute apex and with evidently attenuated base.

Local Distribution.

Site – 6, Spring 2004.

G. angustatum (Kuetzing) grunow

Tiffany and Britton 1952, P. 271, Pl. 72, Fig. 842.

Cells 5-9 x 12-45 μm ; valves slender; clavate-lanceolate, nearly symmetric, with slightly constricted and abruptly rounded poles; axial area narrow but evident; central area broad, one-sided, with isolated dot; transverse striations radial, indistinctly punctuate, 9-14 in 10 μm .

Local Distribution.

Sites - 4, 6, 7, Autumn, Winter 2004 – 2005.

G. intricatum Kuetzing

Tiffany and Britton. 1952, P. 271, Pl. 72, Fig. 836.

Cells 5-9 x 25-70 μm ; valves linear-clavate, expanded medianly, with broadly rounded apex and attenuated base; axial area wide; central area broad, one-sided, with isolated dot and median striations short, often lacking transverse striations somewhat radial, evidently punctuate, about 8-11 in 10 μm .

Local Distribution.

Sites – 4, 5, Spring, Summer, Winter 2004 - 2005.

G. constrictum Ehrenberg

Tiffany and Britton. 1952, P. 271, Pl. 72, Fig. 839.

Cells 8-14 x 25-65 μm ; valves clavate, constricted below the broad rounded apical pole, with attenuated basal pole; axial area narrow; central area broad and

irregularly defined, with a dot on one side; transverse striations 10-12 in 10 μ m, radial, evidently punctuate, alternately long and short in the middle of the valve.

Local Distribution.

Site – 3, Spring 2004.

***G. geminatum* (Lyngbye) C.A. Agardh**

Tiffany and Britton. 1952, P. 270, Pl. 73, Fig. 850.

Cells 25-43 x 60-135 μ m; valves biconstricted, with broad rounded subtruncate poles, the apex considerable larger than the base; axial area linear; central area rounded, with 2 to 4 dots in a longitudinal row; raphe terminally with dorsal hooks; transverse striations, 9-10 in 10 μ m, generally radiate, medianly alternately long and short, coarsely punctuate.

Local Distribution.

Site – 9, Autumn, Winter 2004 - 2005.

***G. olivaceum* (Lyngbye) Kuetzing**

Tiffany and Briton, 1952, P. 270, Pl. 72, Figs. 844. 845.

Cells 5-10 x 15-40 μ m; valves ovoid-clavate, with broadly rounded apex and acutely rounded base; axial area narrow, linear; central area widened transversely without dorf; raphe straight transverse striations 10-14 in 10 μ m.

Local Distribution.

Sites – 1, 4, Spring, Summer, Winter 2004 – 2005.

***G. olivaceum* var. *calcareum* Cleve**

Majeed 1953, P. 31, Pl. 2, Fig. 21.

Salim and Khan 1964, P. 44, Pl. 7, Figs, 62.

Cells 8-10 μ m; valves clavate, broad obtuse apices and drawn out bases; axial area narrow with rectangular central area; raphe straight; parallel, radiating in the middle, 12-14 in 10 μ m.

Local Distribution.

Sites – 2, 5, 6, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

***G. parvulum* (Kuetzing) Grun**

Tiffany and Britton, 1952, P. 272, Pl. 72, Fig. 838.

Whitford and Schumacher, 1973, P. 42, Pl. 56, Fig. 6.

Cells 4-7 x 12-30 μm ; valves clavate-lanceolate, with shortly constricted poles; axial area very narrow; central area small, one-sided, with isolated dot; transverse striations radial, indistinctly punctuate, 14-16 in 10 μm .

Local Distribution.

Sites – 2, 5, 9, Spring, Winter 2004 – 2005.

***G. sphaerophorum* Ehrenberg**

Tiffany and Britton 1952, P. 272, Pl. 72, Fig. 847.

Cells 7-10 x 30-47 μm ; valves elliptic-clavate, sharply narrowing toward a rounded and slightly capitate basal pole and with a much wider knob-like apical pole; axial area narrow, linear; central area small, with a dot at one side; transverse striations 11-16 in 10 μm .

Local Distribution.

Site – 4, Summer 2004.

Genus: *Navicula* Bory 1822.

Cells generally solitary and free-floating, sometimes aggregated into irregularly radiating clusters, rectangular in girdle view, symmetric, with smooth girdles and without intercalary bands; valves elongate, transversely and longitudinally symmetric, usually attenuated toward capitate, rounded or rostrate poles; axial field narrow with distinct, straight raphe and polar and central expansions, nodules small; transverse striations, sometimes somewhat medianly radial, punctuate; two laminate chromatophores, rarely four to eight, infrequently with one or more pyrepsoids; auxospores formed in pairs by the fusion of two gametes from each of two approximated cells.

Key to the Species

1. Diameter of the cell 5-7 μm ----- *N. cryptocephala*
1. Diameter of the cell 8-10 μm ----- *N. gastrum*
1. Diameter of the cell 10-13 μm ----- *N. rhyncocephala*
2. Valves broadly linear ----- *N. dicephala*
2. Valves lanceolate ----- *N. anglica*
3. Valves with nearly parallel sides ----- *N. gracilis*
3. Valves with gradually attenuated sides ----- *N. radiosa*
4. Central area with a single isolated puncta ----- *N. mutica*
4. Central area without an isolated puncta ----- *N. seminulum*
5. Valves 10-20 μm wide, linear ----- *N. bacillum*
5. Valves gradually attenuated, poles rounded ----- *N. cuspidata*
5. Valves 7-15 μm elliptic and lanceolate ----- *N. exigua*
6. Valves with blunt and broad ends ----- *N. viridula*
6. Valves with broadly rostrate ends ----- *N. protracta*
7. Transverse striations interrupted by longitudinal hyaline lines ----- *N. tuscula*
8. Axial area broad, somewhat lanceolate ----- *N. confervacea*

Description of the Species

N. anglica Ralfs

Tiffany and Britton. 1952, P. 256, Pl. 67, Fig. 764.

Cells 8-14 x 20-40 μm ; valves elliptic with short rostrate and slightly capitate ends; transverse striations radial, 9-12 in 10 μm , shortened on either side of the rounded central area.

Local Distribution.

Site - 5, Autumn 2004.

Navicula cryptocephala Kuetzing

Tiffany and Britton 1952, Pl. 67, Fig. 767.

Schumacher and Whitford 1959, P. 103,

Cells 5-7 x 20-40 μm ; valves lanceolate with slender, somewhat capitate ends,

central area elongated transversely.

Local Distribution.

Sites – 2, 3, 5, 6, 8, 9, Spring, Summer, Autumn, Winter 2004 – 2005.

***N. rhyncocephala* Kuetzing**

Tiffany and Britton. 1952, P. 255, Pl. 67, Fig. 782.

Cells 10-13 x 35-60 μ m; valves lanceolate with slender, slightly capitate ends; central area round; transverse striations, medianly radial, polarly convergent, 10-12 in 10 μ m.

Local Distribution.

Site – 1, Spring 2004.

***N. gastrum* Ehrenberg**

Tiffany and Britton. 1952, P. 256, Pl. 67, Fig. 776.

Cells 12-20 x 25-60 μ m; valves broadly elliptic with short rostrate and broadly rounded ends; central area widened, irregular; transverse striations radial, 8-10 in 10 μ m, medianly alternately long and short.

Local Distribution.

Site – 2. Spring, Autumn 2004.

***N. dicephala* (Ehrenberg) Wm. Smith**

Tiffany and Britton, 1952, P. 256, Pl. 67, Fig. 768.

Anjum and Hussain. 1983, P. 4, Pl. 1, Fig. 14.

Cells 8-13 x 20-40 μ m; valves broadly linear to lanceolate with ends abruptly rostrate and somewhat capitate; transverse striations radial.

Local Distribution.

Site – 4, Autumn 2004.

***N. cuspidata* Kuetzing**

Tiffany and Britton. 1952, P. 254, Pl. 68, Fig. 789.

Cells 17-37 x 50-170 μ m; valves rhombo-lanceolate, tapering sharply to

rounded ends, transverse striations, evidently punctuate, 11-19 in 10 μm ; longitudinal striations about 25 in 10 μm and parallel to narrow axial area.

Local Distribution.

Site – 9, Winter 2005.

***N. exigna* (Gregory) Mueller**

Tiffany and Britton, 1952, P. 256, Pl. 67, Fig. 770.

Cells 7-15 x 16-35 μm ; valves elliptic-lanceolate with rostrate, sometimes slightly capitate, ends; central area transversely widened, irregular; transverse striations radial, 12-14 in 10 μm .

Local Distribution.

Site – 2, Summer 2004.

***N. confervacea* (Kuetzing) Grunow**

Tiffany and Britton. 1952, P. 254, Pl. 67, Fig. 766.

Cells 6-8 x 17-25 μm ; valves lanceolate, axial area lanceolate and medianly broad; transverse striations often weak, radial, 20-22 in 10 μm .

Local Distribution.

Site – 4, Winter 2005.

***N. gracilis* Ehrenberg**

Tiffany and Britton, 1952, P. 255, Pl. 67, Fig. 774.

Anjum and Hussain, 1983, P. 4, Pl. 1, Fig. 15.

Cells 6-10 x 36-60 μm ; valves linear with nearly parallel sides rounded ends, central area rectangular; transverse striations, only slightly radial in the middle, 11-12 in 10 μm .

Local Distribution.

Sites – 2, 7, Spring, Summer, Winter 2004 – 2005.

***N. bacillum* Ehrenberg**

Tiffany and Britton. 1952, P. 254, Pl. 67, Fig. 765.

Cells 10-20 x 30-80 μm ; valves linear, with straight or slightly convex sides and broadly rounded ends; transverse striations slightly radial, 12-14 in 10 μm at the middle and 18-20 in 10 μm at the poles; central area rounded.

Local Distribution.

Site – 4, Autumn 2004.

***N. mutica* Kuetzing**

Tiffany and Britton. 1952, P. 254, Pl. 67, Fig. 773.

Cells 7-12 x 10-40 μm ; valves lanceolate with broadly rounded ends, central area rectangular, with a single isolated punctuate, radial, 15-20 in 10 μm .

Local Distribution.

Site – 10, Autumn 2004.

