Research Article

Taxonomic Study of Fresh Water Algae from Sehnsa and its Allied Areas in Azad Jammu and Kashmir

Mehpara Nasar[1], Shakeel Sabir[1,2]*, Karamit Hussain[1], Sajid Safeer[1] and Muhammad Imran[1]

[1]Department of Botany, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan; [2]Higher Education Department, Azad Government State of Jammu and Kashmir, Pakistan.

Abstract | Eukaryotic algae and cyanobacteria occur virtually in every terrestrial habitat on our planet. Organisms belonging to these groups are present even in some of the most extreme terrestrial environments, such as rocks in hot and cold deserts. Forty-nine freshwater species of algae of twenty-six genera were reported from the aquatic habitat of Sehnsa and its allied areas of District Kotli Azad Kashmir. These species were taxonomically investigated and found to belong to four classes including Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. The class Cyanophyceae five genera and eleven species, class Chlorophyceae ten genera and seventeen species, class Bacillariophyceae ten genera and nineteen species and class Euglenophyceae two genera and two species were reported in the present study. The species belonging to Bacillariophyceae, Chlorophyceae, and Cyanophyceae were identified as economically important. The maximum number of species was recorded in the class Bacillariophyceae and a minimum number of species was recorded in the class Euglenophyceae. The economically important algal species *Chlorella, Anabaena* and *Spirogyra* were identified from the studied area.

Received | January 03, 2023; **Accepted** | May 07, 2024; **Published** | Septemer 08, 2025
***Correspondence** | S. Sabir, Department of Botany, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan; **Email:** shakeelsabir555@gmail.com
Citation | M. Nasar, S. Sabir, K. Hussain, S. Safeer and M. Imran. 2025. Taxonomic study of fresh water algae from Sehnsa and its allied areas in Azad Jammu and Kashmir. *Advances in Agriculture and Animal Sciences,* 41(1): 10-22.
DOI | https://dx.doi.org/10.17582/journal.aaas/2025/41.1.10.22
Keywords | Algae, Economic importance, Phycology, Specimen, Terrestrial environment

Introduction

Algae are a diverse group of organisms closely related to plants. The term Algae is derived from the Greek word "alga" (means seaweed) and the study of algae is called phycology which is derived from two words (phycossea weed; logos-study). There are about 1800 genera and 21000 species of algae (Ścieszka and Klewicka, 2019; Wilson *et al.*, 2003). Algae occur in a variety of ecosystems ranging from the bare rocks and soil/regolith, soil crusts and microbiological mats, moss cushions, streams, seepages, lakes and wet bottoms of glaciers, snow and ice. Many species occur in salt water, few in brackish water and a smaller number of species occur in both fresh and salty water. When nutritional conditions for planktonic algae is favourable algae increase numerously in number in aquatic environments and form the algal bloom in water (Hou *et al.*, 2023). One of the most important function of algae is that they are the primary producer of organic matter in an aquatic environment because of their photo-synthetic activity (Domingues and Calado, 2022). The animal life in the aquatic environment depends on algae for their food. In Brown algae, there is 6.15% proteins, 1.65% fats and 57.04% carbohydrates are present (Domingues and Calado, 2022). It is a jelly-like substance obtained from many genera of Rhodophyceae. It is used as a base in different cultural media, cosmetic, leather, textile and paper industries. It is also used in packing canned food (Domingues and Calado, 2022). Nitrogen fixation is one of the most important functions blue green algae like *Nostoc* and *Anabaena*etc grow in moist places and fix the atmospheric nitrogen and help in increasing the soil fertility (Domingues and Calado, 2022). Antibiotic chlorellin is extracted from *chlorella vulgaris* which inhibits the growth of certain bacteria and few algae. Algae can be used pollution indicator and its function is treated with sewage treatment e.g. Bacillariophyceae (Marella *et al*., 2019). The aim of the study was the Isolation of freshwater algae of sehnsa valley, district kotli, the Identification of economically important algae and the acquisition knowledge of algae and of their role in environment.

Materials and Methods

Selection site and algal sampling

Different sites were selected for the study of the algal flora of district Kotli which were Pligala, Kritot, Tangoa, Sehnsa, Badli and Tarala. The collection was carried out in July and August. Filamentous algae were picked up with the help of force. Blue-green algae were collected with the help of a knife.

Algal specimen

The collected algal samples were washed with distilled water and then each sample was stored in plastic bottles with some amount of water and 2-3% formalin to preserve the algae (Wu *et al*., 2022).

Photography

Photography and identification of the entire algal specimen were carried out in the Botanical lab of the Pakistan Museum of Natural History Shakarparian, Islamabad. One drop of each sample is taken one by one with the help of a pipette and dropped on a glass slide. The slide was then covered with the cover slip and observed under Photomicroscope. Species identification was carried out by using a light microscope comparison with previously recorded data. The objective was used as 10x, 20x, 40x, 100x and but usually 20x and 10x eyepieces were used. After microscopic examination photographs of each slide under observation were taken.

Identification

Identification of algal samples was confirmed with the help of available literature (Hirano, 1974; Khalil *et al*., 2021; Saleem and Laghari, 2011; Tilden, 1910).

Results

A total of forty-nine freshwater species of algae of twenty-six genera were reported from the aquatic habitat of Sehnsa and its allied areas of District Kotli Azad Kashmir. These species were taxonomically investigated and found to be belonging to four classes including Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae (Table 1).

The class Cyanophyceae five genera and eleven species, class Chlorophyceae ten genera and seventeen species, class Bacillariophyceae ten genera and nineteen species and class Euglenophyceae two genera and two species were reported in the present study (Table 2).

Characteristics

The general characteristics and taxonomic classification of recorded algal species with references to previous literature are described below and a pictorial view of identified species is shown in Figures 1 to 9.

Aphanocapsa endophytica G.M Smith

Cells spherical, appearing ellipsoid and nearly hemispherical in the division, colonies many-celled, attached to the substrate, usually microscopic at maturity, gelatinous matrix homogeneous (Figure 1A).

Aphanocapsa grevillei (Barkeley) Raben horst

The cells are without sheath 4-5micron in diameter, spherical, scattered or closely aggregated, bright blue-green, homogeneous or slightly granular; gelatinous matrix hyaline, homogenous; often forming indefinite blue-green layers on submerged substrate (Figure 1B).

