TAXONOMIC STUDY OF ALGAL SPECIES OF ISLAMABAD AND KAHUTA

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Abstract

This study was conducted to ascertain various freshwater algae found in seven different locations: Tangi Dam, Punjar Stream, Rumly Stream, Bari Imam, Bara Dari, Japan Road and Miana Thub located in the Islamabad and Kahuta regions. The sample were algae were collected during the months of March and April 2025.The specimen were brought back to Algae Research Laboratory in Pakistan Museum of Natural History. There were a total of 19 types of freshwater algae and were divided into three main groups: Cyanobacteria, Chlorophyta and Charophyta. The study found that green algae were the common type of freshwater algae with types like Spirogyra, Chlamydomonas, Zygnema and Mougeotia being very common in ball locations. The variation in water quality helped to distribute diatoms like Navicula, Nitzschia, Tabellaria and Ulnaria. The presence of Cyanobacteria, like Oscillatoria sp. and Lyngbya sp. suggested that water had a lot of nutrients or had polluted. Bari Imam stream water was comparatively clean than Rumly Stream. The richnutrients and pollution indicated Zygnema and Tabellaria flocculosa that could survive in polluted whereas Oscillatoria limnetica supported important information about the quality of the water. The study showed that freshwater algae can be very useful for monitoring the health of freshwater ecosystems and provides information about the different types of freshwater algae found in Pakistan.

KEY WORDS: Taxonomical, Morphological, Ecological, Algal, Distribution, Abundance

Introduction

Algae play a crucial role for our planet. Algae play a crucial role in aquatic life as they produce food for many organisms.

Algae exist in various forms and dimensions, ranging from tiny cells to large seaweeds. They perform photosynthesis and release oxygen, contributing significantly to the global oxygen budget and forming the base of most aquatic food chains (Round, 1981; Prescott, 1962). In freshwater systems, algae contribute to energy flow and nutrient cycling, influence the chemistry of the water, and provide food and habitat for various forms of aquatic life (Wehr & Sheath, 2003). The species composition and abundance of algae in any water body are affected by environmental factors such as temperature, light intensity, pH, and nutrient levels (Palmer, 1969). Therefore, algal communities can be used as indicators of water quality and ecosystem health. Despite the ecological or environmental importance of freshwater algae, the freshwater algae of much of Pakistan remain unstudied.

Taxonomic studies are useful to understand the primary richness and ecological condition, but also possibly use in various fields, including water quality monitoring, biofertilizers, pharmaceuticals and biofuels (Shameel & Tanaka, 1992; Rehman et al., 2016). In the context of freshwater algae, taxonomy helps establish the presence and distribution of different algal groups in a particular ecosystem. Algal taxonomy is really important because it helps us understand how the environment is doing. It also helps us make plans to protect the environment and keep it healthy.

In freshwater systems, algae contribute to the energy flow and nutrient cycling, influence water chemistry, and support various forms of aquatic life (Wehr & Sheath, 2003). To do the scientists, used to look at the shape of the algae cells what kinds of pigments they had, if they had flagella and how they made algae. Alga are used as water quality indicators, to control the nutrient dynamics, and serve as food to other aquatic invertebrates like zooplankton and macroinvertebrates. Under enrich conditions or nutrient-rich environment, certain algae can grow out of control and form harmful algal blooms (HABs), causing the deterioration of water quality and endangering aquatic organisms. By contrast, in less perturbed aquatic systems algal communities are more diverse and evenhanded, regularly indicating excellent water quality and ecological steadiness. Thus, taxonomic classification does not only contribute to knowledge of biodiversity, but also provides information on conservation and management. With the fast urbanization of regions such as Islamabad and the increasing impacts of farming activities and infrastructure development in Kahuta, there is a need to examine the algae in the regions, hence its timely investigation. There are few studies of algal biodiversity in Islamabad which has described ecological importance. Ecological niche theory predicts that species distribution and abundance are dependent on the occurrence of favorable environmental resources and conditions (Hutchinson, 1957; Chase & Leibold, 2003). Algal flora was studied in the local wetland sites and observed dominance of Chlorophyta and Cyanophyta (Abid & Sarwar, 2005). Kahuta is geologically undulating valley and capable of holding spring-based aquatic ecosystems alongwith rain-fed nullahs. Nevertheless, no algal taxonomic data have been published relating to Kahuta, covering Miana thub and Bara Dari. Since PAEC (Pakistan Atomic Energy Commission) is engaged in environmental studies, the physicochemical analysis of soil and water is of primary importance because of the existence of sensitive installations, and biological aspects of the environment, including algae, are ignored. The unavailability of the baseline data on such areas impairs the environmental assessment and management of the biodiversity. The study therefore presents baseline information that will be used in future ecological and conservation-related activities in Kahuta.

