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Research Article

Diversity of freshwater algae in some selected sites in river Naguman district Charsadda, Khyber Pakhtunkhwa, Pakistan

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Abstract

In the current research work algal collection was made at different sites of River Naguman near its joining point with Sardaryab. Various sites expected to have rich algal flora across an area of 10 Km^2 were selected to obtain algal samples. A total of 38 species belonging to 16 genera of freshwater algae were collected and identified. Keys were constructed both at generic and specific levels for identifications and description. Out of these 16 genera Chlorophyta contributed 50%, Bacillariophyta 25%, Charophyta 6.25%, Xanthophyta 12.5% and Cyanophyta contributed 6.25% genera. Chlorophyceae were the most common represented by 60.53% species, Bacillariophyceae were next with 18.42% species, Charophyceae by 5.26%, Xanthophyceae by 5.26% and Cyanophyceae were represented by 10.53% species. The most dominant genus in terms of species was *Spirogyra* with eight species 21.1%. *Cladophora* and *Oscillatoria* were next dominants with 10.5% species. *Rhizoclonium*, *Zygnema* and *Nitzschia* were each represented by 7.9%. *Closterium*, *Diatoma* and *Chara* each contributed 5.3% species. All the remaining genera including *Ulothrix, Mougeotia*, *Desmidium*, *Cyclotella*, *Tabellaria, Ophiocytium* and *Vaucheria* each contributed 2.6% species.

Keywords: River Naguman; Algae; Chlorophyta; Bacillariophyta; Charophyta; Xanthophyta; Cyanophyta

Introduction

Algal collection was done in some selected sites in River Naguman, District Charsadda. District Charsadda lies between 34-03' and 34-38' north latitudes and 71-28' and 71-53' east longitudes. Charsadda is located in the west of Khyber Pakhtunkhwa and is bounded by Malakand District on the north, district Mardan on the east, Nowshera and Peshawar districts on the south and Mohmand Agency of the Federally Administered Tribal Areas on the west. The district covers an area of 996 square kilometers.

Algae are chlorophyll bearing organisms which are thalliod in nature. Algae are divided into different groups on the basis of characteristic pigments and resulting colours of thalli. Brown algae are the largest type of algae. The brown or yellow-brown colour is due to fucoxanthin. Red algae often have brilliant colours due to phycoerythrin and phycocyanin. Green algae contain chlorophyll-a and chlorophyll-b in the same proportion as in higher plants **[1]**. Many species of algae are involved in algal blooms and these species change over time based on temperature, light, nutrients, and other factors **[2]**. According to **[3]** attached algae may also live as epiphytes on other living organisms including larger attached algae, large planktonic colonial algae and higher plants. Fresh algae, frozen or heat killed algae, algae powder and baker's yeast are some of the food sources that have been exploited for the culture of rotifers **[4]**. Freshwater harmful algal blooms (HABs) can have serious ecological, toxicological and physiological effects on aquatic and terrestrial biota. Microalgae are unique photosynthetic microorganisms which have the ability to convert solar energy into biomass. Global distribution of toxic cyanobacterial incidents reveals to have increased which may be related to the global climate changes **[5]**.

Materials and methods

Fresh algal samples were collected from some selected sites in River Naguman in a 10 Km^2 area selected as the water runs slowly in this area and great algal populations are present. Samples were selected in five sites. Water pH recorded via electric pH meter at different sites ranged from 6.70-7.5 while temperature of water ranged from 15-35 ^0C. The samples were collected in spring and summer of the year 2015. These samples were collected from running water, shallow water and standing water **[6]** in order to get a complete profile of free floating and attached algal forms. Sampling was also done from the bottom of the stream and also from aquatic plants. Five samples were collected from each site. The samples were collected with the help of knife and stored in polythene bags. The samples were analyzed and characterized in the laboratory of Bacha Khan University Charsadda in polythene bags. Algae samples were preserved by storing in glass bottles with 4% formalin. To visualize and characterize algae a portion of the specimen was mounted on the glass slides covered by cover slips and observed under light microscope using different magnifications i.e. 10X, 40X and 100X. Plates of each algal specimen were made by capturing photographs through a digital camera from the respective slide under the highest (100X) power of the microscope; also taken from **[7]**. Algal identification and characterization were achieved with the help of Prescott's manual and Tiffany & Britton **[6, 7].**

Aim of the study

The aim of the current research work was to identify and characterize various forms of freshwater algae collected from different sites in River Naguman.