***N. viridula* Kuetzing**

Tiffany and Britton. 1952, P. 255, Pl. 67, Fig. 785.

Cells 10-15 x 40-80 μm ; valves linear-lanceolate with bluntly and broadly rounded ends, central area round; transverse striations, radial in the middle, lightly convergent at the poles, about 10 in 10 μm .

Local Distribution.

Site – 2, Autumn 2004.

***N. protracta* (Grun) Cleve**

Tiffany and Britton, 1952, P. 254, Pl. 67, Fig. 775.

Anjum and Hussain, 1983, P. 4, Pl. 1, Fig. 20.

Cells 7-10 x 20-35 μm ; valves linear with broadly rostrate ends, axial area very narrow; transverse striations slightly radial except at the extremities, 18-22 in 10 μm .

Local Distribution.

Sites – 3, 4, 5, 9, Summer, Spring, Autumn, Winter 2004 – 2005.

***N. solinarum* (Grunow) Cleve**

Tiffany and Britton, 1952, P. 255, Pl. 67, Fig. 777.

Cells 4-5 x 11-16 μm ; valves linear elliptic, with slight median expansion and broadly rounded poles; transverse striations radial, 18-20 in 10 μm .

Local Distribution.

Sites – 5, 6, 8, 9, 10, Autumn 2004.

***N. radiosa* Kuetzing**

Tiffany and Britton, 1952, P. 255, Pl. 67, Fig. 780.

Schumacher and Whitford 1959, P. 114, Pl. 54, Fig. 22.

Cells 10-19 x 40-120 μm ; valves lanceolate, gradually tapering to more or less pointed ends; transverse striations radial, except at the ends, 10-12 in 10 μm .

Local Distribution.

Sites – 1, 2, 3, 4, 5, 8, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

***N. tuscula* (Ehrenberg) Grunow**

Tiffany and Britton. 1952, P. 255, Pl. 67, Fig. 779.

Cells 7-22 x 12-70 μm ; valves elliptic, with more or less rostrate-capitate ends, linear and narrow axial area; transverse striations radial, interrupted by longitudinal hyaline lines, 10-14 in 10 μm .

Local Distribution.

Sites – 4, 5, 10, Spring, Autumn, Winter 2004 – 2005.

***N. seminulum* Grunow**

Tiffany and Britton. 1952, P. 255, Pl. 67, Fig. 783.

Cells 8-12 x 23-41 μm ; valves lanceolate with more or less rostrate, often lightly capitate ends, central area round; transverse striations, medianly alternately long and short, radial, 14-16 in 10 μm .

Local Distribution.

Site – 1, Autumn 2004.

Genus: *Diatoma* Decandole 1805

Cells rectangularly tabular in girdle view, united at the corners into free-floating or sessile, zigzag to linear chains, with one or two intercalary bands, with several transverse septa appearing as transverse costae; valves lanceolate to linear, bilaterally symmetric, with transverse, finely punctuate striations between the costae; pseudoraphe narrow, without median expansion; chromatophores numerous, ellipsoid.

Key to the Species

1. Valves capitate, narrowly linear ----- *D. anceps*
2. Cells 100-300 μm long ----- *D. hiemale*
2. Cells about 2 μm broad ----- *D. elongatum*

Description of the Species

Diatoma anceps (Ehren) Kirchner

Tiffany and Britton 1952, P. 230, Pl. 61, Fig. 683.

Hadi *et al.* 1988, P. 679, Pl. 5, Fig. 4.

Cells 4-8 x 15-100 μm united into nearly closed chains, with few or no intercalary bands; valves linear, capitate at the poles, with narrow pseudoraphe; costae delicate, 3-6 in 10 μm ; transverse striations 18-20 in 10 μm .

Local Distribution.

Sites – 1, 3, 4, 6, 7, 8, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

D. elongatum Agardh

Majeed 1935, P. 13, Pl. 2, figs. 16.17.

Cells 3-5 x 30-45 μm ; rectangular, solitary, in zigzag chains, sometimes linear or stellately united with one another; girdle view long, narrow, slightly drawn in the middle; valve view linear, straight, elongated; apices slightly rounded. Costate, pseudoraphe, narrow, linear.

Local Distribution.

Site – 8, Summer 2004.

***D. hiemale* (Lyngbya) Heiberg**

Tiffany and Britton. 1952, P. 230, Pl. 61, Fig. 684.

Cells 7-13 x 30-100 μm ; united into closed chains, with numerous intercalary bands; valves linear-lanceolate, only slightly narrowed toward the rounded poles; costae prominent, 2-4 in 10 μm .

Local Distribution.

Sites – 5, 6, Autumn, Winter 2004 – 2005.

Genus: *Gyrosigma* Hassal 1845

Cells solitary and free-floating, sometimes in gelatinous tubes, elliptic-lanceolate in girdle view, intercalary bands and septa absent, symmetric; valves sigmoid, transversely and longitudinally symmetric; usually gradually attenuate sometimes narrowly so, rarely with nearly straight sides to broadly rounded poles; raphe sigmoid, with small central and polar nodules; axial area narrow with small, usually rounded central area; transverse striations crossing longitudinal striations at right angles; two chromatophores, regularly or irregularly shaped plates, generally with several pyrenoids.

Key to the Species.

1. Diameter of cells 5-10 μm -----*G. scalproides*
2. Cells tapering to narrowly rounded ends-----*G. kuetzingii*
2. Cells abruptly narrowed to produced -----*G. wormleyi*

Description of the Species***Gyrosigma kuetzingii* (Grun) Cleve**

Tiffany and Britton 1952, P. 269. Pl. 66. Fig. 761.

Cells 12-15 x 80-120 μm ; valves sigmoid, lanceolate, tapering to narrowly rounded ends; transverse striations, radial in the middle, perpendicular to the middle

line elsewhere, 20-23 in 10 μm ; longitudinal striations 24-26 in 10 μm .

Local Distribution.

Sites – 2, 3, 6, 9, Summer, Autumn, Winter 2004 – 2005.

***G. wormleyi* (Sullivan) Boyer**

Tiffany and Britton 1952, P. 268, Pl 66, Fig. 757.

Cells 28-30 x 75-86 μm ; valves lanceolate, strongly sigmoid, abruptly narrowed to produced, subacute ends; raphe sometimes excentric, usually sigmoid; transverse and longitudinal striations 21-23 in 10 μm .

Local Distribution.

Site - 4, Autumn 2004.

***G. scalpoides* (Rabenhorst) Cleve**

Khan 1964, P. 38, Pl. 5 Fig. 50.

Cells 5-10 x 25-70 μm ; valves lanceolate, sigmoid, gradually attenuated to rounded poles; transverse striations, usually perpendicular to the middle line, sometimes medianly radial, 22-24 in 10 μm ; longitudinal striations about 28-30 in 10 μm .

Local Distribution.

Sites - 2, 3, 5, 6, 10, Spring, Summer, Autumn, Winter 2004 - 2005.

Genus: *Nitzschia* Hassal 1845

Cells solitary and free-floating or densely clustered in simple or unbranched gelatinous tubes, elongate-rectangular, or sigmoid in girdle view, with somewhat attenuated poles, rhombic in cross-section. Valves longitudinally asymmetric, very variable in shape; straight, sigmoid, linear, elliptic, somewhat undulate, medianly constricted or not, poles acute or rostrate or capitate often much attenuate; near one margin is a keel with a raphe having small nodules and a row of circular pores ("carinal dots") opening toward the interior of the cell; transversely striate or punctuate; two chromatophores on the same girdle face; two auxospores formed by the conjugation of two cells in a somewhat crossed apposition.

Key to the Species

1. Diameter of cells 5-7 μm -----*N. vermicularis*
1. Diameter of cells 6-8 in 10 μm .-----*N. amphibian*
1. Diameter of cells 9-12 in 10 μm -----*N. angustata*
 2. Poles rounded with straight or slightly convex -----*N. denticula*
 2. Poles long attenuate, not capitate-----*N. acicularis*

Description of the Species

Nitzschia acicularis (Kuetzing) Wm. Smith

Tiffany and Britton 1952, P. 286, Pl. 77, Fig. 904.

Cells 3-4 x 50-150 μm ; medianly spindle-shaped with long attenuated poles, weakly silicified; striations very fine, scarcely visible, keel punctae 17-20 in 10 μm .

Local Distribution.

Site - 10, Autumn 2004.

N. amphibian Grun

Hussain and Anjum 1982, P. 189.

Cells 4-5 x 32-33 μm ; valves linear lanceolate, with tapering, somewhat rounded ends; keel punctae clear; striae well marked, 6-8 in 10 μm .

Local Distribution.

Sites -3, 6, Autumn, Winter 2004 - 2005.

N. angustata (W. Smith) Grun

Anjum and Hussain 1984, P. 85.

Cells 8-9 x 85-88 μm ; valves linear-lanceolate, attenuated to subrostrate ends; striae transverse, 9-12 in 10 μm .

Local Distribution.

Sites - 1, 3, Spring, Autumn, Winter 2004 - 2005.

***N. denticula* Grunow**

Tiffany and Britton 1952. P. 286, Pl. 77, Fig. 902.

Cells 3-8 x 10-100 μ m; rectangular in girdle view, with straight or slightly convex side and rounded poles; valves long-lanceolate, with acutely rounded poles; transverse striations 14-20 in 10 μ m, keel punctae appearing costate, 5-8 in 10 μ m.

Local Distribution.

Site - 3, Spring, Autumn 2004.

***N. vermicularis* (Kuetzing) Hantzsch**

Tiffany and Britton 1952, P. 286, Pl. 76, Fig. 890.

Cells 5-7 x 90-250 μ m; slightly sigmoid with parallel sides in girdle view; valves slender, somewhat naviculoid with capitate poles; striations 30-36 in 10 μ m.

Local Distribution.

Site - 1, 2, 3, 5, 8, 9, 10, Spring, Summer, Autumn, Winter 2004 - 2005.

Genus: *Synedra* Ehrenberg 1830

Cells narrow, much elongated, solitary or in tufted, fan-shaped or radiating colonies, free-floating or epiphytic sessile or stalked; valves linear to lanceolated, straight or sometimes curved, with poles attenuated or not, often capitate; transversely and longitudinally symmetric; transverse striation lateral to a conspicuous narrow pseudoraphe; central smooth area present or not; in girdle view elongate with truncate ends and striated, symmetric; chromatophores two large plates, each usually with three or more pyrenoids; 1-2 auxospores in a single cell, without conjugation.