Materials and Methods

Study Areas

This research was conducted in freshwater ecosystems of Islamabad and Kahuta regions of District Rawalpindi, Punjab, Pakistan. Sampling locations were equally selected to give a diversity of microhabitats, comprising natural fresh water streams and roadside water bodies. The sampling sites were Rumly Stream, Bari Imam, Miana thub, Bara Dari, Punjar, Tangi dam and Japan Road. The regions lie in a sub-tropical climate zone with moderate to high precipitation and seasonal temperature range which has a major effect in algal productivity. The sampling period was chosen in March and April of the year 2025, which is early spring season. This was the best time because of the growing light supply, enrichment of nutrients and favorable temperatures, which favor the growth of algal growth (Round, 1981). Moreover, sampling at this time kept the excess water flow during monsoon at bay and minimized the possibility of floods and runoffs being polluted.

Sampling Period

In April 2025, during spring's transition into summer, there was sampling. This is the time when algal productivity is enhanced as a result of a combination of high nutrient runoff, growing daylight, and temperate conditions. Owing to the accurate timing of the sampling, a diverse array of algal species belonging to different divisions and forms could be acquired.

Algal Sample Collection

Traditional phycological techniques applicable to both qualitative and quantitative freshwater algae analysis were utilized in a bid to conduct field sampling.

Sampling Equipment and Containers

- 50 ml sterile falcon tubes were employed to collect planktonic algae found in surface water.
- Macroscopic or filamentous algal material that is bound to substrates were kept in sterile plastic zip-lock bags.
- Periphytic algae was carefully scraped from stones, aquatic plants, and other substrates using soft brushes and tweezers.
- The physical-chemical water samples were collected in sterile screw-capped bottles.

Algae were scraped from streambed sediments, aquatic plant surfaces, and underwater rocks in Punjar Stream. Substrate type and water current were noted at each sampling station. The samples were taken from the surface of the water and submerged structures of Tangi Dam. Submerged colonies and floating mats were placed directly into sterile tubes and bags. All the containers were dated, site named and habitat recorded.

Transportation and Sample Preservation

The samples were taken to the Pakistan Museum of Natural History (PMNH) laboratory in Islamabad as soon as they were collected.

To maintain the integrity of the samples;

- Distilled water was used for preventing desiccation in order to hydrate each sample that was collected. The samples were kept in a dark and cold place in the laboratory before they were analyzed.
- For preservation of the living properties required for morphological identification, no chemical preservatives, such as formalin or Lugol's iodine, were used.

This method prevented the loss of delicate morphological information important for efficient taxonomic analysis.

Lab Analysis and Identification

After reaching the laboratory, the samples were put under the microscope for easy identification and classification of the algae.

Microscopic Examination

The samples have been preserved and temporary wet mounts prepared. A single drop of the algal suspension was mounted on a clean glass slide and a cover slip was placed on it gently so as not to introduce air bubbles as well as mechano-damage the cells. No staining was used because most fresh water algae have natural pigmentation that helps them to be identified visually. Dilutions with distilled water were done in certain instances whereby the density of the algal colonies was required to be lowered in order to observe individual cells clearly. A compound light microscope with bright-field and phase-contrast optics were used to carry out microscopic examination. Different magnifications (100x to 1000x), were used to observe the algae according to their sizes and details of the structure. Cell morphology, colonial structure, flagellate structure, chloroplast structure, and special structures like sheaths, mucilage and silica frustules in diatoms were observed and assessed. High-resolution images of algal taxa were collected by using a digital microscope camera. Such pictures helped in taxonomic verification, documentation and illustration in the results section.

Methods of Identification

Standard taxonomic keys and literature were employed to determine algae, such as: algae of the Western Great Lakes Area (Prescott, 1962), preliminary Checklist of Algae from Pakistan (Shameel & Tanaka, 1992), freshwater Algae in North America (Wehr & Sheath, 2003) and The Ecology of Algae (Round, 1981).