Results and discussion

Algae are autotrophic organisms, constitute an important group of thallophyta, so it was desired to work out the diversity of freshwater algae of district Charsadda. A taxonomic study was carried out for the identification of Algae of the research area on the basis of their cytological and morphological features. River Naguman has rich algal flora. Algae have remarkable importance for life on earth surface. Algae play a basic role in different food chains as they are primary producers in almost all types of ecosystems. Algal members are adding fresh oxygen to the atmosphere regularly, contaminated by animals adding CO_2. They directly or indirectly serve as food for fish and other aquatic animals

important to man. Freshwater algae are known to produce a large number of toxic, Noxious and bioactive metabolites, thus rendering it difficult to select one specific test to quantify environmental effects.

In present study 38 species belonging to 16 genera and 5 classes were identified from different freshwater habitats of River Naguman district Charsadda. In the research work 16 Genera with 38 belonged to 5 classes i.e. Chlorophyta, Bacillariophyta, Charophyta, Xanthophyta and Cyanophyta. The most frequent genus in term of species was *Spirogyra* with 8 species. *Cladophora* and *Oscillatoria* were next dominants with 4 species each. *Rhizoclonium*, *Zygnema* and *Nitzschia* were each represented by 3 species. *Closterium*, *Diatoma* and *Chara* each contributed 2 species. All the remaining genera including *Ulothrix*, *Mougeotia*, *Desmidium*, *Cyclotella*, *Tabellaria*, *Ophiocytium* and *Vaucheria* each contributed a single species (Table 1).

Table 1. Percentage of different classes of freshwater algae of district Charsadda

Class	No. of genera	No. of Species	Relative Representation
Chlorophyceae	8	23	60.53%
Bacillariophyceae	4	7	18.42%
Charophyceae	1	2	5.26%
Xanthophyceae	2	2	5.26%
Cyanophyceae	1	4	10.53%

Major class was found to be *Chlorophyceae* (1 order Conjugales (8) sp., Siphonales sp. (1), Zygnematales (1) sp., Cladophorales (4) sp. species of order Conjugales on plate (1-8) result is agreed with Sarim & Zaman **[8]** because this class previously identified by **[9]** carried out an extensive study and reported 89 species belonging to 31, genera of *Chlorophyceae, Bacillariophyceae, Xanthophyceae* and *Cyanophyceae*, from District Charsadda (Figure 1). Cladophorales (4) sp. Plate no. 4 so our result agree with **[8]** who previously reported member of this class from Charssada previously this class also reported **[10]** from India. Siphonales sp. (1), Zygnematales (4) sp. on plate no. 5, 6 and 8 previously this class reported by Silvia Alfinito 2011 from Africa and Shameel reported from various areas of Azad Kashmir and KPK.

Charophyceae one genera and three species order Charales sp. on plate no. 5; so the result is agreed with **[11, 12]** previously reported *Chara* species from various freshwater habitat of Pakistan. Bacillariophyceae in our research is represented by the species of *Diatoma*, *Nitzschia*, *Cyclotella* and *Tabellaria* on plate no. 9, 10 and 11 (Figure 2). The results agreed to Sarim and Zaman because this class previously identified by Sarim & Zaman (2005), carried out an extensive study Chrysophyceae from District Charsadda. Similar observations were made in the previous studies at Karachi **[13, 14]**.

During the present study the species were found observed in Unicellular, unbranched filamentous, colonial, branched filamentous, pseudo filamentous and mesh like thallus & irregular forms. Seasonal variation of freshwater algae was also noticed, generally green & blue green algae were studied which breed in summer and spring season, but in summer they also survive. Water temperature is important, as the temperature increases the dissolved oxygen content decrease in water due to increase metabolism and respiration. High temperature has a direct effect on growth of algal species and communities and aquatic life. The Dissolved oxygen content of the

freshwater dependent on several factors i.e., water movement, pollution, temperature of water, addition of freshwater from other sources, production of oxygen by plants and its consumption by plants, animals and bacteria. In summer, the temperature was high up to 38 ºC tremendous Sunlight and sluggish water was the most favorable environment for growth of algae. The rate of reproduction is very rapid of those species that reproduced in summer and rainy season and created a heavy mass on the surface of water. Their growth was most frequent in the aquatic medium especially in planktonic state as compared to the terrestrial environment.