Key to the Species.

1. Cells 10-25 μ m long, -----*S. parasitica*
1. Cells 27-70 μ m long -----*S. rumpens*
 2. Central pseudonodule absent -----*S. pulehella*
3. Valves with parallel sides and angularly capitate ends -----*S. capitata*
 4. Transverse striae less than 20 in 10 μ m -----*S. tenera*

6. Diameter of valves at poles less than 3 μm ----- *S. acus*
 6. Diameter of valve at poles more than 3 μm ----- *S. ulna*

Description of the Species

Synedra acus (Kuetzing) Hustedt

Tiffany and Britton 1951, P. 237, Pl 63, Fig. 720.

Cells 5-6 x 100-300 μm , solitary; valves linear-lanceolate, becoming needle-like toward the scarcely rounded poles (about 1.5 μm in diameter); transverse striation 12-14 in 10 μm .

Local Distribution.

Sites – 3, 4, 5, 6, 9, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

S. pulchella (Ralfs) Kuetzing

Tiffany and Britton 1952, P. 236, Pl. 63, Fig. 712.

Cells 5-8 x 33-150 μm ; solitary, linear-lanceolate in girdle view; valves lanceolate with rounded or slightly capitate ends and with central pseudonodule; transverse striations 12-15 (sometimes 20) in 10 μm ; conspicuous central area, rectangular to quadrate in shape; pseudoraphe narrow and linear.

Local Distribution.

Site – 3, Autumn 2004.

S. parasitica (Wm. Smith) Hustedt

Tiffany and Britton. 1952, P. 236, Pl. 63, Fig. 712.

Cells 3-5 x 10-25 μm , solitary and epitphytic, rectangular in girdle view; valves lanceolate to rhombo-lanceolate becoming slenderly beaked toward the slightly capitate poles; transverse striations fine, somewhat radial, 16-19 in 10 μm ; no central area; pseudoraphe lanceolate.

Local Distribution.

Sites – 1, 4, Winter 2005.

***S. capitata* Ehrenberg**

Tiffany and Britton 1952, P. 236, Pl. 63, Fig. 722.

Cells 7-10 x 125-500 μm , solitary, broadly linear in girdle view; valve conspicuously linear with parallel edges and angularly capitate ends; transverse striations evident, 8-11 in 10 μm ; pseudoraphe narrowly linear, central area usually not evident.

Local Distribution.

Site – 2, Winter 2005.

***S. tenera* Wm. Smith**

Tiffany and Britton 1952, P. 236, Pl. 63, Fig. 719.

Cells 2-4 x 3-120 μm , solitary; valves narrowly lanceolate, scarcely capitate; transverse striations 19-20 in 10 μm ; pseudoraphe very narrow, linear, with central area generally absent.

Local Distribution.

Site – 3, Autumn 2004.

***S. rumpens* Kuetzing**

Tiffany and Britton 1952, P. 237

Cells 2-3 x 27-70 μm ; solitary, narrowly linear; valves narrowly lanceolate, scarcely capitate; transverse striations 19-20 in 10 μm .

Local Distribution.

Site – 2, Winter 2005.

***S. ulna* Kuetzing**

Tiffany and Britton 1952, P. 237, Pl. 63, Fig. 720.

Cells 2-3 x 27-70 μm , solitary; valves linear-lanceolate, becoming needle-like toward the scarcely rounded poles (about 1.5 μm in diameter); transverse striations 12-14 μm ; pseudoraphe narrow, linear, with central area usually present, rectangular.

Local Distribution.

Site – 3, Summer, Winter 2004 - 2005.

***S. ulna* (Nitzsch) Ehrenberg**

Tiffany and Britton 1952, P. 273, Pl. 63, Fig. 713.

Cells 5-9 x 50-350 μ m, linear in girdle view, with widened extremities, solitary; valves linear to linear-lanceolate, gradually narrowed toward the ends, with broadly rounded poles (2.5-3 μ m in diameter); transverse striations 8-12 in 10 μ m, finely but plainly punctuate; pseudoraphe narrowly linear, with central area varying, often absent.

Local Distribution.

Sites -1, 2, 3, 4, 5, 6, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

***S. ulna* Var. *aequalis* (Kuetzing) Hustedt**

Tiffany and Britton 1952, P. 237, Pl. 63, Fig. 714.

Cells 5-9 x 50-350 μ m; cells with straight sides in valves view, scarcely narrowed toward the rounded ends.

Local Distribution.

Site – 10, Summer 2004.

Genus: *Pinnularia* Ehrenberg 1840

Cells solitary and free-floating, rarely in short filaments, symmetric, rectangular in girdle view, girdles smooth, intercalary bands absent; valves usually with straight sides, sometimes medianly inflated or undulate, generally with broadly rounded poles; axial field usually broad, expanded both polarly and medianly, with complicated straight or sigmoid raphe; costae, with internal openings, smooth, radial or transverse (convergent at the poles), with two longitudinal lines visible in the costate part of the valve; chromatophores two, laminate, usually with pyrenoids.

Key to the Species

1. Cells taper apically, widened in the middle-----*P. major*
1. Cells band like in central area -----*P. parva*

Description of the Species

Pinnularia major (Kuetzing) Wm. Smith

Tiffany and Britton 1952, P. 260, Pl. 68, Fig. 795.

Cells 25-40 x 140-180 μ m; valves with nearly straight sides, tapering apically to rounded poles; axial area about 1/3 of the diameter of the cells, widened in the middle; raphe broad, with a one-sided central pore; transverse striations medianly radial, polarly convergent, 5-7 in 10 μ m.

Local Distribution.

Sites - 3, 4, Autumn 2004.

P. parva Gregory

Tiffany and Britton 1952, P. 257, Pl. 70, Fig. 813.

Cells 7-13 x 40-100 μ m; valves linear, gradually tapering to obtuse, somewhat capitate ends; axial area broad; central area band-like, often extending to the margin; transverse striations, slightly radiate in the middle, convergent at the poles, sometimes bilaterally interrupted in the middle, 8-12 in 10 μ m.

Local Distribution.

Sites - 4, 9, Spring, Autumn 2004.

Genus: *Stauroneis* Ehrenberg 1843

Cells solitary or united valve to valve in short filaments, sometimes with intercalary bands and longitudinal septa visible at the poles; valves with straight raphe having small polar modules and a central nodule thickened and extended laterally to the margins-stauros.

Key to the Species.

1. Cells solitary, without polar septum-----*S. anceps*

Description of the Species

Stauroneis anceps Ehrenberg

Tiffany and Britton 1952, P. 266, Pl. 71, Fig. 822.

Whitford and Schumacher 1973, P. 113, Pl. 53, Fig. 13.

Cells 6-18 x 25-130 μm , solitary, without polar septum; valves elliptic to linear-lanceolate, with rostrate-capitate ends; raphe straight, usually narrow; axial area narrow; stauros a band, wider at the margins; transverse striations all radial, finely punctate, 20-30 in 10 μm .

Local Distribution.

Site - 1, Autumn 2004.

Genus: *Surirella* Turpin 1828

Cells generally solitary and free-floating, rectangular, naviculoid, cuneate or sigmoid in girdle view, girdles smooth; valves linear, elliptic or ovate, sometimes spirally twisted; valve-faces transversely folded, the folds appearing as costae; along each valve-margin is a keel, containing a raphe; transverse costae parallel, either long or short, and delicate striations across the valve face, interrupted by a median longitudinal pseudoraphe; chromatophore single, appearing as two laminate plates.

Key to the Species

1. Costae 9-10 in 10 μm ----- *S. apiculata*
2. Cells 90-110 μm broad ----- *S. oregonica*
3. Spaces between costae very narrow ----- *S. elegans*

Description of the Species

Surirella apiculata Wm. Smith

Tiffany and Britton 1952, P. 294, Pl. 78, Fig. 913.

Cells isopolar, 15-18 x 50-70 μm ; valves rectangular with broadly cuneate to rectangularly narrowed poles; costae alternately long and short, mostly radiate, 9-10 in 10 μm ; an imperfectly known species.

Local Distribution.

Site – 3, Summer 2004.

***S. oregonica* Ehrenberg**

Tiffany and Britton 1952, P. 294, Pl. 79, Fig. 927.

Cells isopolar, 90-110 x 180-125 μm ; valves rhombic, about twice as long as wide, with rounded poles; axial area fusiform; costae radiate, 0.8-1.5 in 10 μm .

Local Distribution.

Site – 9, Winter 2005.

***S. elegans* Ehrenberg**

Tiffany and Britton 1952, P. 296, Pl. 78, Fig. 914.

Cells not isopolar, 40-90 x 130-435 μm ; valves usually ovate, sometimes nearly linear, with both poles broadly rounded; costae 1.2-2.0 in 10 μm . With spaces between the costae slender; wall transversely finely striate; pseudoraphe broad.

Local Distribution.

Site – 9, Winter 2005.

Genus: *Cyclotella* Kuetzing 1834

Cells solitary or filamentous or colonial within a gelatinous envelope, discoid, drum-shaped; valve view circular or sometimes elliptic; ornamentation of valve in two concentric regions; outer zone radially striate or punctate, inner zone smooth or irregularly and finely punctate; girdle view straight or undulate; chromatophores numerous, small and discoid.

Key to the Species

1. Central zone with a ring of triangular depressions -----*C. antiqua*
2. Chains loose, with spaces between cells -----*C. glomerata*

Description of the Species

Cyclotella antiqua Smith

Tiffany and Britton 1952, P. 220, Pl. 58, Fig. 651.

Cells 10-30 μm in diameter; outer concentric zone 2-3 μm wide, striae about 16 in 10 μm and dots about 6 in 10 μm .

Local Distribution.

Site - 3, Autumn 2004.

C. glomerata Bachmann

Tiffany and Britton 1952, P. 220, Pl 58, Fig. 656.

Cells 4-10 μm in diameter, forming colonies of coiled and intertwining chains, cells not touching each other; outer zone with radial striae, about 13-15 in 10 μm ; inner zone smooth or with a ring of short striae in the central part.

Local Distribution.

Sites - 1, 3, 10, Spring 2004.