Chroococcus minutes (Kutz) Naegeli

Cells spherical or oblong, single or in groups of 2-4, light blue-green, with sheath 6-15 micron diameter, colonies10-13x15-20 micron; sheath not lamellated, colourless. Skuja reports a form from Burma with

Table 1: *Identified Algal species and their distribution in different localities of District Kotli.*

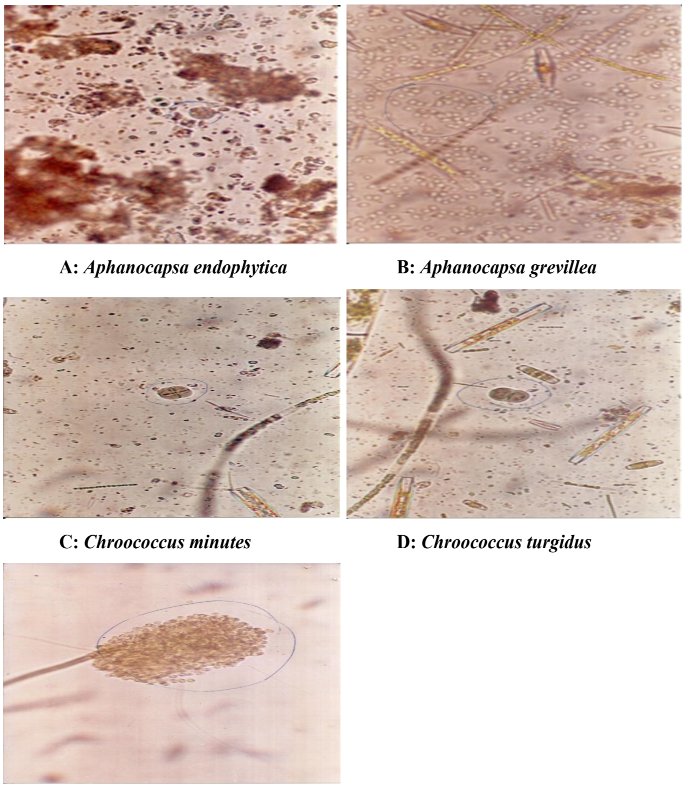
Kingdom: Monera	L1	L2	L3	L4	L5	L6	L7
Division: Cyanophyta							
Class: Cyanophyceae							
Order: Chroococcales							
Family: Chroococcaceae							
Aphanocapsa endophytica	-	-	-	+	+	-	-
Aphanocapsa grevillei	-	-	-	+	-	-	-
Chroococcus minutes	-	-	+	-	-	-	-
Chroococcus turgidus	-	-	+	-	-	-	-
Microcystis aeruginosa	+	-	-	-	-	-	-
Order: Oscillatoriales							
Family: Oscillatoriaceae							
Oscillatoria agardhii	+	-	-	+	-	-	-
Oscillatoria amphibia	+	-	-	+	-	-	-
Oscillatoria tenus	+	-	-	+	-	-	-
Oscillatoria limosa	-	-	-	-	-	+	-
Oscillatoria princeps	-	-	-	-	-	+	-
Order: Nostocales							
Family: Nostocaceae							
Anabaena variabilis	-	+	-	-	-	-	-
Kingdom: Protista							
Division: Chlorophyta							
Class: Chlorophyceae							
Order: Chlorellales							
Family: Chlorellaceae							
Chlorella elipsoidea	+	-	-	-	+	-	-
Chlorella vulgaris	+	-	-	-	+	-	-
Order: Desmidiales							
Family: Desmidiaceae							
Closterium lanceolatum	+	-	-	-	+	-	-
Cosmarium granatum	+	-	-	-	-	-	-
Cosmarium occidentale	+	-	+	-	-	-	-
Cosmarium phaseolusvar.phaseolus	+	-	-	-	-	-	-
Cosmarium punctulatum	+	-	+	-	-	-	-
Cosmarium speciosum	+	-	-	-	-	-	-
Cosmarium tetrachondrumvar. peronatum	+	-	-	-	-	-	-
Order: Chlorococcales							
Family: Hydrodictyaceae							
Hydrodictyan reticulatum	-	-	-	-	-	+	-
Order: Chlorococcales							
Family: Chlorococcaceae							
Tetraedron muticum	-	-	-	-	+	-	-
Order: Palmelales							
Family: Palmelaceae							
Palmella miniate	-	-	-	-	+	-	-
Order: Chlorococcales							
Family: Scenedesmaceae							
Scenedesmmus arcuatus	-	-	+	-	+	-	-
Scenedesmmus incrassatulus	-	-	+	-	+	-	-
Order: Ulotrichales							
Family: Ulotrichaceae							
Ulothrix variabilis	-	+	-	-	-	-	-
Order: Zygnematales							
Family: Zygnemataceae							
Spirogyra species	+	-	-	-	-	+	-
Zygnema sterile	+	-	-	-	-	-	-
Kingdom: Protista							
Division: Bacillariophyta							
Class: Bacillariophycae							
Order: Bacillariales/Pennales							
Family: Cymbellaceae							
Amphora normani	+	-	+	-	-	-	-
Cymbella affinis	-	+	+	-	-	-	-
Cymbella cistula	-	+	+	-	-	-	-
Cymbella tumida	-	-	-	-	-	+	-
Family: Epithemiaceae							
Epithemia zebra	-	-	-	-	-	+	-
Order: Naviculales							
Family: Pinnulariaceae							
Pinnularia parva	-	-	-	-	+	+	-
Pinnularia viridis	-	-	-	-	+	+	-
Order: Fragilariaceae							
Fragilaria capucina	+	-	+	-	-	-	-
Fragilaria construensvar.subsalina	+	-	+	-	-	-	-
Fragilaria construens	+	-	+	-	-	-	-
Synedra tenera	-	-	+	-	-	-	-
Synedrate ulna	-	-	+	-	-	-	-
Family: Gomphonemaceae							
Gomphonema ventricosum	-	-	-	-	-	-	+
Family: Naviculaceae							
Navicula grimmei	-	-	-	-	-	+	-
Family: Nitzschiaceae							
Nitzschia hybrida	-	-	-	-	-	+	-
Nitzschia sublinearis	-	-	-	-	-	+	-
Nitzschia hungarica	-	-	-	-	-	+	-
Family: Surirelliaceae							
Surirella elegans	-	-	-	-	-	+	+
Surirella linearis var.constricta	-	-	-	-	-	+	+
Division: Euglenophyta							
Class: Euglenophyceae							
Order: Euglenales							
Family: Euglenaceae							
Phacus incospicuus	-	-	-	-	-	-	+
Trachelomonas lacustris	+	-	-	-	-	-	-

Table continues on next column......

Total Occurrence of the species=49; L represents the Location from where algae samples were taken; L1= Pligala: L2= Pligala away from road: L3= Kritot: L4= Tarala: L5= Tangoa L6= Sehnsa: L7= Badli; + = Presence of algal species; - = Absence of algal species.

Table 2: *Total number of genera and species identified from district Kotli.*

S. No	Class	Number of genera	Number of species
1.	Cyanophyceae	05	11
2.	Chlorophyceae	10	17
3.	Bascillariophyceae	10	19
4.	Euglenophyceae	02	02
Total	4	27	49



A: ***Aphanocapsa endophytica*** **B:** ***Aphanocapsa grevillea***

C: ***Chroococcus minutes*** **D:** ***Chroococcus turgidus***

E: ***Microcystis aeruginosa***

Figure 1: *Algal species identified in study area.*

a thick, occasionally lamellated sheath, the colony having 4-16 cells and 25-50 microns x23-26 microns. The cells are 6-10 microns in diameter with a sheath (Figure 1C).