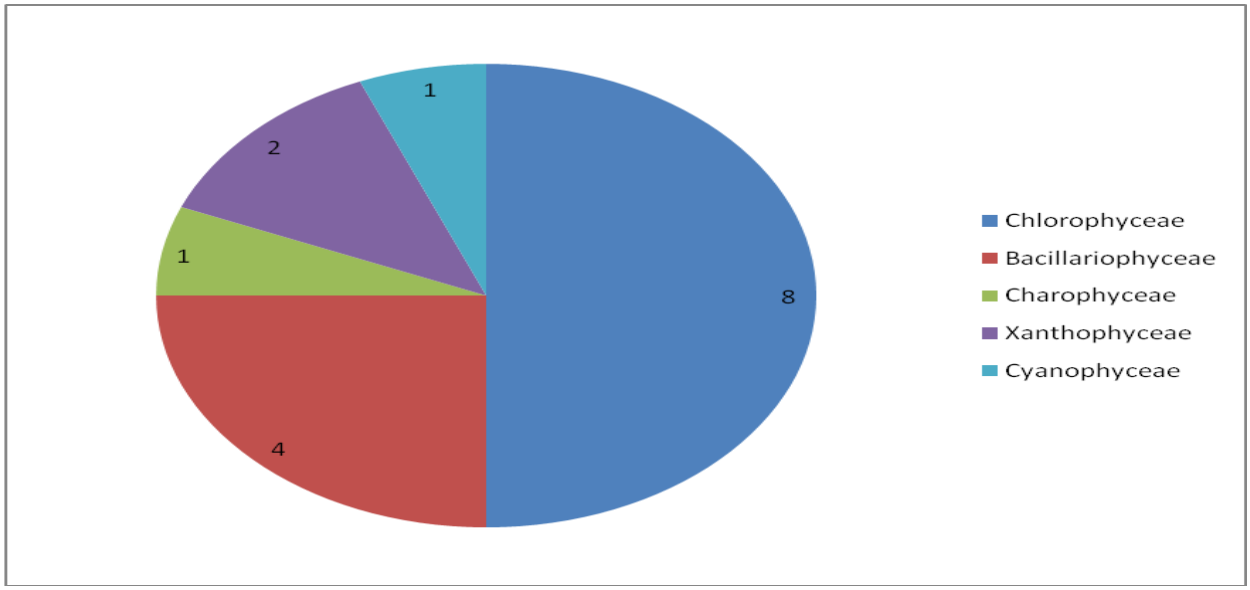

Figure 1. Showing contribution of genera and species by each class of algae

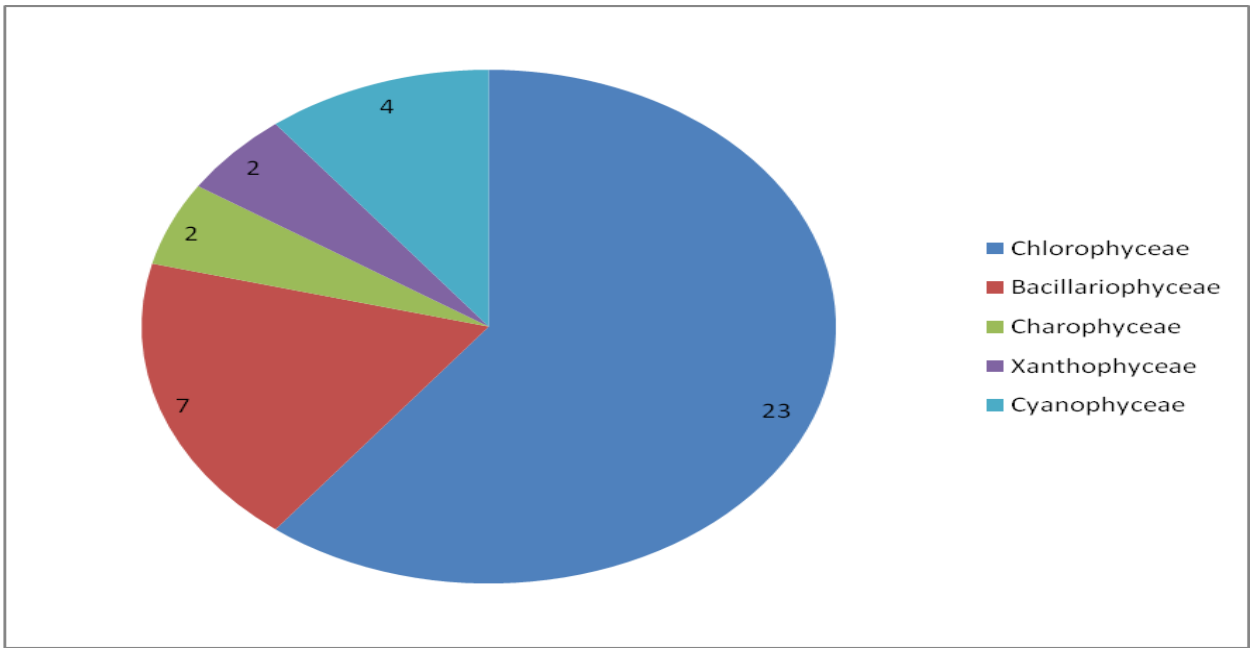

Figure 2. Showing % contribution of species by each class of algae

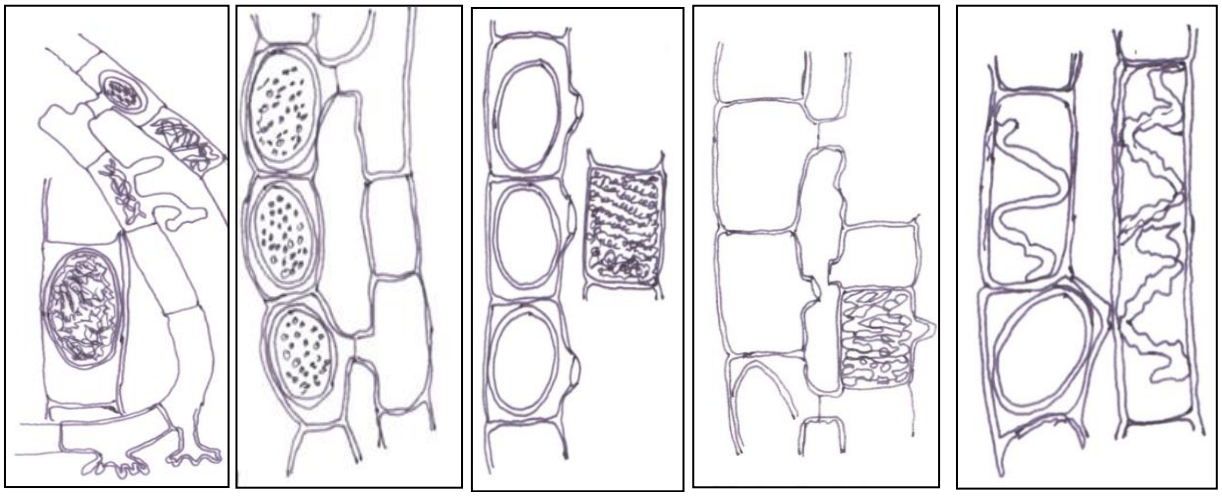