Genus: *Epithemia* Brebisson 1838

Cells solitary, usually epiphytic upon submerged aquatics, attached at the girdle, rectangular in girdle view, smooth girdles, intercalary bands; valves slightly to strongly curved dorsally convex, ventrally straight to concave, with broadly rounded to capitate and sometimes recurved poles; axial field near ventral side except for V-shaped median extension toward dorsal side; raphe with polar and central nodules.

Key to the Species

1. Costae alternating with 3-8 rows of punctae ----- *E. argus*

Description of the Species

Epithemia argus Kuetzing

Tiffany and Britton 1952, P. 281, Pl. 75, Fig. 878.

Cells 6-15 x 30-130 μm ; valves ventrally straight to slightly concave, dorsally

quite convex, with recurved, broadly rounded ends; costae somewhat radial, 1-2 in 10 um.

Local Distribution.

Sites – 3, 4, Spring 2004.

Genus: *Pleurosigma* Wm. Smith 1852

Cells solitary, elliptic-lanceolate in girdle view, intercalary bands and septa usually absent; valves sigmoid, gradually tapering to rounded or subacute ends; raphe sigmoid, with small central and polar nodules.

Key to the Species

1. Cells medianly angular and polarly and sharp ----- *P. angulatum*

Description of the Species

Pleurosigma angulatum Wm. Smith

Tiffany and Britton 1952, P. 269, Pl. 68, Fig. 791.

Cells 36-50 x 150-360 um; valves sigmoid, rhombo-lanceolate, medianly angular and polarly sharp rounded; central area small, rhombic; striations 18-22 in 10 um.

Local Distribution.

Site – 9, Spring 2004.

Genus: *Rhopalodia* O. Mueller 1895

Cells usually solitary and free-floating, girdle faces broader than valve faces, girdles linnar, nearly elliptic, clavate, medianly inflated, with broadly rounded to nearly flat poles; valves lunate to sickle-shaped, convex margin often inflated, with acute ends.

Key to the Species

1. Cells broadly linear and broadly rounded----- *R. gibba*

Description of the Species

Rhopalodia gibba O. Muell

Tiffany and Britton 1952, P. 282, Pl 75, Fig. 884.

Cells in girdle view broadly linear with median inflation and broadly rounded poles, 18-30 x 35-300 μm ; valves very broadly lunate with almost straight ventral sides and recurved acute poles; costae 6-8 in 10 μm .

Local Distribution.

Site - 9, Winter 2005.

Genus: *Botryococcus* Kuetzing 1849

Colonies free-floating, indefinite in shape, with cells closely appressed and enclosed in a gelatinous or tough membrane; cells usually in several aggregates connected by broad or delicate strands of the colonial membrane; cells spherical, ovoid or cuneate; chromatophore single, parietal, laminate or disciform, yellowish-green to nearly green; affinities uncertain because of reported presence of starch in cells and of pyrenoids in chloroplasts.

Key to the Species

1. Colonial envelope tough, irregular ----- *B. braunii*

Description of the Species

Botryococcus braunii Kuetzing

Tiffany and Britton. 1952, P. 207, Pl. 57, Figs. 642, 643.

Cells 3.5 - 5.5 x 6-11 μm , ovoid or ellipsoid, forming a single layer around a central cavity, held together by an irregular, tough membrane; sometimes brick red in color, due to a reddish oil.

Local Distribution

Sites - 4, 6, Spring 2004.

Genus: *Ophiocytium* Naegeli 1849

Cells epiphytic or free-floating, solitary or colonial, straight, curved or spiral cylinders with round or capitate extremities that may or may not be apiculate or attenuate; chromatophores pale yellowish-green, H-shaped in optical cross-section, without pyrenoids; coenocytic cells with a homogeneous cap at one end and with the remainder of the wall laminate.

Key to the Species

1. Spine apically knobbed ----- *O. majus*

Description of the Species

Ophiocytium majus Naegeli

Tiffany and Britton. 1952, P. 208, Pl. 56, Figs. 636, 637.

Cells 8-25 μm in diameter, scarcely bent, sometimes coiled, solitary, with a single knobbed polar spine.

Local Distribution

Site – 7, Summer, Autumn 2004.

Genus: *Vaucheria* Decondolle 1803

Filaments coenocytic, sparsely or numerously branched, multinucleate, aquatic or terrestrial, often attached by rhizoids, sometimes forming densely tufted, velvety masses; chromatophores numerous, small discoid and rather peripherally located in the protoplasm, each with a pyrenoid, or pyrenoids absent; nuclei minute.

Key to the Species

1. Antheridium 30-40 μm in diameter ----- *V. aversa*
2. Oogonial pedicel nearly equal in length to antheridial ----- *V. hamata*
3. Pedicels supporting sex organs more than 100 μm long ----- *V. longipes*
4. Filament 50-130 μm in diameter ----- *V. sessilis*

Description of the Species

Vaucheria aversa Hassal

Tiffany and Britton. 1952, P. 212, Pl. 37, Figs. 381.

Filaments 50-131 μm in diameter, oogonia obliquely ovoid; sessile or shortly stipitate, 2, rarely more in a series, the beaks usually in opposite directions, mostly erect, 125-250 μm in diameter.

Local Distribution

Site – 8, Spring 2004.

V. hamata (Vaucher) Decandole

Tiffany and Britton. 1952, P. 213, Pl. 37, Figs. 380.

Filaments 38-80 μm in diameter; oogonium solitary 75-90 x 60-75 μm , ovoid to convex-concave, borne on the shorter division of the apparently forking branch, the longer division recurved, bearing the hooked or circinate antheridium.

Local Distribution

Site – 9, Spring 2004.

V. longipes Collins

Tiffany and Britton. 1952, P. 213, Pl. 37, Figs. 386.

Filaments 80-90 μm in diameter; oogonia 35-40 x 70-85 μm , ovoid, slightly oblique, 2-4 on pedicels 20-30 x 100-150 μm , arising a little above antheridium and usually surpassing it; antheridium terminal, cylindric or slightly tapering, hooked or circinate; both sex organs borne at end of a branch.

Local Distribution

Site – 4, Spring 2004.

V. sessilis (Vaucher) Decandole

Tiffany and Britton. 1952, P. 213, Pl. 36, Fig. 378.

Filaments 50-130 μm in diameter; oogonia usually 2, sometimes single, sessile or on very short stalks, ovoid or oblong-ovoid, 70-85 x 75-100 μm , more or less

oblique, with short beak; anthridium between the 2 oogonia or beside the single oogonium, on a short pedicel.

Local Distribution

Sites – 2, 10, Spring 2004.

Genus: *Euglena* Ehrenberg 1838

Cells elongate, oblong, lanceolate or spindle-shaped, ridged or spirally twisted, sometimes atyenuate at posterior end, solitary, motile by means of a single flagellum, usually metabolic; flagellum of varied length, bifurcate at lower end and with a granular swelling at point of branching, each branch terminating in a blepharoplast; periplast more or less plastic and usually nmarked by striations.

Key to the Species

1. Cells widest below the middle -----*E. viridis*
1. Cells widest at the middle -----*E. gracilis*
 2. Posterior end sharp-pointed -----*E. acutissima*
 2. Posterior end both narrowed and truncate-----*E. acus*
3. Chromatophores discoid -----*E. deses*
 4. Striations composed of prominent raised processes-----*E. spirogyra*
5. Periplast not longitudinally striate -----*E. torta*

Description of the Species

Euglena acutissima Lemmermann

Tiffany and Britton. 1952, P. 320, Pl. 87, Figs. 1005.

Cells elongate-cylindric, 7-11 x 120-150 um, anterior end narrowed and truncate, posterior end extended into a colorless sharp-pointed tip, slightly metabolic; periplast longitudinally striate; flagellum 16-20 um long.

Local Distribution

Sites – 1, 9, Spring, Summer, Autumn 2004.

***E. acus* Ehrenberg**

Tiffany and Britton. 1952, P. 321, Pl. 87, Figs. 1003.

Cell cylindric to spindle-shaped, 7-18 x 52-200 μm , anterior end narrowed and truncate, posterior end narrowed into colorless truncate tip, weakly metabolic; periplast with delicate spiral striations; flagellum 0.2 -0.3 body length; reservoir 6-16 μm in diameter, the canal 10-20 μm long.

Local Distribution

Sites – 1, 3, 5, 7, 8, 9, 10, Spring, Summer, Autumn, Winter 2004 – 2005.

***E. gracilis* Klebs**

Tiffany and Britton. 1952, P. 322, Pl. 87, Figs. 1012.

Cell cylindrically fusiform, 6-22 x 35-55 μm , anterior end rounded, posterior end usually with a blunt tip or expanded due to metabolic movement, strongly metabolic, very active, periplast with delicate spiral striations; flagellum about equal to body length; reservoir 5-6 μm in diameter, the canal 5 μm long.

Local Distribution

Site – 5, Autumn 2004.

***E. polymorpha* Dangeard**

Prescott. 1951, P. 393, Pl 85, Figs. 21, 22.

Cells 20-26 μm in diameter, 80-90 μm long; cells metabolic, ovoid-pyriform to subcylindric, narrowed gradually posteriorly to a short, blunt tip; periplast with spiral striations; paramylon bodies small ovoid grains

Local Distribution

Sites – 1, 10, Spring, Autumn 2004.

***E. splendor* Schmitz**

Tiffany and Britton. 1952, P. 220, Pl. 87, Fig. 1004.

Cell oval to short-cylindric, 25-40 x 50-70 μm , anterior end usually rounded, posterior end rounded or with a short tip, metabolic; periplast with spiral striations; flagellum of body length or longer; reservoir 7-9 μm in diameter.

Local Distribution.

Site – 2, Autumn 2004.

***E. torta* Stokes**

Tiffany and Britton. 1952, P. 317, Pl. 87, Figs. 1004.

Cell elongate-fusiform, 60-63 μm long, spirally twisted, not metabolic; periplast smooth; flagellum about equal to body length; paramylum bodies 2, long and rod-shaped, one anterior and one posterior to the nucleus.

Local Distribution.

Site – 9, Summer 2004.

***E. deses* Ehrenberg**

Tiffany and Britton. 1952, P. 321, Pl. 87, Figs. 1007.