Identifications were achieved at the species and genus levels when the morphological characteristics were distinctive and agreed with published descriptions present.

Recording and Documentation of Data

Each species was noted down together with the sampling site and the date it was collected. The images that were taken throughout the process of microscopic analysis were assigned labels with taxon name, magnification, and site data. This data was subsequently employed in the making of comparative analysis amid sampling localities in order to evaluate algal diversity and community structure. The species were grouped by higher taxonomic categories (class, genus, phylum) and analyzed for their ecological preferences, such as their occurrence in lentic (standing) or lotic (flowing) water, or their dominance in nutrient-rich versus clean water. This allowed for preliminary ecological interpretation of algal distribution patterns across the different sites.

Comparative Analysis

All observations were entered into an Excel-based data sheet which includes; scientific name of algal species their taxonomic classification and sites where they occur. The quantitative analyses included the calculation of species richness, comparative statistics across sites and bar charts for relative abundance.

Results and Discussion

Morphological Identification of Algal Species

The morphological identification was carried out using (McFadden et al., 2014) and (Mathieson & Hehre, 1981) methods involving the physical characteristics based on the cellular and structural microscopic observations like the traditional classification based on taxonomic principles, without removing the attached diatoms. Microscopy observations showed abundant variety of algal species from various phyla like Cyanophyta (blue green algae), Chlorophyta (green algae), Bacillariophyta (diatoms) and Euglenophyta. All the species were photographed by using a compound microscope, and were identified on the basis of standard taxonomical keys.

Identified Species from Tangi Dam

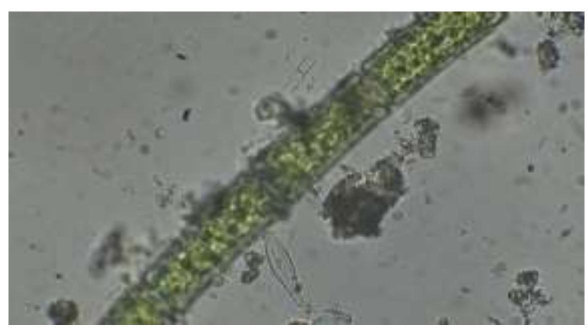

Figure 1: *Spirogyra sp.*

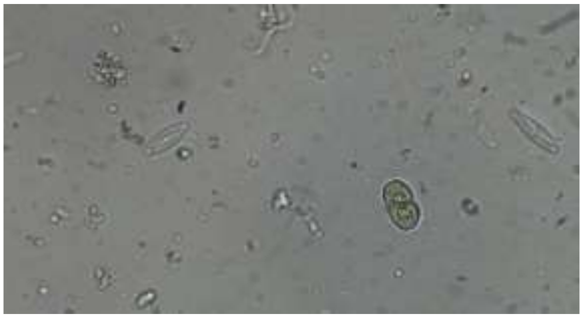

Figure 2: *Cosmarium sp*.

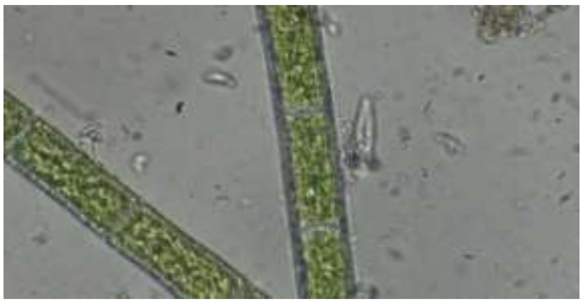

Figure 3: *Spirogyra sp*.