Plate 1. *S. rhizobrachialis* Plate 2. *S. aequinoctialis* Plate 3. *S. crassa* Plate 4. *S. ellipsopora* Plate 5: *S. condensata*

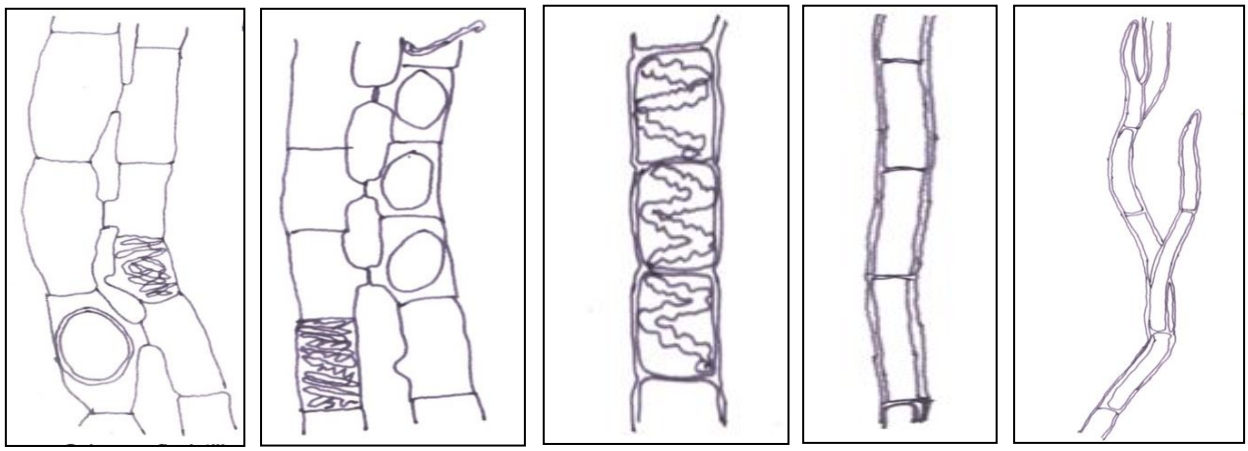

Plate 6. *S. fluviatilis* Plate 7. *S. fuelleboprnei* Plate 8. *S. daedaleoides* Plate 9. *R. hieroglyphicum* Plate 10 *R. fontanum*