Cell elongately cylindric or slightly flattened, 11-24 x 70-200 μm , anterior end round or slightly truncate, posterior end blunt and colored, metabolic movement sluggish; periplast with delicate spiral striations; flagellum short; reservoir canal slightly curved, 8-14 μm long; eyespot evident, crescent-shaped, 4-7 μm long.

Local Distribution

Sites – 3, 5, 8, 9, Summer, Autumn 2004.

***E. spirogyra* Ehrenberg**

Tiffany and Britton. 1952, P. 320, Pl. 87, Figs. 1011.

Cell cylindric or flattened, 6-35 x 80-150 μm , anterior end rounded and slightly narrowed, posterior end produced into an acute and frequently curved tip, metabolic; periplast yellowish-brown, spirally striate with pyramidal to conical and frequently truncate processes, prominent striations often alternating with less prominent ones; flagellum 0.2 body length or shorter; reservoir 7-12 μm in diameter.

Local Distribution

Site – 10, Winter 2004.

Genus: *Phacus* Dujardin 1841

Cells solitary, usually flattened, the flat faces oval or elliptic in outline, sometimes twisted along the longitudinal axis, motile by means of a single flagellum; periplast rigid, not metabolic, smooth, longitudinally or spirally striate, or covered with wart-like processes; posterior end sometimes bearing a straight, twisted, or uncinat spine of variable length; bifurcate flagellum, reservoir with canal similar to *Euglena*; chromatophores numerous, discoid, pointed; eyespot may be present at anterior end.

Key to the Species

1. Dorsal keel extending full length of cell -----*P. triqueter*
2. Flat or slightly twisted along longitudinal axis-----*P. longicauda*
3. Posterior spine straight or slightly oblique-----*P. acuminata*

Description of the Species

Phacus triqueter (Ehrenberg) Dujardin

Tiffany and Britton. 1952, P. 323, Pl. 88, Figs. 1019.

Cell 29-70 x 40-100 μ m; broadly ovoid, slightly twisted, posterior spine short and uncinat; periplast longitudinally striate; flagellum approximately body length; dorsal keel extending from anterior end to middle of cell; paramylum body usually single, large, discoid.

Local Distribution

Sites- 5, 9, Autumn 2004.

P. acuminata Stokes

Tiffany and Britton. 1952, P. 323, Pl. 88, Figs. 1024.

Cell 20-30 x 25-40 μ m; oval in outline or appearing triangular in some cells having straight lateral margins, very thin, greatest width below the middle, periplast longitudinally striate; flagellum approximately body length; usually one large paramylum body, sometimes a second smaller one near the base of spine; shallow dorsal furrow extending 0.5 -0.7 of body length.

Local Distribution

Sites – 4, 10, Spring, Autumn 2004.

P. logicauda (Ehrenberg) Dujardin

Tiffany and Britton. 1952, P. 323, Pl. 88, Figs. 1020.

Cell 45-70 x 85-170 μm ; posterior end bearing spine up to 70 μm long; periplast longitudinally striate; ovoid, flat or slightly twisted along longitudinal axis, flagellum approximately body length; one large paramylum body sometimes accompanied by several smaller ones; chromatophores discoid.

Local Distribution

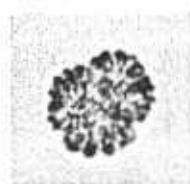
Sites – 4, 5, 6, 8, 10, Summer, Autumn, Winter 2004 – 2005.

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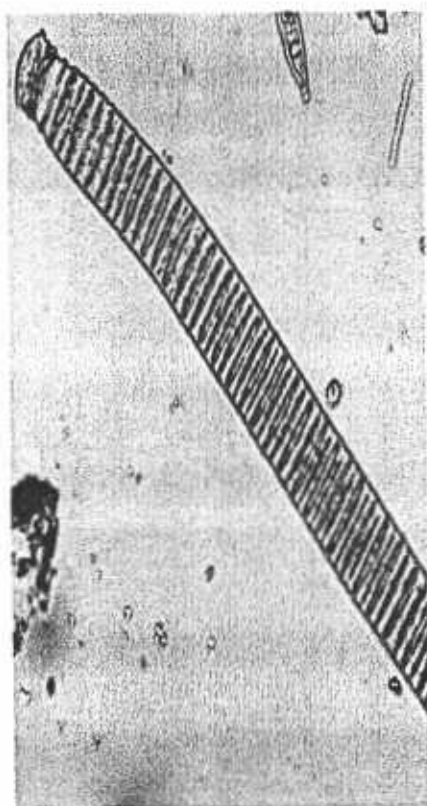
Plate 1

Text Page	Fig. No	Plants
139	1	<i>Oscillatoria formosa</i> x 750
140	2	<i>O. limosa</i> x 335
141	3	<i>O. tenuis</i> x 450
141	4	<i>O. princeps</i> x 250
142	5	<i>Gomphosphaeria lacustris</i> x 1950
143	6	<i>Aphanocapsa grevillei</i> x 1500
144	7	<i>Lyngbya aestuarii</i> x 275
146	8	<i>L. versicolor</i> x 375
147	9	<i>Phormidium foveolarum</i> x 850
147	10	<i>P. fragile</i> x 450

Plate 1



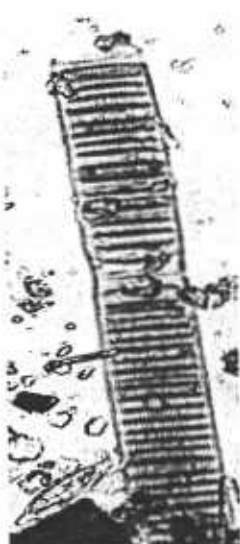
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CONTENTS

Plate 2

Text Page	Fig. No	Plants
147	1	<i>Phormidium inundatum</i> x 450
148	2	<i>P. purpurascens</i> x 775
148	3	<i>P. uncinatum</i> x 700
149	4	<i>Spirulina subtilissima</i> x 1050
151	5	<i>Microcystis marginata</i> x 1000
151	6	<i>Merismopedia convoluta</i> x 1250
152	7	<i>M. punctata</i> x 1200
153	8	<i>Anabaena gelatinicolax</i> 1800
153	9	<i>A. viguieri</i> x 1075
154	10	<i>Chroococcus turgidus</i> x 1430

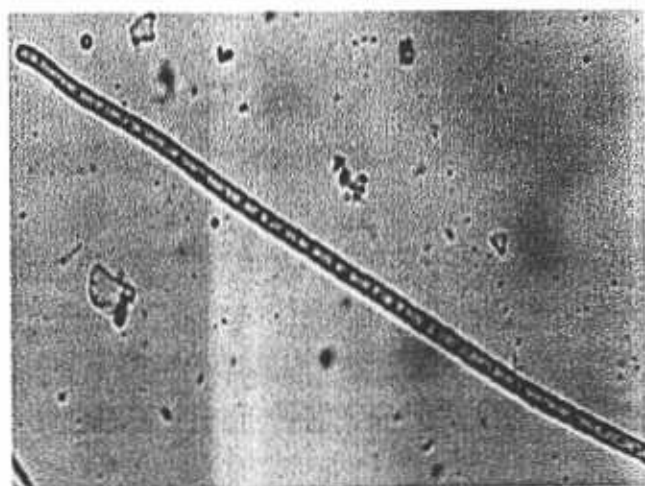
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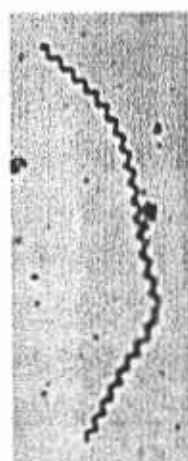
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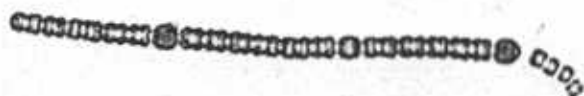
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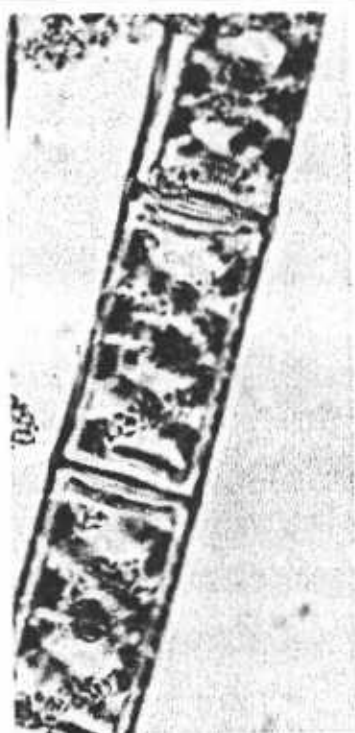
Plate 3

Text Page	Fig. No	Plants
157	1	<i>Spirogyra aequinoctialis</i> x 540
158	2	<i>S. condensata</i> x 280
159	3	<i>S. crassa</i> x 250
159	4	<i>S. daedaleoides</i> x 200
159	5	<i>S. ellipsospora</i> x 470
160	6	<i>S. fluviatilis</i> x 400