Identified Species from Punjar Stream

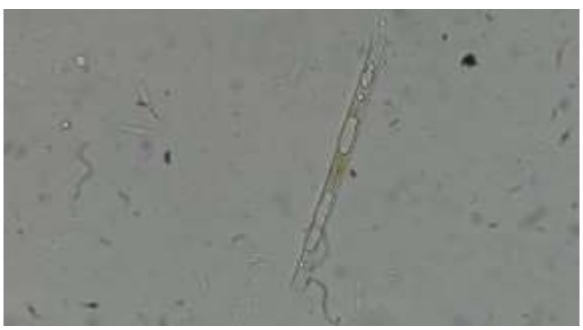

Figure 4: *Ulnaria sp.*

Figure 5: Zygosporus stage of *Spirogyra minuticrassoidea*

Figure 6: *Spirogyra Sp. Oscillatoria sp Cosmarium sp.*

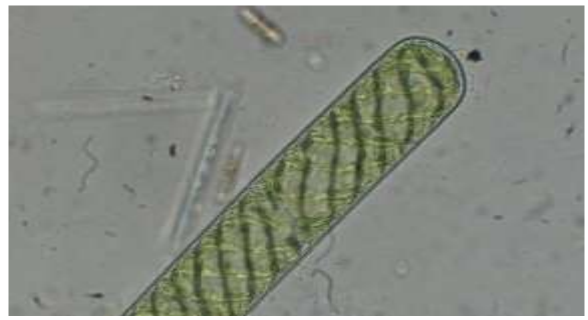

Figure 7: *Spirogyra sp*.

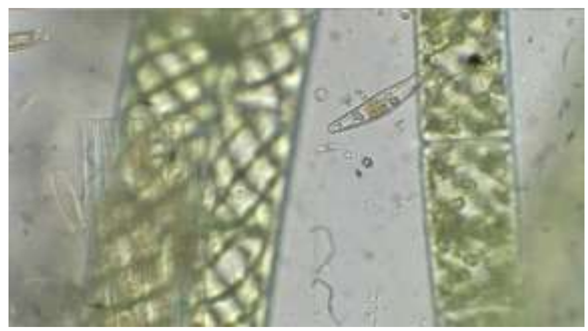

Figure 8: *Spirogyra sp.* (on left), and. on right side *Cymbella cymbiformis*

Figure 9: *Tabellaria sp*.

Identified Species from Miana thub

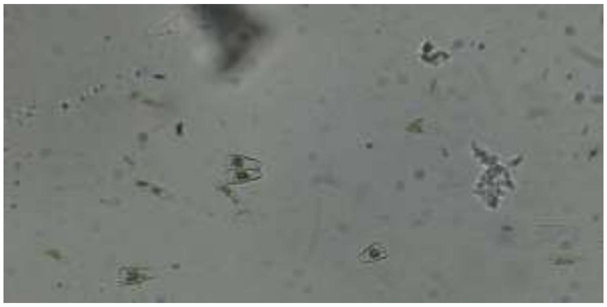

Figure 10: *Rhoicosphenia abbreviata*

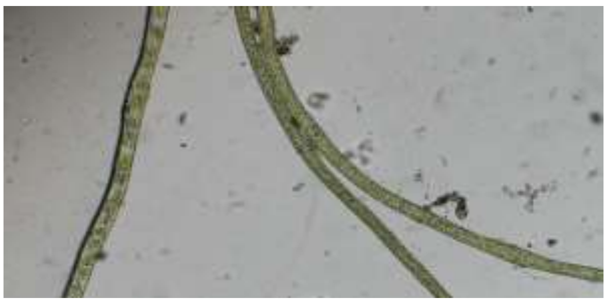

Figure 11: *Spirogyra sp.*

Identified Species from Bara Dari

Figure 12: *Oscillatoria sp*.