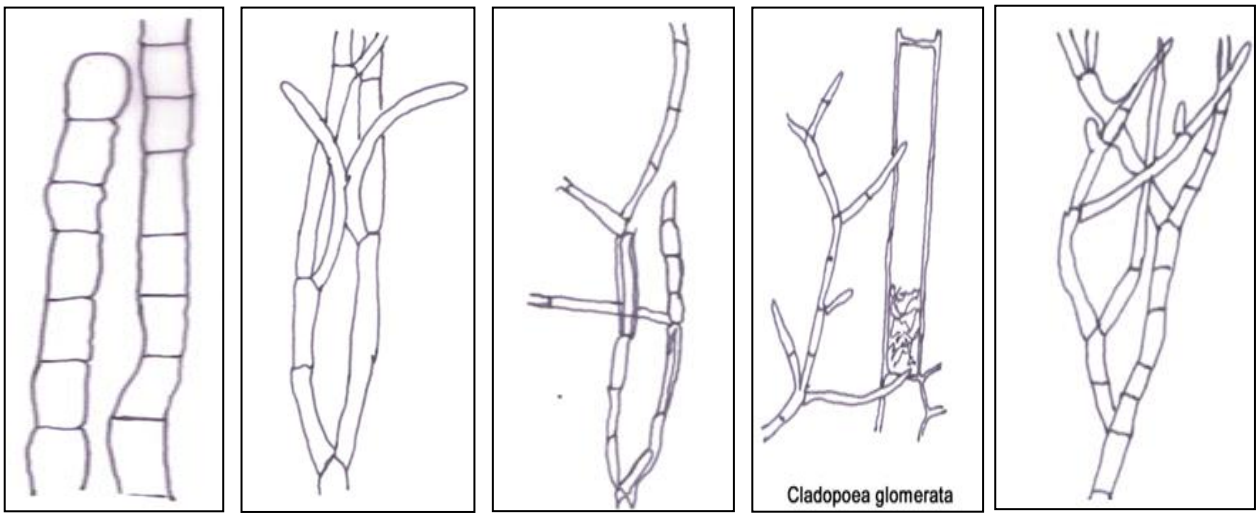

Plate 11. *R. hookeri* Plate 12. *C. oligoclona* Plate 13. *C. fracta* Plate 14. *C. glomerata* Plate 15. *C. crispate*

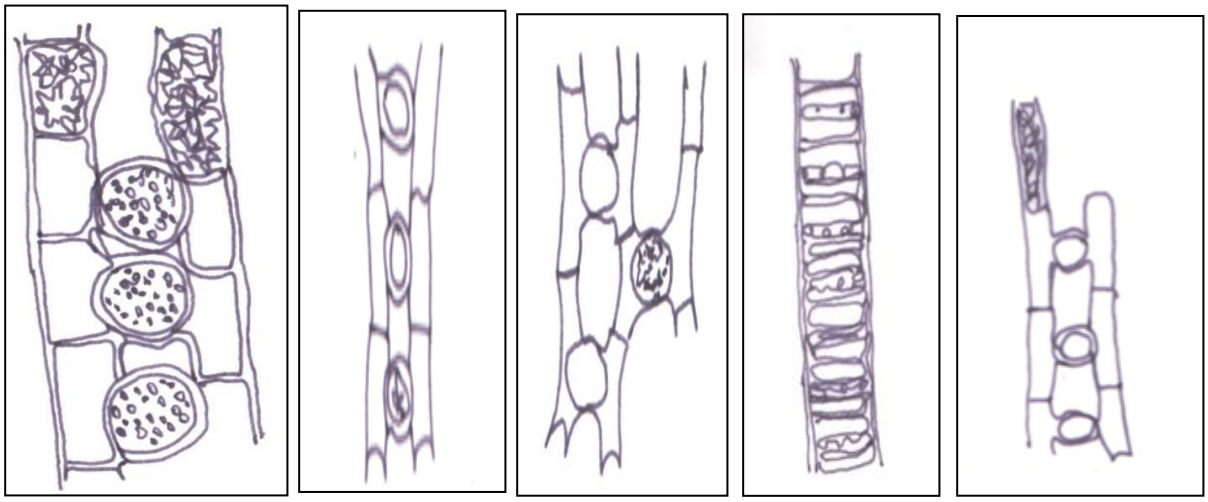

Plate 16. *Z. pectinatum* Plate 17. *Z. decussatum* Plate 18. *Z. synadelphum* Plate 19. *U. zonata* Plate 20. *M. robusta*