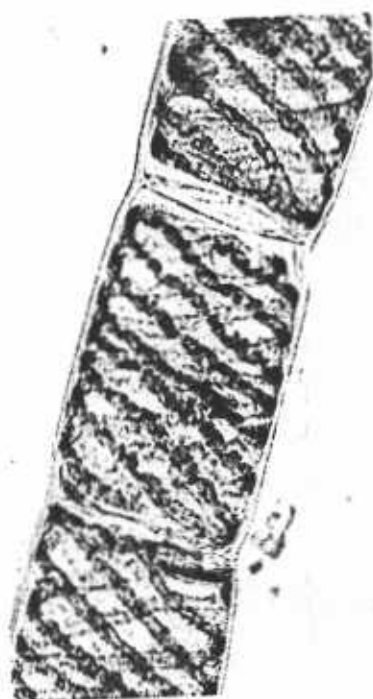
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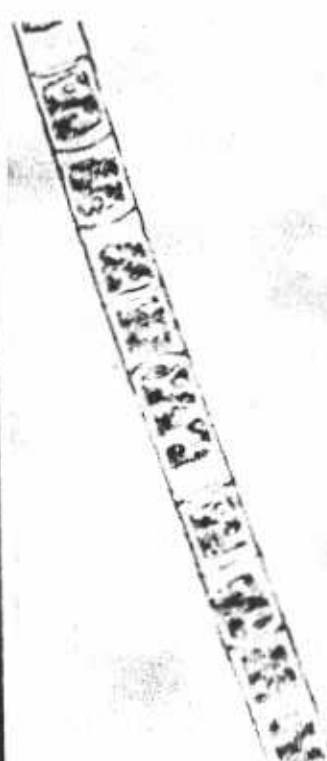
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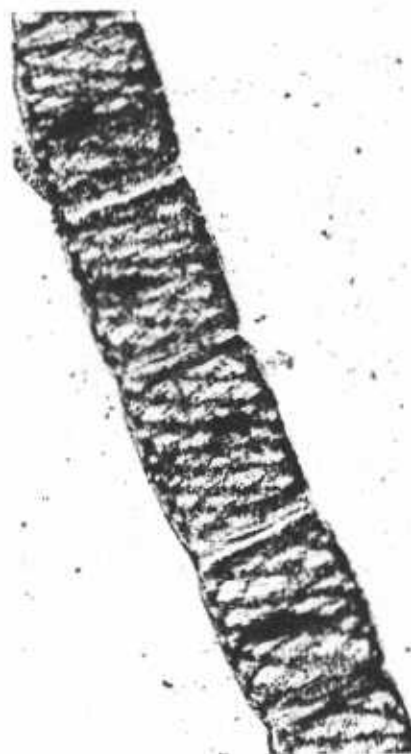
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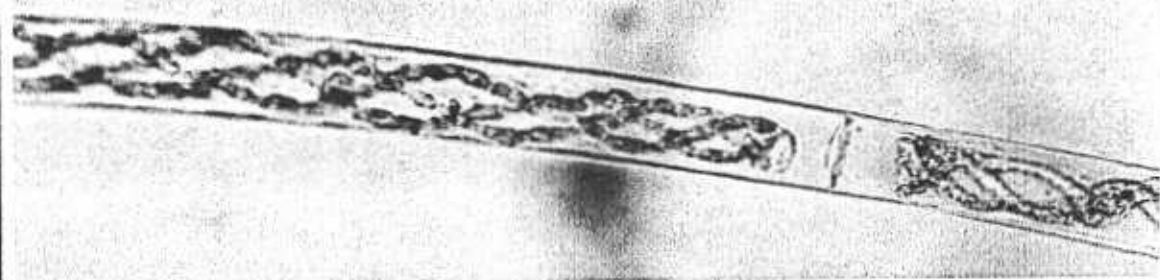
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Plate 4

Text Page	Fig. No	Plants
160	1	<i>Spirogyra majuscula</i> x 270
161	2	<i>S. mirabilis</i> x 250
161	3	<i>S. porticalis</i> x 275
161	4	<i>S. pratensis</i> x 270
162	5	<i>S. punctiformis</i> x 255
162	6	<i>S. rectangularis</i> x 220

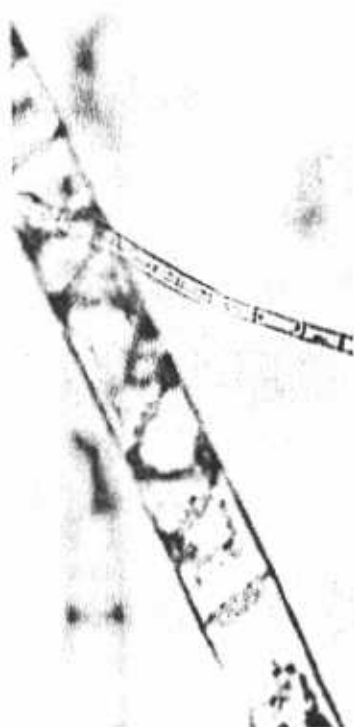
Plate 4



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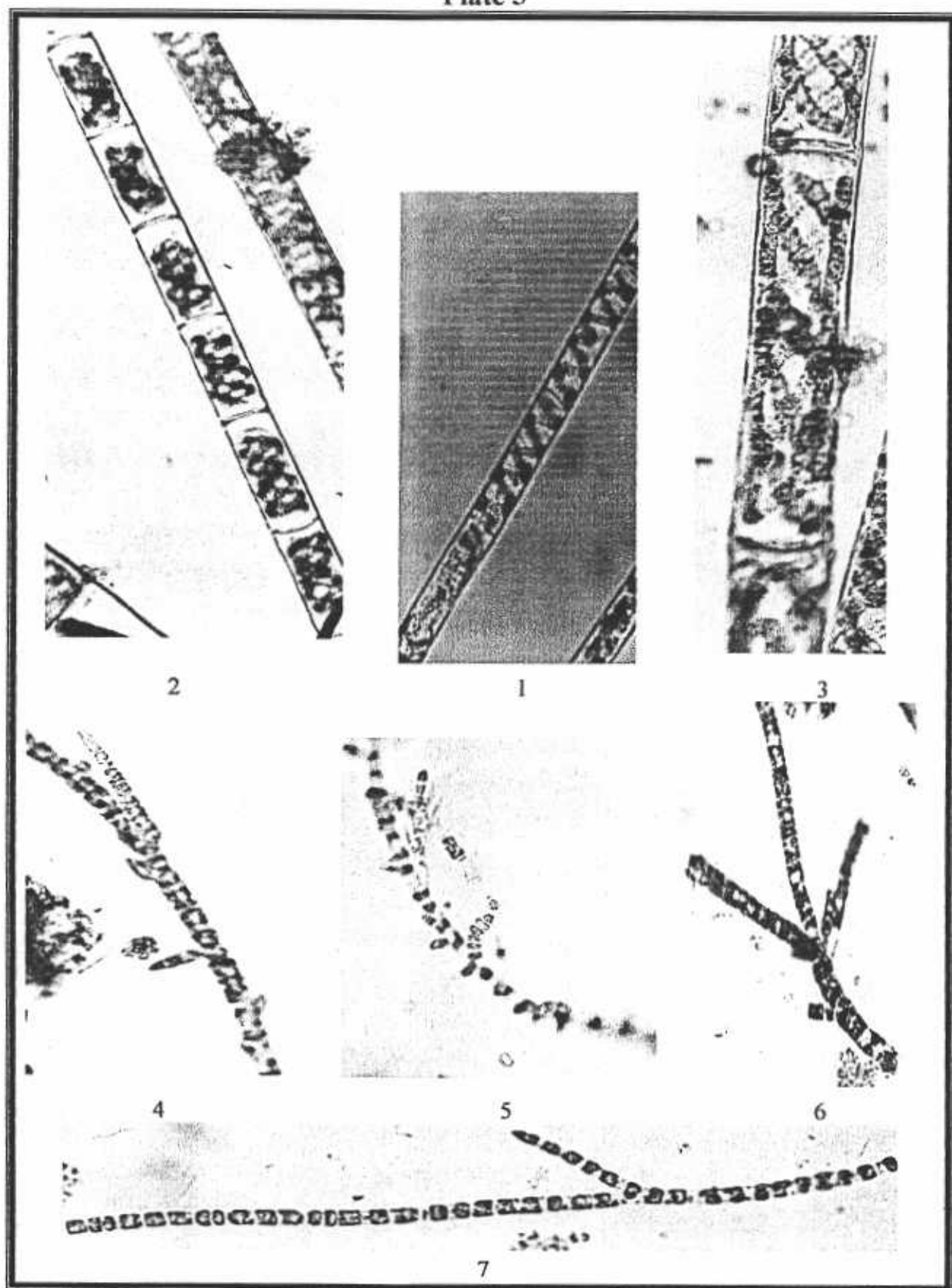
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Plate 5

Text Page	Fig. No	Plants
162	1	<i>Spirogyra scrobiculata</i> x 250
162	2	<i>S. setiformis</i> x 200
163	3	<i>S. subsalsa</i> x 190
164	4	<i>Stigeoclonium lubricum</i> x 265
164	5	<i>S. pachydermum</i> x 445
165	6	<i>S. subsecundum</i> x 500
165	7	<i>S. tenue</i> x 350

Plate 5



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Plate 6

Text Page	Fig. No	Plants
166	1	<i>Cladophora fracta</i> x 65
167	2	<i>C. glomerata</i> x 70
168	3	<i>Closterium acerosum</i> x 210
169	4	<i>C. diana</i> x 270
169	5	<i>C. ehrenbergii</i> x 250
169	6	<i>C. lanceolatum</i> x 220
170	7	<i>C. leibleinii</i> x 230
170	8	<i>C. littorale</i> x 320
170	9	<i>C. moniliferum</i> x 450

Plate 6

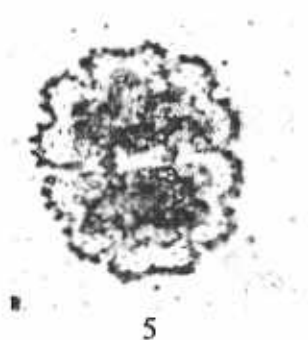


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Plate 7

Text Page	Fig. No	Plants
172	1	<i>Asterococcus limneticus</i> x 1450
172	2	<i>Chalamydomonas globosa</i> x 1650
173	3	<i>Characium ambiguum</i> x 1475
174	4	<i>Cosmarium nitidulum</i> x 1630
175	5	<i>C. subimpressulum</i> x 1250
176	6	<i>Oocystis elliptica</i> x 2500
176	7	<i>O. solitaria</i> x 2250
177	8	<i>Pediastrum duplex</i> x 2025
178	9	<i>P. simplex</i> x 2265
178	10	<i>P. tetras</i> x 2000
178	11	<i>Rhizoclonium fontanum</i> x 250
179	12	<i>Scenedesmus acuminatus</i> x 1950
179	13	<i>S. arcuatus</i> x 1400
180	14	<i>S. longus</i> x 1800
180	15	<i>S. obliquus</i> x 1550
181	16	<i>Sphaeroplea annulina</i> x 1130