Chroococcus turgidus (Kutz) Naegeli

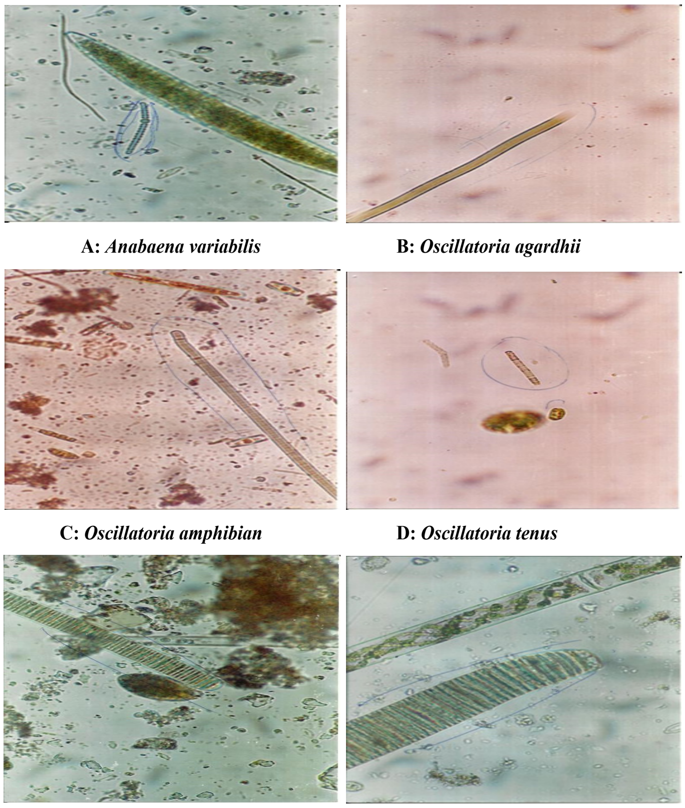
A free-floating colony of 2-4 ovoid or hemispherical cells enclosed by a very wide hyaline and lamellate colonial sheath; cells bright blue-green, contents sometimes coarsely granular enclosed by individual sheath, 8-32 micron in diameter without sheath, 15-50 micron wide including sheath. This is a relatively large species attaining maximum size and abundance in sphagnum bogs (Figure 1D).

Microcystis aerugino sakuetzing

Cells up to 2 microns broad, pale blue-green, with small and inconspicuous pseudovacuoles; colonies spherical, ovoid or irregularly lobed; gelatinious matrix diffluent at the margin; forming extensive water blooms (Figure 1E).

Anabaena variabilis kuetzing

Cells 4-6 x 2.5-6 microns, barrel-shaped; heterocyst rounded or elongated, about 6 x 8 microns; akinetes 7-9 x 8-14 micron, barrel-shaped, remote from the heterocyst's, generally in series, smooth and yellow-brown; trichomes variously bent, usually without sheath, forming a dark green, gelatinous mass. Brown, trichomes are variously bent, usually without sheath, forming a dark green, gelatinous mass (Figure 2A).



A: ***Anabaena variabilis*** **B:** ***Oscillatoria agardhii***

C: ***Oscillatoria amphibian*** **D:** ***Oscillatoria tenus***

E: ***Oscillatoria limosa*** **F:** ***Oscillatoria princeps***

Figure 2: *Algal species identified in study area.*

Oscillatoria agardhii Gomont

Cells 4-6 x 2.5-4 microns, coarsely granulate, with pseudovacuoles; trichome 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 the moist soils; cross walls granulate; end cells convex to broadly rounded, sometimes acute, often capitates, with convex calyptra (Figure 2B).

Oscillatoria amphibian

Trichome unbranched, cylindric, without an evident sheath or amorphous jelly, solitary or in masses, cell contents homogenous or granular, colour variable; species often exhibiting oscillating or gliding movements (Figure 2C).

Oscillatoria tenus C. A Agardh

Cells 4-10 x 2.5 -5 microns, with coarsely granular protoplasm, usually granulate at cross walls; trichomes bright blue-green, straight, slightly constricted at cross walls, gradually curved at the apex, end cells convex and with thick outer membrane, hemispherical, forming thin blue green, slimy masses, attached or free-floating (Figure 2D).

Oscillatoria limosa C.A Agardh

Cells 11-22 x 2-5 microns, granulate at cross walls; trichome 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 (Figure 2E).

Oscillatoria princeps Vaucher ex Gomont

Cells 1 6-60 x 3.5-7 micron, with granulose protoplasm, not granulate at cross walls; trichome blue-green to brownish, reddish or violet, not constricted at cross walls, generally straight, terminally lightly and abruptly constricted and bent, end cells broadly rounded, lightly capitates, without calyptras; generally in masses, sometimes single; plant mask dark blue-green (Figure 2F).

Chlorella elipsoidea

Cells are small, globose or rarely ellipsoid, solitary or aggregated into a chitin mucous layer; chromatophores are single, parietal, often cup-shaped, usually without pyrenoid (Figure 3A).

Chlorella vulgaris

Cells 5-10 microns in diameter, spherical, forming 2-8 auto spores (Figure 3B).

Closterium lanceolatum Kuetzing

Cells 32-72 x 234-550 microns, 5-10 times longer than wide, sublanceolate, almost straight, outer margin slightly curved, 30-55 degrees of arc, inner margin straight or slightly convex, gradually narrow toward the acutely rounded apices; cell wall smooth, colourless; chromatophores with 7-8 ridges; pyrenoids 6-7 in a median series; terminal vacuoles with several moving granules, zygote subglobose or oblong ellipsoid, smooth, 81-104 micron in diameter (Figure 3C).

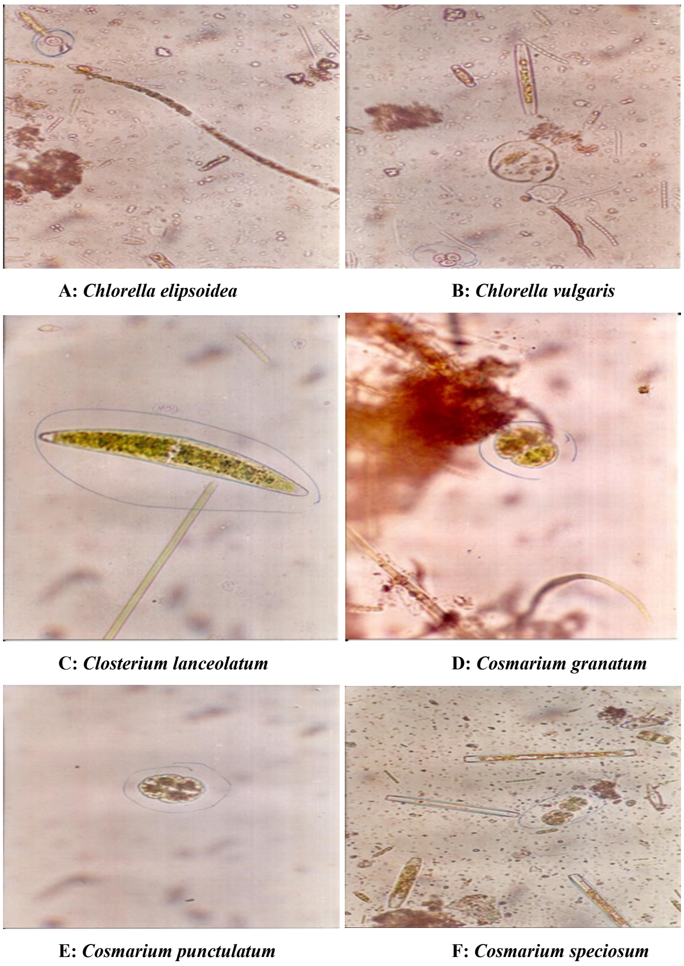


Figure 3: *Algal species identified in study area.*

Cosmarium granatum

Cells 19-30 x 26-52 microns and 10.5-17.5 microns thick, longer than wide, sub rhomboid-elliptic, deeply constricted, sinus linear, slightly dilated at the apex; semi cells truncate-pyramid ate, basal angles rounded, sides straight, slightly convex, or rarely slightly concave, sub-parallel at the base and converging toward the apex, upper angles obtuse, apex narrowly truncate and straight; vertical view elliptic; lateral view of semi cell elliptic-ovate; cell wall finely punctuate; chromatophores axial; pyrenoid single, central (Figure 3D).