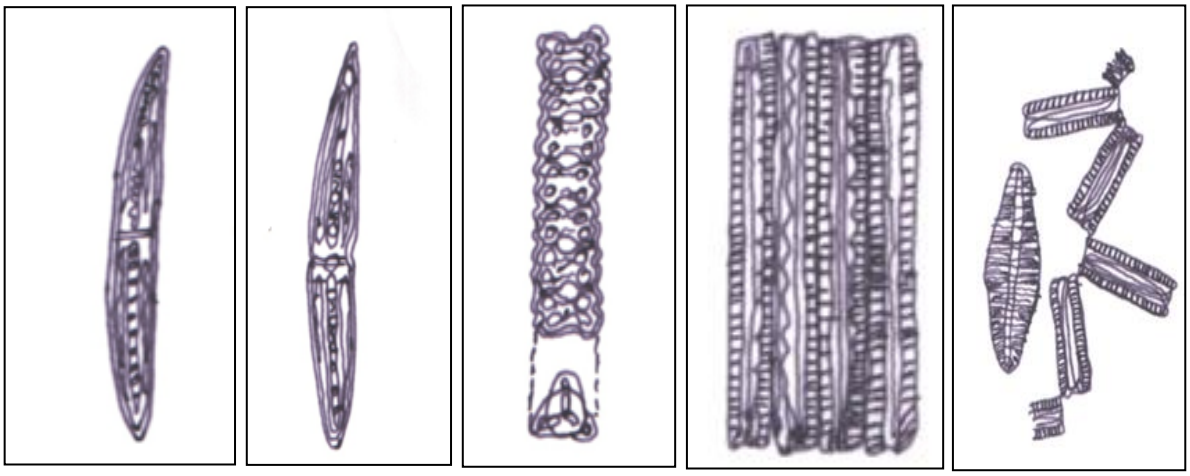

Plate 21. *C. acersoum* Plate 22. *C. lanceolatum* Plate 23. *D. aptogonum* Plate 24. *D. anceps* Plate 25. *D. vulgare*

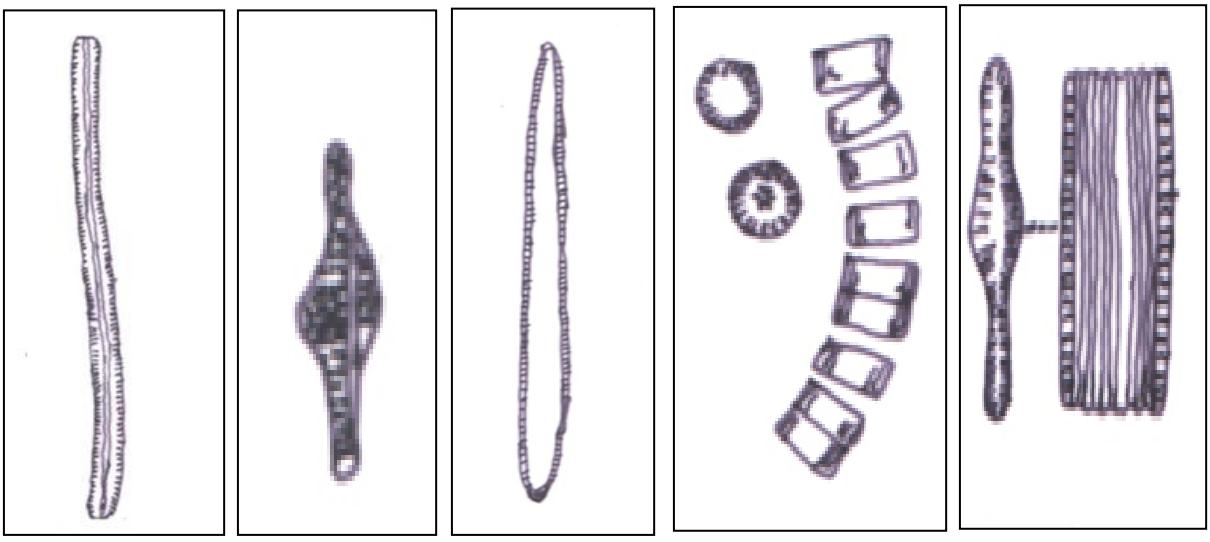

Plate 26. *N. vermicularis* Plate 27. *N. sinuata* Plate 28. *N. linearis* Plate 29. *C. glomerata* Plate 30. *T. flocculosa*