Plate 7



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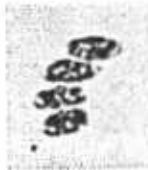
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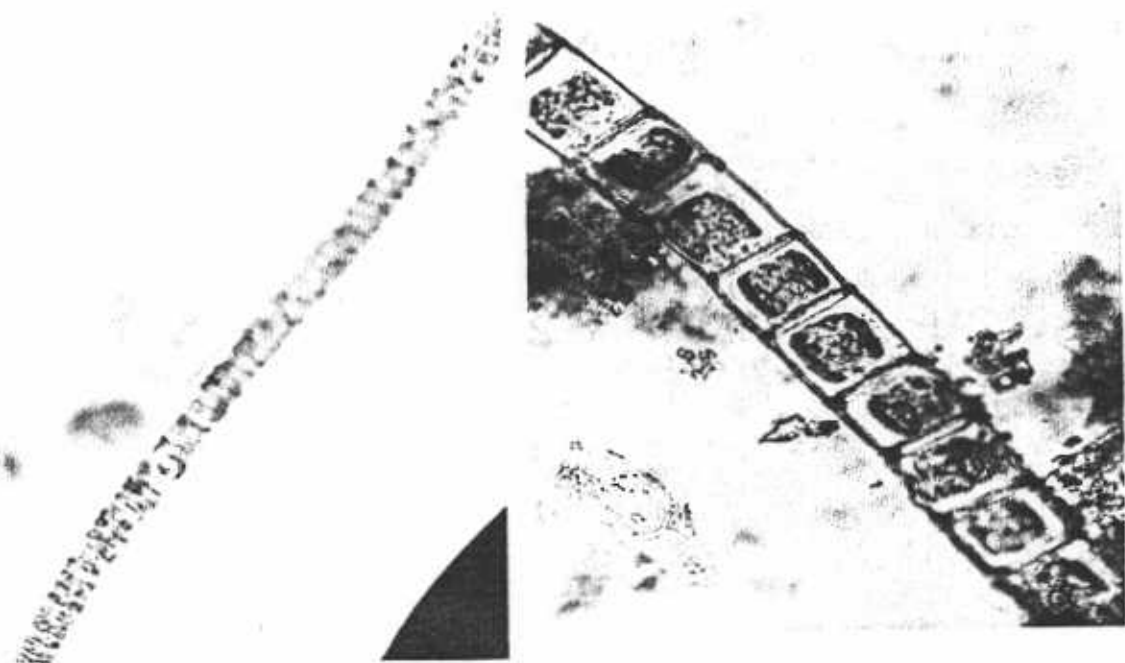
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Plate 8

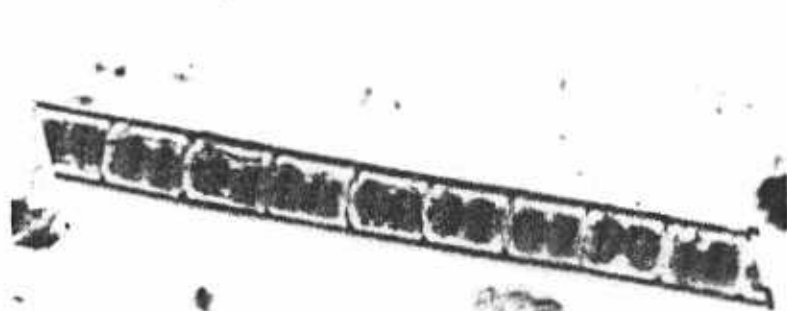
Text Page	Fig. No	Plants
182	1	<i>Basicladia chelonum</i> x 100
182	2	<i>B. crassa</i> x 80
183	3	<i>Ulothrix tenuissima</i> x 260
184	4	<i>U. zonata</i> x 250
184	5	<i>Uronema elongatum</i> x 600
185	6	<i>Zygnema sterile</i> x 375

Plate 8



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CONTENTS

Plate No. 9

Text Page	Fig. No	Plants
186	1	<i>Microspora loefgrenii</i> x 105
186	2	<i>M. pachyderma</i> x 150
186	3	<i>M. quadrata</i> x 135
187	4	<i>M. willeana</i> x 125
188	5	<i>Mougeotia gracillima</i> x 175
188	6	<i>M. spaerocarpa</i> x 200
189	7	<i>M. virescens</i> x 165

Plate 9



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Plate 10

Text Page	Fig. No	Plants
190	1	<i>Oedogonium illinoisense</i> x 450
190	2	<i>Schroederia setigera</i> x 1650
191	3	<i>Penium margaritaceum</i> x 740
191	4	<i>Geminella minor</i> x 930
192	5	<i>Ankistrodesmus falcatus</i> x 1300
192	6	<i>Chaetophora elegans</i> x 70



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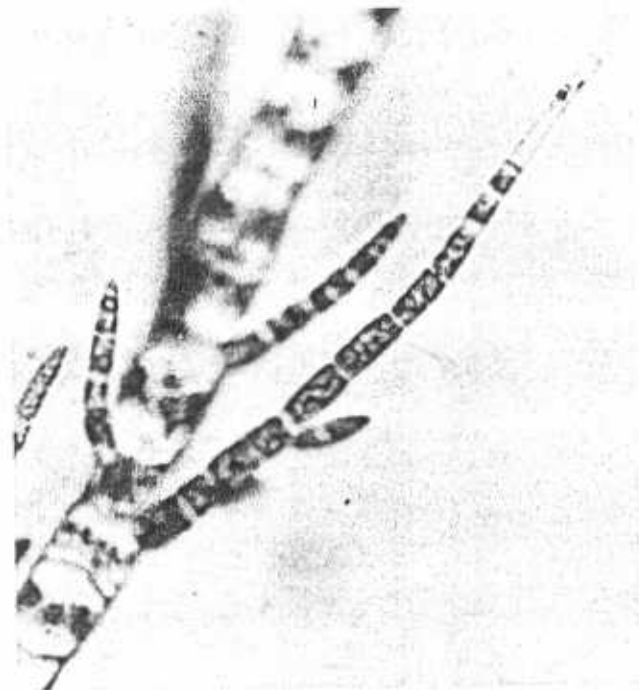


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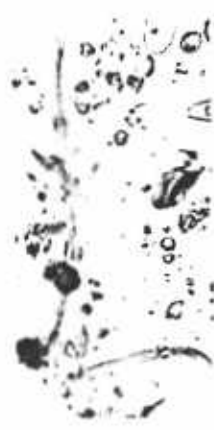
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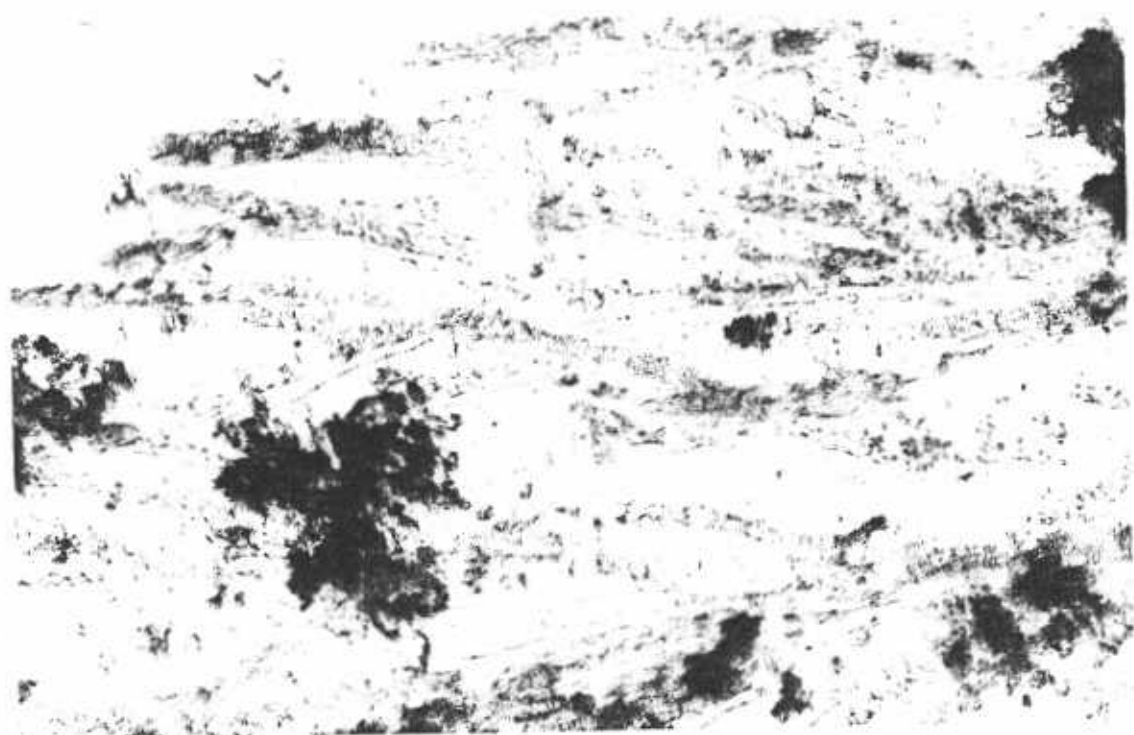
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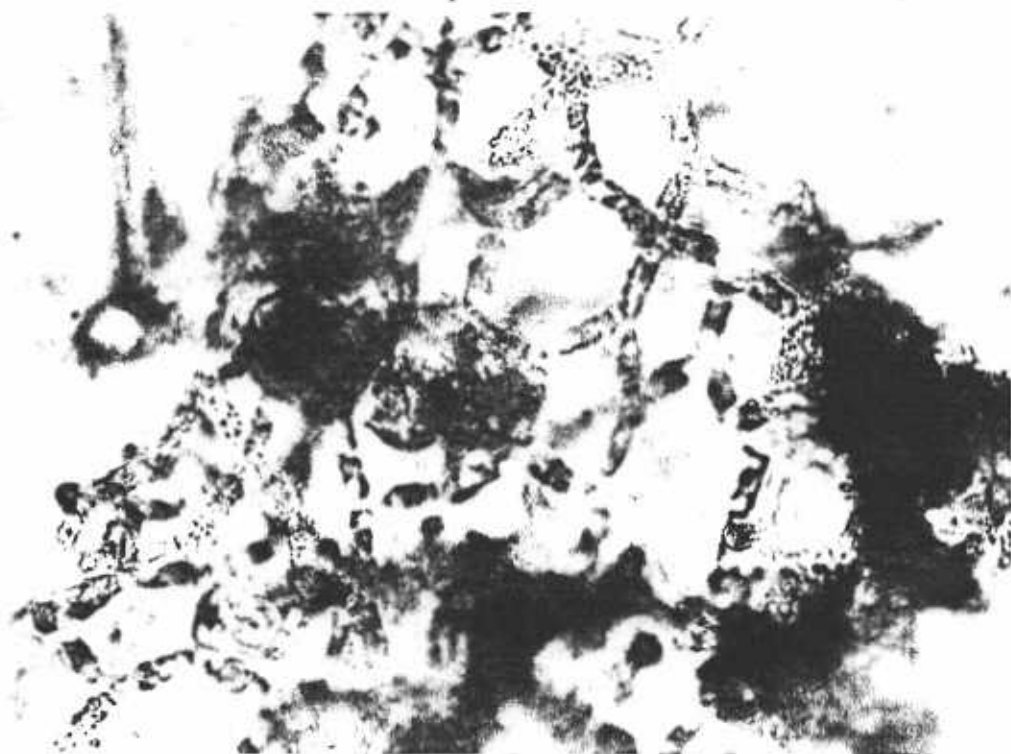
Plate 11