Cosmarium punctulatum

Cells 27-38 x 28-40 microns and 17-19 microns thick, length slightly greater than width; deeply constricted, sinus linear, with apex slightly dilated and outer extremity open, isthmus narrow; semi cells oblong-trapeziform, some-what reniform,orsubpyramidate in outline, finely granular, basal and apical angles broadly rounded, apex truncate or slightly convex, lateral margins convex; lateral view of semi cells circular; vertical view elliptic, sometimes with a very slight inflation at the middle on each side; cell wall granulate, granules small and uniform, sometimes reduce or absent in the central area; chromatophores axial; pyrenoidsingle, central; zygotes spherical, with numerous long spines with broadly conical bases and deeply emarginated, or bifurcate and emarginated apices, 65-68 micron in diameter with spines, 42-45 micron without spines (Figure 3E).

Cosmarium speciosum

Cells 37-41 x 54-64 microns and 25-28 microns thick, moderately constricted, basal angles slightly rounded, gradually attenuated upward, apical angles rounded, apex truncate, margins with four apical and seven lateral crenations; lateral view of semi cell ovate-oblong, with a broadly rounded apex; vertical view elliptic, the poles delicately crenulate and with granules arranged in curved transverse series; cell wall granulate within the margins, the granules in regular radial and concentric series each across the base just above the isthmus; chromatophores axial, 1 in each semi cell; pyrenoid single, central (Figure 3F)

Cosmarium occidentale (Turp) Gerloff

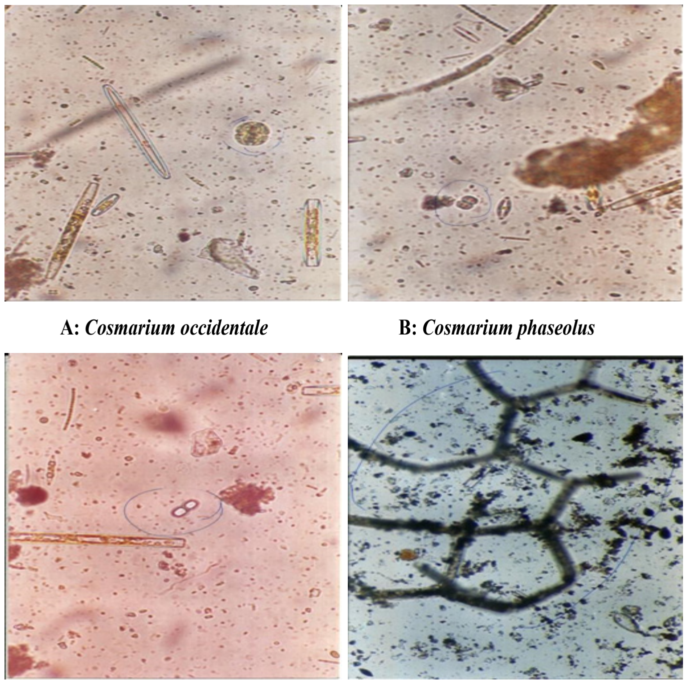
Generally unicellular, the cells are compressed with a length slightly greater than the breadth and a distinct median constriction; some have their cells joined into long filaments. The cell wall is smooth or variously ornamented. The front view of the semi-cells may be semicircular, elliptic, reniform, trapezoidal or sub quadrate. The vertical view is usually elliptical in outline and often with lateral elevations midway between the poles. Each semi-cell has a single axial chloroplast with four radiating plates and the pyrenoids are found in the axial portion (Figure 4A).

Cosmarium phaseolus var. phaseolus

Semi-cells compressed; hemispherical with slightly rounded lower angles; cells 25-26 μm long and 22-23 μm broad; isthmus 10-11 μm wide (Figure 4B).

Cosmarium tetrachondrum var. peronatum Lundell Skuja

The semi-cells differ from the type in having rounded undulating margins with four very small granules within each margin and with a truncate or slightly convex apex; the walls are covered with pores. As with the type, there are two prominent granules near the isthmus just above the deep closed sinus and a single pyrenoid in the centre of each semi-cell. The Cells are 20-23 um long; 24-26 um broad; and 8-10 um thick; isthmus is 7-7.5 um broad (Figure 4C).



A: ***Cosmarium occidentale*** **B:** ***Cosmarium phaseolus***

C: ***Cosmarium tetrachondrum*** **D:** ***Hydrodictyan reticulatum***

Figure 4: *Algal species identified in study area.*

Hydrodictyan reticulatum (Linnaeus) Legharhein

Cells are 5-2 50 microns in diameter ranging up to 1.5 cm long. Coenobia free-floating, flat composed of a single layer of cells, compact or perforate; cells coenocytic, with smooth or rough walls, margin cells usually differently shapes from those of the interior, with processes; chromatophores parietal discs, later filling entire cells, 1-4 pyrenoids (Figure 4D).

Tetraedron muticum (Reinsch) Detoni

Cells 5-8 microns thick and 15 microns long, triangular, with concave sides, and angles truncate (Figure 5A).

Palmella miniata Leiblein

Cell 3-40 microns in diameter, coloured by hemato chrome, solitary or in groups of 2-8 in irregular gelatinous masses; on damp soil. Colony spherical with a group of 4-32 cells arranged toward the periphery of a hyaline, homogenous envelop; cell spherical, sometimes with individual sheath, chromatophores cup-shaped or filling the cell, with 1 pyrenoid and fragmentation of the colony and formation of zoospores (Figure 5B).

Scenedesmmus arcuatus Lemmernanm

Cells 3-9 x9-17 micron, ovoid or angular, in a double row, forming a curved coenobium with small interstices between cells, cell wall smooth, without teeth or spines (Figure 5C).

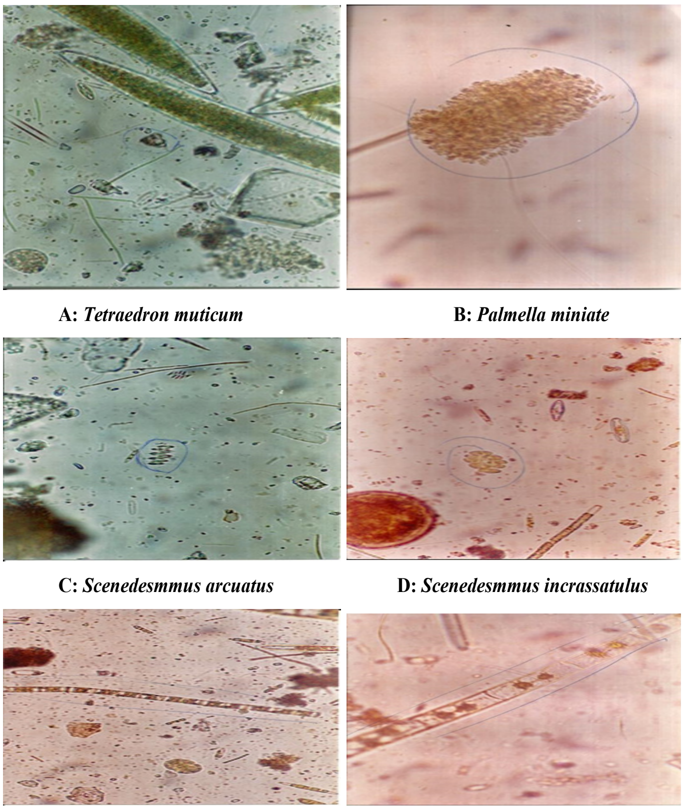

A: *Tetraedron muticum* B: *Palmella miniate*
C: *Scenedesmmus arcuatus* D: *Scenedesmmus incrassatulus*
E: *Ulothrix variabilis* F: *Spirogyra species*

Figure 5: *Algal species identified in study area.*

Scenedesmmus incrassatulus Bohlin
Coenobia generally flat plates of the ellipsoid, oblong, fusiform, acicular or ovoid cells in multiples of 2; cells latterly in contact or rarely connected by short processes, in 1 or 2 rows, cell wall smooth or ornamented, with or without terminal or lateral spines or teeth; chromatophores single, pyrenoid generally single. Formation of 2-32 auto spores (Figure 5D).