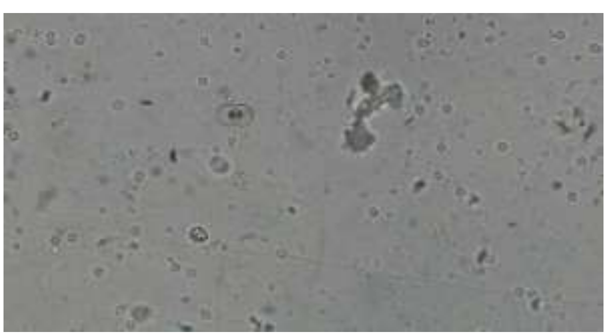

Figure 13: *Chlorella vulgaris*

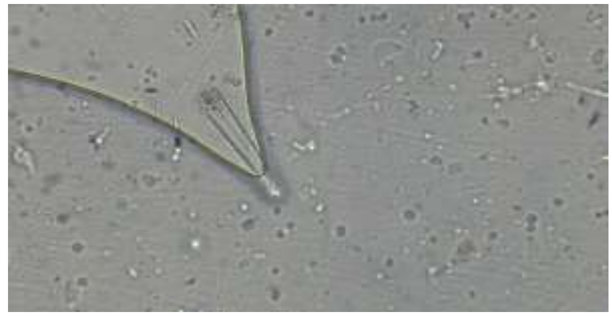

Figure 14: *Gomphonema sp.*

Identified Species from Japan road

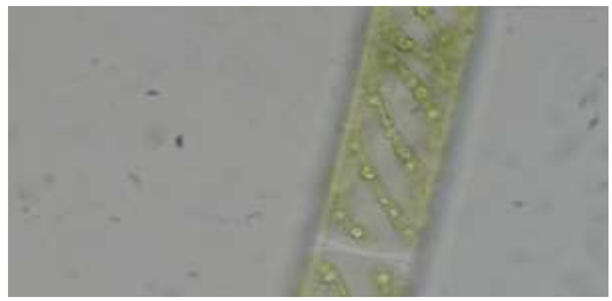

Figure 15: *Spirogyra sp.*

Identified Species from Bari Imam

Figure 16: *Ulothrix sp.*

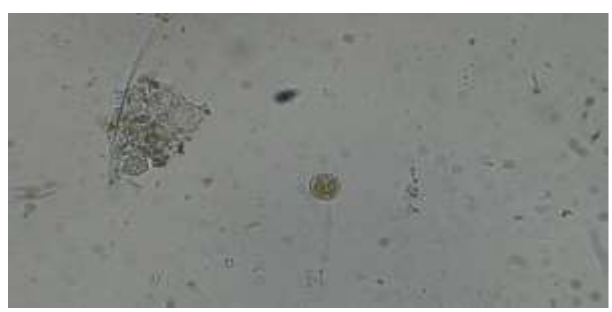

Figure 17: *Stepphaodiscus sp.*

Figure 18: *Lyngbya sp.*

Figure 19: *Chlorella sp*.

Figure 20: *Oscillatoria sp.*

Figure 21: *Ulothrix sp*.

Figure 22: *Closterium sp.*

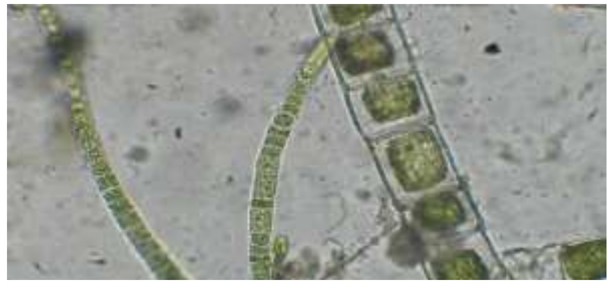

Figure 23: *Ulothrix sp.*

Figure 24: *Closterium sp*.

Identified Species from Rumli

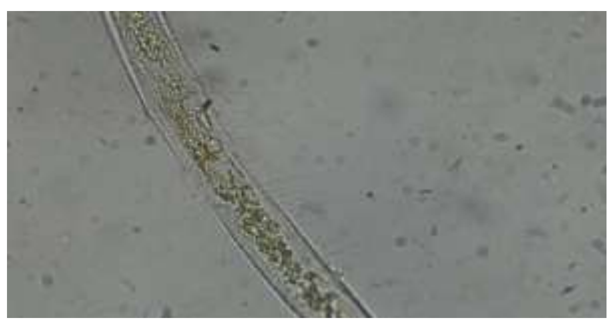

Figure 25: *Spirogyra sp*.