Text Page	Fig. No	Plants
193	1	<i>Chaetophora attenuata</i> x 200
193	2	<i>Hydrodictyon reticulatum</i> x 900

Plate 11



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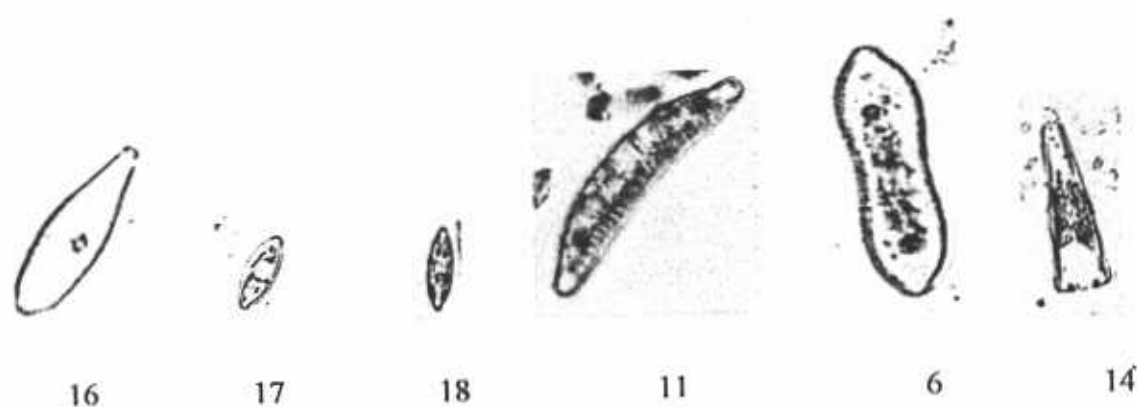
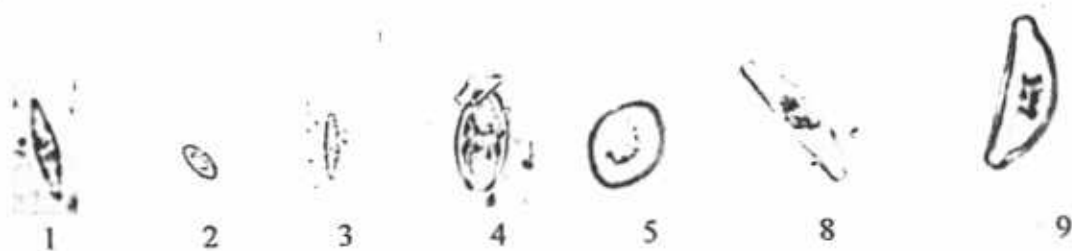
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Plate 12

Text Page	Fig. No	Plants
198	1	<i>Achnanthes exilis</i> x 1600
199	2	<i>A. lanceolata</i> x 1850
199	3	<i>A. minutissima</i> x 2150
200	4	<i>Amphora ovalis</i> x 1025
201	5	<i>Cocconeis placentula</i> x 2000
202	6	<i>Cymatopleura solea</i> x 1325
203	7	<i>Cymbella aequalis</i> x 1275
203	8	<i>C. amphicephala</i> x 1150
204	9	<i>C. cistola</i> x 1025
205	10	<i>C. ventricosa</i> x 1900
206	11	<i>Eunotia pectinalis</i> x 975
207	12	<i>Fragilaria capucina</i> x 1500
207	13	<i>F. construens</i> x 2350
209	14	<i>Gomphonema acuminatum</i> x 1025
209	15	<i>G. angustatum</i> x 1075
209	16	<i>G. constrictum</i> x 925
210	17	<i>G. olivaceum</i> x 1100
211	18	<i>G. parvulum</i> x 1275
212	19	<i>Navicula anglica</i> x 1800
212	20	<i>N. cryptocephala</i> x 2050
214	21	<i>N. gracilis</i> x 1900
215	22	<i>N. mutica</i> x 1875
216	23	<i>N. radiosa</i> x 2000
216	24	<i>N. tuscula</i> x 1650

Plate 12

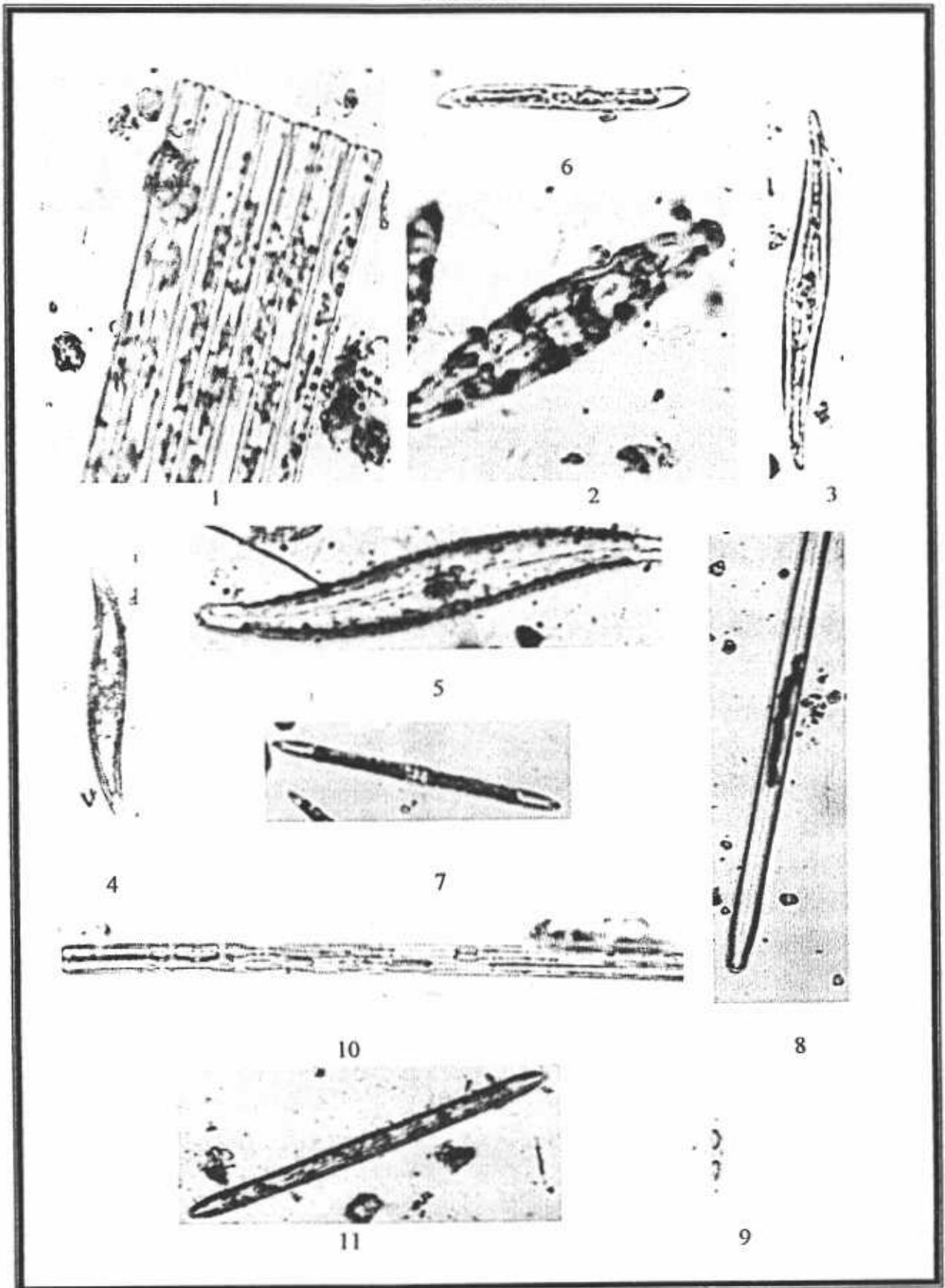


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Plate 13

Text Page	Fig. No	Plants
217	1	<i>Diatoma anceps</i> x 1750
218	2	<i>D. hiemale</i> x 1075
218	3	<i>Gyrosigma kuetzingii</i> x 1900
219	4	<i>G. scalproides</i> x 2200
219	5	<i>G. wormleyi</i> x 1800
220	6	<i>Nitzschia amphibian</i> x 2000
222	7	<i>Synedra acus</i> x 1050
222	8	<i>S. pulchella</i> x 1125
223	9	<i>S. rumpens</i> x 1200
223	10	<i>S. ulna</i> x 925
224	11	<i>S. ulna</i> Var. <i>aequalis</i> x 1050

Plate 13



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Plate 14

Text Page	Fig. No	Plants
225	1	<i>Pinnularia major</i> x 525
226	2	<i>Stauroneis anceps</i> x 850
227	3	<i>Surirella elegans</i> x 650
227	4	<i>S. oregonica</i> x 935
230	5	<i>Botryococcus braunii</i> x 350
231	6	<i>Ophiocytium majus</i> x 725
232	7	<i>Vaucheria sessilis</i> x 200
234	8	<i>Euglena acus</i> x 875
234	9	<i>E. gracilis</i> x 925
234	10	<i>E. polymorpha</i> x 975
234	11	<i>E. splendor</i> x 975
235	12	<i>E. torta</i> x 825
236	13	<i>Phacus acuminata</i> x 875
237	14	<i>P. logicauda</i> x 800

Plate 14