Ulothrix variabilis Kuetzing
Vegetative cell cylindric, 5-6 x 3-9 microns, with a thin wall; chromatophores, often irregular, occupying about one half of the cell, 1 pyrenoid (Figure 5E).

Spirogyra species
Simple filaments with cylindric cells, 0.5-30 diameter long, end wall plane, colligate, semi replicate, replicate; chromatophores 1-16, straight or spirally arranged parietal or ribbon-like bodies embedded in the cytoplasm, each with several too many more or less distinct pyrenoids; nucleus centrally placed, supported by many strands of cytoplasm which terminate nearby pyrenoid (Figure 5F).

Zygnema sterile Transeau
Vegetative cells 44-54 x22-69 micron, with heavy cell wall, often with outer pectic layer 6-15 microns in thickness; usually passing the dormant season as heavy walled akinetes; rarely reproducing by aplanospores; median spore wall brown and often distinctly colligate; zygote not known (Figure 6A).

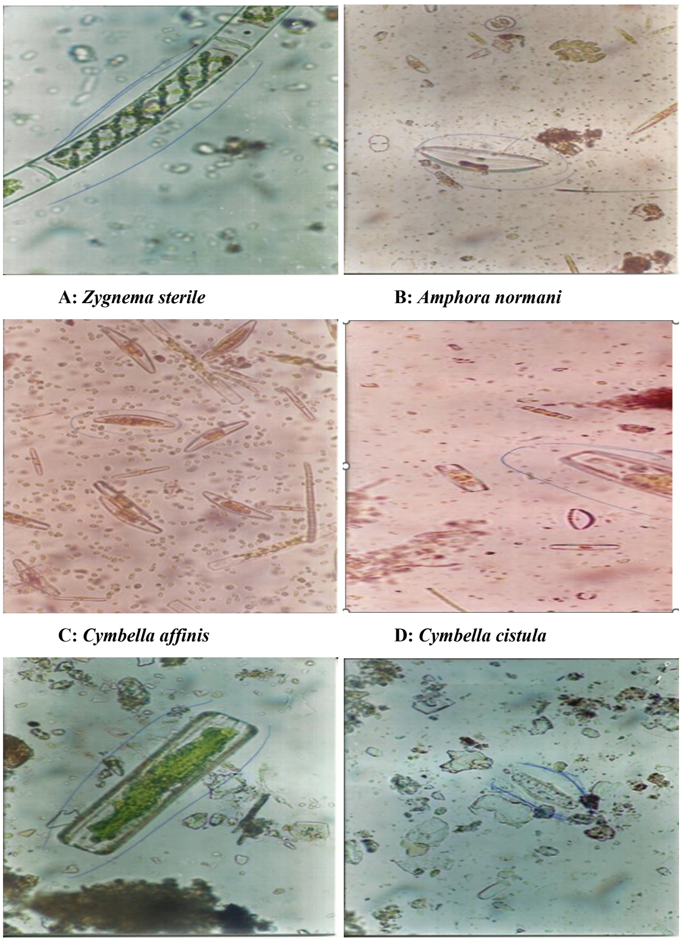

A: *Zygnema sterile* B: *Amphora normani*
C: *Cymbella affinis* D: *Cymbella cistula*
E: *Cymbella tumida* F: *Epithemia zebra*

Figure 6: *Algal species identified in study area.*

Amphora normani Rabenhorst
Cells in girdle view long-elliptic with broadly rounded ends, 10-14 x 16-40 microns; intercalary bands numerous, about 12-10 microns on the dorsal sides, finely cross lined; valves lunate with constriction below the capitates poles and dorsally slightly undulate; axial area narrow, central area absent; central nodule large, transverse striations somewhat radial, 16-18 in 10 micron; ventral side of the valve without any ornamentation except at the margin (Figure 6B).

Cymbella affinis Kuetzing
Cells 7-16 x 20-70 micron; valves quite asymmetric, semi lanceolate to semielliptic, convex dorsally, concave to straight ventrally, with rostrate, rounded poles; raphe excentric undulate toward the central nodule; axial area narrows slightly medianly widened, with ventral median stria ending in an isolated dot; transverse striations 9-12 in 10 micron, radiate with

cross lines 24-30 in 10 micron (Figure 6C).

Cymbella fistula (Hemprich) Grunow
Cells 15-36 x 35-180 micron; valves strongly asymmetric, navicular in shape with dorsal sides convex, ventral sides concave with a median expansion; raphe excentric, broad, dorsally convex; axial area narrow, some-what widen at the middle; transverse striations radiate, 6-9 in 10 microns, with puncate about 18-22 in 10 microns; median ventral striations ending in two or more dots (Figure 6D).

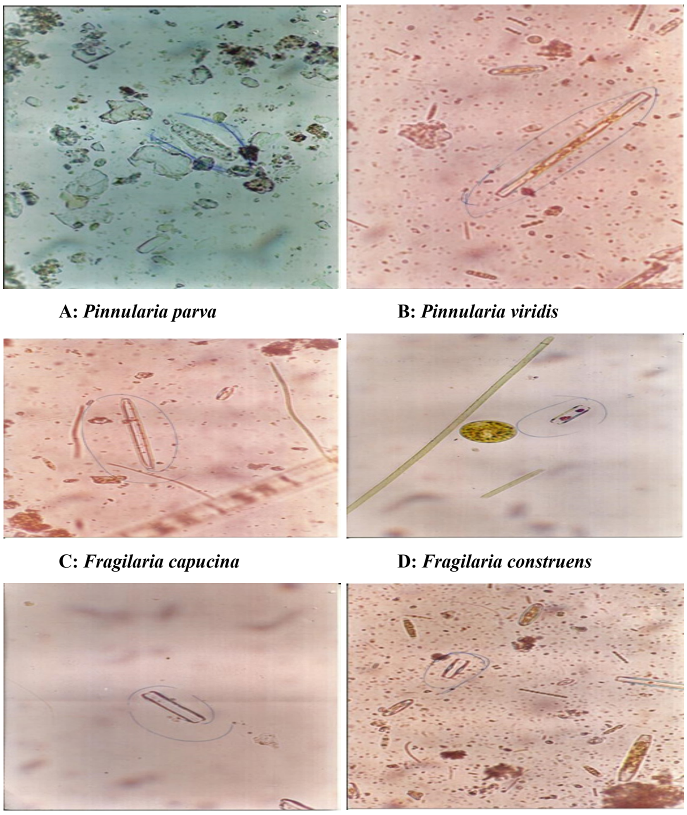
Cymbella tumida (Brebisson) VanHeurck
Cells 15-23 x 40-105 microns; valves asymmetric and curved, broadly navicular, with rostrate poles, convex dorsal; sides having a median expansion; raphe excentric; axial area narrow; central area large, round, with a ventrally placed prominent isolated dots, transverse striations 8-10 in 10 microns, radiate, punctuate (Figure 6E).