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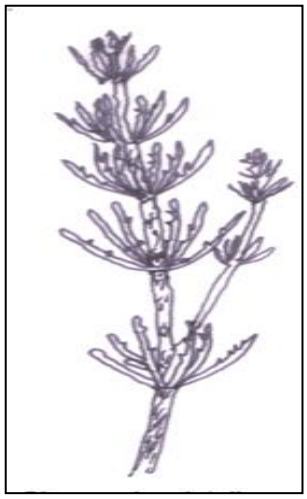

Plate 31. *C. schweinitzii*

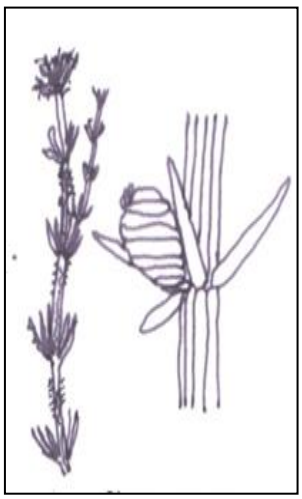

Plate 32. *C. conescens*

Plate 33. *O. capitatum*

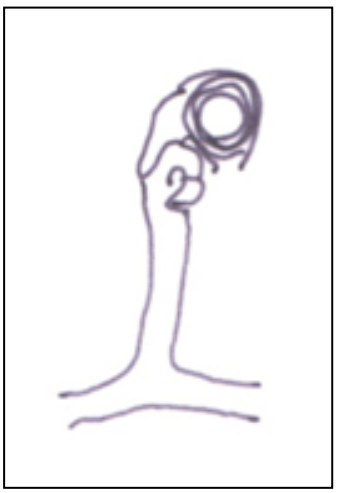

Plate 34. *V. terrestris*

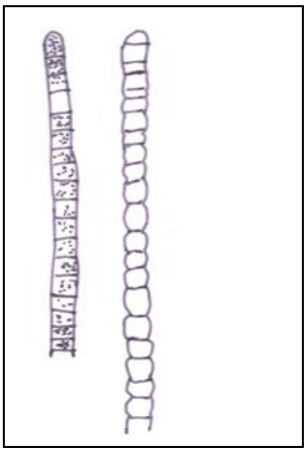

Plate 35: *O. tenuis*

Plate 36: *O. prolifica*

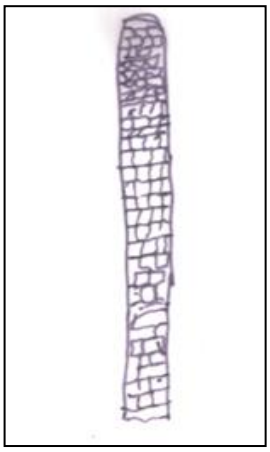

Plate 37: *O. bornetti*

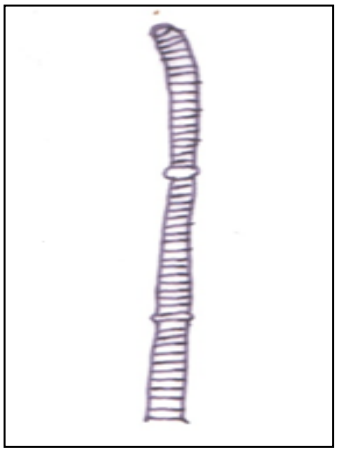

Plate 38: *O. anguina*

Taxonomic Description

I. Class: Chlorophyceae

A. *Spirogyra* Link (Plat 1-8)

Key to the species

1. Zygospore averaging larger 38-62µ in diameter, median spore's wall irregularly reticulate filaments of rather stout cell 40-59in diameter..... .....*S. rhizobrachialis*
2. Vegetative cells 23- 25µ in diameter .....*S. aequinoctialis*
3. Vegetative cell 140-165µ in diameter spores compressed.....*S. crassa*
4. Vegetative cell 125-150µ in diameter.....*S. ellipsopora*
5. Vegetative cell 48-62µ in diameter.....*S. condensata*
6. Fertile cell inflated…….....*S. fluviatilis*
7. Vegetative cell 40-44µ in diameter chloroplast making 1-2 turn .....*S. fuelleboprnei*
8. Spore ellipsoid 35-44µ in diameter…….....*S. daedaleoides*