Epithemia zebra (Ehrenberg) Kuetzing
Cells 7-14 x 30-150 microns; valves lanceolate, gently curved with nearly parallel sides, gradually attenuated to round poles; costate radial, 2-4 in 10 microns, alternating. With 4-8 rows of striations, 12-14 in 10 microns (Figure 6F).

Pinnularia parva (Ehr) Graun
Cells 7-13 x 40-100 microns; valves linear, gradually tapering to obtuse, somewhat capitates 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 microns (Figure 7A).

Pinnularia viridis (Nitzsch) Ehrenberg
Cells 10-30 x 50-130 microns; valves elliptic to linear with slightly convex sides and broadly rounded ends; axial is usually less than a fourth the cell diameter, widen centrally; raphe complex, somewhat undulate, and with a one-sided central pore; transverse striations medially lightly radial, polarly convergent, 6-9 in 10 microns, crossed by a wide longitudinal band (Figure 7B).

Fragilaria capucina Desmazieres
Cells 2-5 x 25-100 microns, united into long chains; valves linear with pseudoraphe and rectangular to elliptical central area; transverse striations fine, about 15 in 10 microns (Figure 7C).



A: ***Pinnularia parva*** **B:** ***Pinnularia viridis***
C: ***Fragilaria capucina*** **D:** ***Fragilaria construens***
E: ***Fragilaria construens*** **F:** ***Synedra tenera***

Figure 7: *Algal species identified in study area.*

Fragilaria construens (Ehr) Grun
Cells 5-12 x 7-25 microns, united into rather long compact chains; valves greatly expanded medianly, almost cruciform, with lance-like pseudoraphe; transverse striations 14-17 in 10 microns, slightly radial (Figure 7D).

Fragilaria Var.subsalina (Ehr) Grun
Cells 10 um in diameter, Cells, united into rather long compact chains, united into rather long compact chains (Figure 7E).

Synedra tenera Wm. Smith
Cells 2-4 x 30-120 microns, solitary; valves narrowly lanceolate, scarcely capitate; transverse striations 19-20 in 10 microns; pseudoraphe very narrow, linear, with central area generally absent (Figure 7F).

Synedra ulna (Nitzsch) Ehrenberg
Cells 5-9 x 50-350 microns, linear in girdle view, with widened extremities, solitary; valves linear to linear-lanceolate, gradually narrow toward the ends, with broadly rounded poles; transverse striations 8-12 in 10 microns, finely but plainly punctuate; pseudoraphe narrowly linear, with ventral area varying, often absent (Figure 8A).

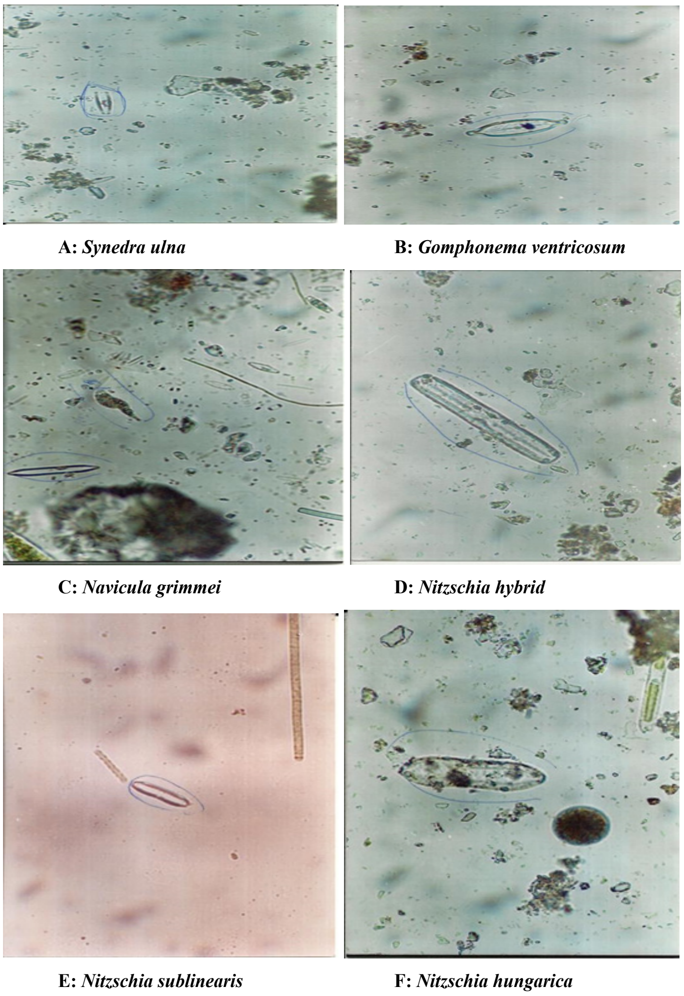


Figure 8: *Algal species identified in study area.*

Gomphonema ventricosum Gregory
Cells usually elliptic on the end of the dichotomously branched gelatinous stalks, sometimes sessile, sometimes solitary and free-floating, transversely asymmetric in both girdle and valves view, cuneate, clavate, lanceolate, or nearly straight, with one pole capitates or broader than the other; axial field narrow, straight raphe and conspicuous central and polar nodules; striations strictly transverse or somewhat radial; central area; sometimes extending toward the margins with an asymmetrically placed dot; chromatophores a single, lobed plate, usually with a single pyrenoid. Auxospores formed in pairs between two conjugating cells (Figure 8B).

Navicula grimmei Krabke
Cells are generally solitary and free-floating, sometimes aggregated into irregularly radiating clusters, rectangular in girdle view, with smooth girdles and without intercalary bands; valves elongate, usually attenuated toward capitates, rounded or rostrate poles; axial field narrow with distinct, straight raphe and polar and central expansions, nodules small; transverse striations, sometimes somewhat medianly radial; two laminate chromatophores, rarely 4-8, infrequently with one or more pyrenoids. Auxospores are formed in pairs by the fusion of two gametes from each of the two approximated cells (Figure 8C).

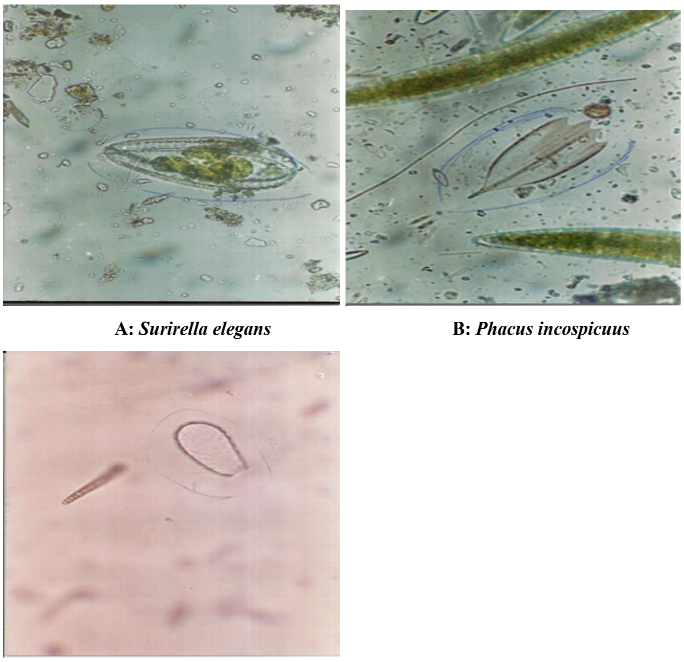
Nitzschia hybrid Grun
Cells solitary and free-floating or densely clustered in simple or unbranched gelatinous tubes, elongate-rectangular, or sigmoid in girdle view, with somewhat attenuated poles, rhombic in cross-section; valves longitudinally asymmetric, very variable in shape: straight, sigmoid, linear, elliptic, some-what undulate, medianly constricted or not, poles acute or rostrate or capitates, often much attenuate; near one margin is a keel with a raphe having small nodules and a row of circular pores opening toward the interior of cell; transversely striate or punctuate; two chromatophores on the same girdle face. Two Auxospores are formed by the conjugation of two cells in some-what crossed positions (Figure 8D).

Nitzschia sublinearis Hust
Cells are solitary. Frustules are polar and bilaterally symmetrical. Cells lie in valve or girdle view and isolated valves are always in valve view. Valves bilaterally symmetrical, linear to linear-lanceolate. Poles sub rostrate or sub-capitate (sometimes capitates). Striae is dense and difficult to see in LM. Raphe system fibulate (the raphe itself is impossible to detect in LM), marginal. Fibulae are rib-like but short. Central pair of fibulae no more widely separated than the others, central raphe endings absent. In frustules, the raphe systems of the two valves lie on opposite sides ('nitzschioid symmetry') Two chloroplasts per cell, one towards each pole. Each chloroplast is a simple plate, which lies against one valve and one side of the girdle (Figure 8E).

Nitzschia hungarica Grunow
Cells 6-9 x 20-110 microns; valves narrowly linear, with parallel or somewhat concave sides and slightly rostrate poles; striations16-20 in 10 microns, interrupted by a fairly wide fold; keel punctae 7-9 in 10 microns (Figure 8F).

Surirella elegans Ehrenberg
Cells not polar, 40-90 x 130-435 microns; valves usually ovate, sometimes nearly linear, with both poles broadly rounded; costae 1.2-2 in 10 microns, with spaces between the costae slender; wall transversely

finely striate; pseudoraphe broad (Figure 9A).



A: *Surirella elegans* B: *Phacus incospicuus*

C: *Trachelomonas lacustris*

Figure 9: *Algal species identified in study area.*

Surirella linearis var. constricta (Ehrenberg) Grunow
Valves with broad median constriction; pseudoraphe often in distinct.

Phacus incospicuus Defl
Cells solitary usually flattened, the flat faces oval or elliptic in outline, sometimes twisted along the longitudinal axis, motile by mean of a single flagellum; periplast rigid, metabolically inactive, smooth, longitudinally or spirally striate, or covered with wart-like processes; posterior and sometimes bearing a straight, twisted, or uncinate spine of variable length; bifurcate flagellum, reservoir with canal similar to Euglena; chromatophores numerous discoid, pointed; eyespot may be present at the anterior end, some species with longitudinal keel, longitudinal furrow, or with lateral edges each spread into two halves separated by a deep furrow; paramylum bodies discoid, disc-shaped with raised margins or ring-shaped, variable in number; longitudinal division of immobile cells; cysts; auto gamy (Figure 9B).

Trachelomonas lacustris Drezepolski
Cells solitary, motile, usually with a single flagellum, the protoplast highly metabolic and loosely encased in a rigid lorica; reservoir at the anterior pole; flagellum bifurcate at the base, with a granular swelling, emerging through a wide circular aperture; usually with an eyespot at anterior pole; lorica spherical or ellipsoid, sometimes campanulate or fusiform, pore at anterior end with or without collar, the surface smooth or variously ornamented, usually brown because of heavy impregnation with iron salts; chromatophores 2-15 or rarely absent, discoid, parietal, with or without pyrenoids, paramylum bodies small, present or absent. Reproduction by division usually within lorica of immobile cells; division of protoplast outside lorica forming palmelloid colonies; cysts (Figure 9C).

Discussion

The present research was a field survey on freshwater algae collected from various localities of Sehnsa, District Kotli such as Pligala, Tangoa, Kritot and Tarala during the month of August to September. All the known algae were collected from freshwater habitats such as lakes, streams, ponds, spring (fresh) and stagnant water. Algae life has tremendous importance on earth (Ahmed *et al.*, 2015). As primary producers in almost all ecosystems, they play a vital role in food chains. Algae are regularly contributing fresh oxygen to the atmosphere, whereas animals are contaminating it by adding carbon dioxide. They directly or indirectly serve as food for fish and other aquatic animals important to man. Their luxuriant growth tells upon the taste and odor of water and sometimes they make it unfit for drinking (Ahmed *et al.*, 2015). During the present study a total of forty-nine freshwater algae species belonging to twenty-six genera, twenty families, twelve orders and four classes were identified from stream and adjoining area of Sehnsa District Kotli as shown in the (Table 2). All species were systematically arranged according to the classification proposed by (Shameel, 2001). Among these Bacillariophyceae was dominated class representing ten genera and nineteen species (Table 1). Other species observed during present study include ten genera and seventeen species of class Chlorophyceae - Among these genera *Chlorella* including two species, *Closterium* having one species, *Cosmarium* having five species, *Hydrodictyan* having one species, *Tetraedron* having one species, *Palmella* having one species, *Scenedesmmus* having two species, *Ulothrix* include one species, *Spirogyra* includeone species and *Zygnema* including one species respectively. *Diatoms* and *Spirogyra* were identified during present research are similar to that used to grow in waste water and then used for biodiesel production as previously reported by (Ahmed *et al.*, 2014).

Chlorella reported from recent survey was a unicellular algae use for human food (Bito *et al*., 2020). Analyses of proteins, fats, carbohydrates, and vitamins indicate that *Chlorella* is an excellent source of these nutrients. The effectiveness of the algae for the support of growth of chickens, mice, rats, and rabbits has been found to be good. Algae can also be used as food for humans. *Chlorella* is available in a form of powder, tablets, capsules, liquids and, also it can be incorporated into different food products and it is most important in human nutrition (Bito *et al*., 2020; Josephine *et al*., 2022). In the class Cyanophyceae include five genera and eleven species including *Aphanocapsa*, *Chroococcus*, *Microcystis*, *Oscillatoria*, and *Anabaena* (Table 2).

The *Anabaena* was reported during present study is one of the important species of Nitrogen fixing algae (Josephine *et al*., 2022; Wenz *et al*., 2019). From the area where *Anabaena* was collected other aquatic plants were rare in number. It shows that this species of algae suppresses the growth of other plants and in addition cause the water to turn green. The algae completely cover the surface of water and light do not reach down to other aquatic plants and inhibit their growth, blue green algae completely dominant in the body of water (Wenz *et al*., 2019).

During present study two species of *Aphanocapsa*, one species of *Microcystis* and two species *Chroococcus* were identified. Sharif *et al*. (2015) studied the four species of *Aphanocapsa,* six species of *Microcystis* and *Chroococcus* from the northern areas of Pakistan in 2004. Chrococaceae play an important role in nitrogen fixation from the atmosphere. Being amphibious they live on moist land as well as in water as well (Sharif *et al*., 2015).