B. *Rhizoclonium* Kuetzing (Plat 9-11)

Key to the species

1. Filaments (10)-25-35-(52)µ in diameter; wall up to 2 µ thick ……...*R. hieroglyphicum*

2. Filaments 12-22µ in diameter; branches simple…….....……*R. fontanum*
3. Filaments 60-64-103µ in diameter, 2nd order branches frequently present.....*R. hookeri*

C. *Cladopora* Kuetzing (Plat 12-15)

Key to species

1. Vegetative cells 45-55 µ in diameter …….....…… *C. oligoclona*
2. Vegetative cells 60-120 µ in diamet…….....…….*C. fracta*
3. Vegetative cells 75-100 µ in diameter without bristles like outgrowths..... *C. glomerata*
4. Vegetative cells 40- 75 µ in diameter …….....……...*C. crispata*

D. *Zygnema* (Plat 16-18)

Key to the species

1. Vegetative cells 30-40µ in diameter…….....…...*Z. pectinatum*
2. Vegetative cell 16-20µ in diameter, 24-50 long…….....……..2
2. Chloroplast with 2 pyrenoids…….……..…*Z. decussatum*
4. Vegetative cells 17-21µ in diameter fertile cells is not inflated…….....*Z. synadelphum*

E. *Ulothrix* Kuetzing (Plat 19)

Key to the species

1. Filaments 20µ or more in diameter, wall thick…….....……..*U. zonata*

F. *Mougeotia* (G.A Agardh) Wittrock (Plat 20)

Key to the species

1. Vegetative cell 25-33µ in diameter …….....….*M. robusta*

G. *Closterium* (Plat 21-22)

Key to Species

1. Cell tapering gradually to subacute or rounded truncate apices…...…..……*C. acersoum*
2. Apices acutely rounded…….……*C. lanceolatum*

H. *Desmidium* (Plat 23)

Key to Species

1. Cell apices with broad depression ……..*D. aptogonum*

II. Class: Bacillariophyceae

I. *Diatoma* (Plat 24-25)

Key to the species

1. Cells united into zigzag chains…….....1
1. Valves capitates, narrowly linear……...*D. anceps*
2. Cells 10-13µ long…….*D. vulgare*

J. *Nitzschia* (Plat 26-28)

Key to Species

1. Valves 5-7 µ broad…….....*N. vermicularis*
2. Valve margins undulate …….....……*N. sinuate*
3. Valves linear, 70-180 µ long…….....……*N. linearis*

K. *Cyclotella* (Plat 29)

Key to the Species

1. 8-chain loose with space between cells …….....*C. glomerata.*

L. *Tabellaria* (Plat 30)

Key to the species

1. Cells with the numerous longitudinal septa…….....*T. flocculosa*

III. Class: Charophyceae

M. *Chara* Toiseleur-Deslongchamps (Plat 31-32)

Key to the Species

1. Bracket about the oogonium as longer than the mature fruit. ……*C. Schweinitzii*
2. Cortication haplostichous…….…….....*C. conescens*

IV. Class: Xanthophyceae

N. *Ophiocytium* (Plat 33)

Key to the species

1. Cells with polar spines with at each pole ……..……..…….*O. capitatum*

O. *Vaucheria* De Condolle (Plat 34)

Key to the species

1. Oogonia 60-103µ in diameter, 85-211µ long without a pedicle.....……*V. terrestris*

V. Class: Cyanophyceae

P. *Oscillatoria* Vaucher (Plat 35-38)

Key to the species

1. Cells with rows of granules at the cross walls…….....….*O. tenuis*
2. Apical cells with flattened calyptra…….……...…….....*O. prolifica*
3. Cells almost colourless with large conpicous alveoli or vacuoles…….....*O. bornetti*
4. Trichomes bent or hooked at the apex, forming a plant mass.……..…..*O. anguina*

Conclusion

The current study revealed that River Naguman has great Algal diversity. Species of the five major classes of algae are present abundantly. The algae present in the area may be investigated for the presence various biochemicals and secondary metabolites.

Authors' contributions

Conceived and designed the experiments: S Wali, Performed the experiments: T Yaseen, S Jan & I Ahmad, Analyzed the data: F Rahim & Noman, Contributed reagents/ materials/ analysis tools: MS Khan, Wrote the paper: S Wali & T Yaseen.

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