The class Bascillariophyceae representing ten genera and nineteen species (Table 2). The number of genera along the number of species *Amphora* including one species, *Cymbella* including three species, *Epithemia* having one species, *Pinnularia* having two species, *Fragilaria* include two species, *Synedra* include two species, *Gomphonema* include one species, *Navicula* include one species, *Nitzschia* includes three species and *Surirella* include one species.

Bacillariophyceae respond rapidly and predictably to a wide range of pollutants and thus provide potentially useful early warning signals of deteriorating conditions and the possible causes. Bacillariophyceae Species identified during recent studies are used in monitoring ecosystem change (Trevathan-Tackett *et al*., 2019).

The class Euglenophyceae includes two genera with one species each, i.e., *Phacus incospicuus* and *Trachelomonas lacustris*. Euglenoid bloom may colour the water green, reddish brown or red. Sometimes these blooms look like spilled paint. Blooms are not toxic and should not be confused with coastal marine red tides. Many species of Euglenoid are considered indicators of organic water pollution (Trevathan-Tackett *et al*., 2019). During the present study different species of *Oscillatoria, Ulothrix, Synedra, Spirogyra* were identified that are economically very important.

Conclusion

The present study survey was conducted in different areas of Sehnsa and its allied areas of District Kotli. Forty-nine different species were identified belonging to Class Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. Maximum numbers of species were identified in the class Bacillariophyceae and minimum number of species in the class Euglenophyceae. Species identified during present survey include *Anabaena variabilis, Chlorella elipsoidea*, *Chlorella vulgaris*, *Ulothrix variabilis*, *Spirogyra* species, *Phacus incospicuus*, and *Trachelomonas lacustris*. Among these the *Spirogyra, Anabaena* and *Chlorella* were mostly economically important genera. In the future these genera can be used for biodiesel production. *Anabaena* helps in nitrogen fixation while *chlorella* is used as food. *Chlorella* can be used for medicine production in the future. Bacillariophyceae species were identified during present study are important in view that they could be used as pollution indicators.

Acknowledgement

We are thankful to the Department of Botany University of Azad Jammu and Kashmir for their Facilitation during research work.

Novelty Statement

This study provides the first taxonomic documentation of freshwater algal diversity in the aquatic habitats of Sehnsa and surrounding areas in District Kotli, Azad Kashmir. It highlights the presence of economically important algal species in a region that was previously unexplored in this context.

Author's Contribution

M. Nasar: Conceived and designed the experiments.
K. Hussain: Performed the experiments.
S. Sabir: Analyzed the data.
S. Safeer: Contributed materials/ analysis/ tools.
M. Imran: Wrote the paper.

Generative AI and AI-assisted technology statement
The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

References

Ahmed, F., K. Fanning, M. Netzel, W. Turner, Y. Li and P.M. Schenk. 2014. Profiling of carotenoids and antioxidant capacity of microalgae from subtropical coastal and brackish waters. Food Chem., 165: 300-306. https://doi.org/10.1016/j.foodchem.2014.05.107

Ahmed, I., M. Ali, N. Ahmad and I. Ahmad. 2015. Production of biodiesel from algae. J. Pure Appl. Microbiol., 9(1): 79-85.

Bito, T., E. Okumura, M. Fujishima and F. Watanabe. 2020. Potential of Chlorella as a dietary supplement to promote human health. Nutrients, 12(9): 2524. https://doi.org/10.3390/nu12092524

Domingues, M.R. and R. Calado. 2022. Lipids of marine algae-biomolecules with high nutritional value and important bioactive properties. Biomolecules, 12(1): 134. https://doi.org/10.3390/biom12010134

Hirano, M., 1974. Freshwater algae from north Borneo. Contribut. Biol. Lab. Kyoto Univ., 24(3): 121.

Hou, C., X. Cheng, X. Zhang, X. Zhu, J. Xu, X. Luo and H. Liang. 2023. Effect of ferrous-activated calcium peroxide oxidation on forward osmosis treatment of algae-laden water: Membrane fouling mitigation and mechanism. Sci. Total Environ., 858: 160100. https://doi.org/10.1016/j.scitotenv.2022.160100

Josephine, A., T. S. Kumar, B. Surendran, S. Rajakumar, R. Kirubagaran and G. Dharani. 2022. Evaluating the effect of various environmental factors on the growth of the marine microalgae, *Chlorella vulgaris*. Front. Mar. Sci., 9: 954622. https://doi.org/10.3389/fmars.2022.954622

Khalil, S., M.H. Mahnashi, M. Hussain, N. Zafar, F.S. Khan, U. Afzal and M. Irfan. 2021. Exploration and determination of algal role as Bioindicator to evaluate water quality-Probing fresh water algae. Saudi J. Biol. Sci., 28(10): 5728-5737. https://doi.org/10.1016/j.sjbs.2021.06.004

Marella, T.K., A. Datta, M.D. Patil, S. Dixit and A. Tiwari. 2019. Biodiesel production through algal cultivation in urban wastewater using algal floway. Bioresour. Technol., 280: 222-228. https://doi.org/10.1016/j.biortech.2019.02.031

Saleem, M. and M. Laghari. 2011. Taxonomic study of freshwater unicellular green algal species from Peshawar valley. Int. J. Physiol. Col. Phycochem., 7(1): 9-22.

Ścieszka, S. and E. Klewicka. 2019. Algae in food: A general review. Crit. Rev. Food Sci. Nutr., 59(21): 3538-3547. https://doi.org/10.1080/10408398.2018.1496319

Shameel, M., 2001. Diversity exhibited by marine benthic algae inhabiting the coast of Balochistan. Pak. J. Mar. Sci., 10(2): 87-103.

Sharif, N., N. Munir, F. Saleem, F. Aslam and S. Naz. 2015. Mass cultivation of various algal species and their evaluation as a potential candidate for lipid production. Natl. Prod. Res., 29(20): 1938-1941. https://doi.org/10.1080/14786419.2015.1010163

Tilden, J.E., 1910. Minnesota Algae (Vol. 8): Board of regents of the University. https://doi.org/10.5962/bhl.title.53938

Trevathan-Tackett, S.M., C.D. Sherman, M.J. Huggett, A.H. Campbell, B. Laverock, V. Hurtado-McCormick and T.D. Ainsworth. 2019. A horizon scan of priorities for coastal marine microbiome research. Nat. Ecol. Evol., 3(11): 1509-1520. https://doi.org/10.1038/s41559-019-0999-7

Wenz, J., J.G. Davis and H. Storteboom. 2019. Influence of light on endogenous phytohormone concentrations of a nitrogen-fixing *Anabaena* sp. cyanobacterium culture in open raceways for use as fertilizer for horticultural crops. J. Appl. Phycol., 31: 3371-3384. https://doi.org/10.1007/

s10811-019-01856-z
Wilson, S.K., D.R. Bellwood, J.H. Choat and M.J. Furnas. 2003. Detritus in the epilithic algal matrix and its use by coral reef fishes. Oceanogr. Mar. Biol., 41: 279-310.
Wu, P., Z. Zhang, Y. Luo, Y. Bai and J. Fan. 2022. Bioremediation of phenolic pollutants by algae-current status and challenges. Bioresour. Technol., 350: 126930. https://doi.org/10.1016/j.biortech.2022.126930