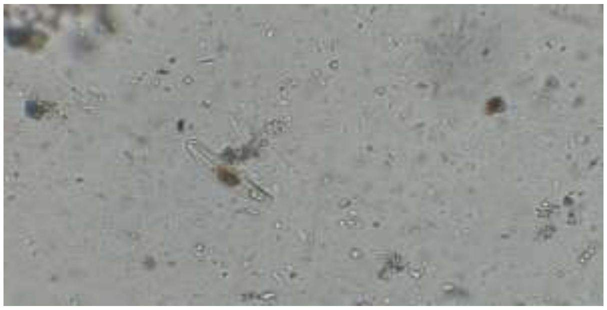

Figure 26: *Navicula sp.*

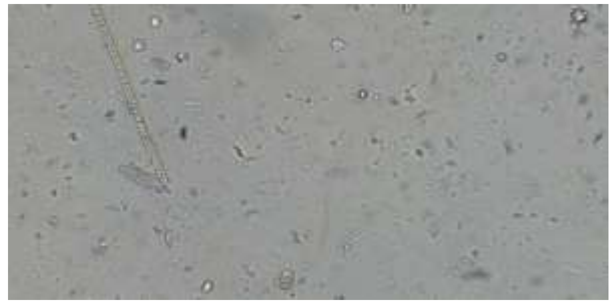

Figure 28: *Ulnaria ulna*

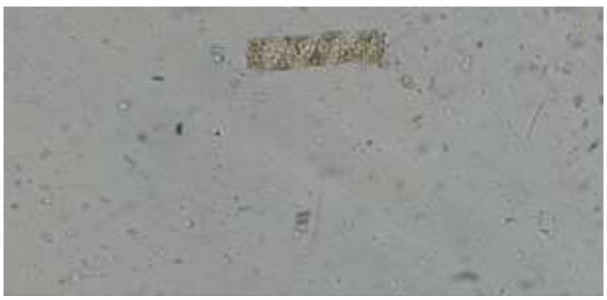

Figure 27: *Tabellaria flocculosa*

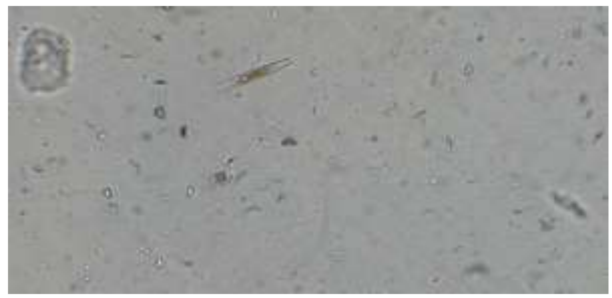

Figure 29: *Nitzschia sp.*

Morphological Classification of Algal Species

Table 1: Cell type, Structure type, Motility and Distinctive morphological features of Different algal species

No.	Species Name	Cell Type	Structure Type	Motility	Distinctive Morphological Features
1	*Oscillatoria sp*.	Prokaryotic	Filamentous	Gliding	Unbranched trichomes, no heterocyst, cylindrical cells
2	*Oscillatoria limnetica*	Prokaryotic	Filamentous	Gliding	Similar to Oscillatoria, adapted to freshwater pollution
3	*Lyngbya sp.*	Prokaryotic	Filamentous	Non-motile	Thick mucilaginous sheath, straight trichomes
4	*Chlorella sp*.	Eukaryotic	Unicellular	Non-motile	Small, spherical green cells
5	*Chlorella vulgaris*	Eukaryotic	Unicellular	Non-motile	Bright green, cup-shaped chloroplast
6	*Chlamydomonas sp.*	Eukaryotic	Unicellular	Flagellated	Cup-shaped chloroplast, 2 flagella, eyespot
7	*Chlamydomonas reinhardtii*	Eukaryotic	Unicellular	Flagellated	Model species, cup-shaped chloroplast, anterior eyespot

8	*Spirogyra sp.*	Eukaryotic	Filamentous	Non-motile	Spiral ribbon-like chloroplasts, unbranched filaments
9	*Spirogyra* (zygospore)	Eukaryotic	Filamentous	Non-motile	Conjugation tubes, thick-walled zygospores
10	*Zygnema sp.*	Eukaryotic	Filamentous	Non-motile	Two star-shaped (stellate) chloroplasts per cell
11	*Mougeotia sp.*	Eukaryotic	Filamentous	Non-motile	Single flat plate-like chloroplast in each cell
12	*Closterium sp.*	Eukaryotic	Unicellular	Non-motile	Crescent-shaped desmid, often with pyrenoids
13	*Oedogonium sp.*	Eukaryotic	Filamentous	Non-motile	Distinct transverse walls, basal holdfast, reproductive cap cells
14	*Microspora floccose*	Eukaryotic	Filamentous	Non-motile	Band-like chloroplasts, thick-walled cells
15	*Navicula sp.*	Eukaryotic	Unicellular (Diatom)	Gliding	Boat-shaped frustule, central raphe, golden-brown pigment
16	*Nitzschia sp.*	Eukaryotic	Unicellular (Diatom)	Gliding	Slender, slightly curved, eccentric raphe
17	*Tabellaria sp.*	Eukaryotic	Colonial (Diatom)	Non-motile	Rectangular cells forming zigzag chains
18	*Tabellaria flocculosa*	Eukaryotic	Colonial (Diatom)	Non-motile	Frilled cell ends, zigzag chains
19	*Ulnaria ulna*	Eukaryotic	Unicellular (Diatom)	Non-motile	Long needle-like cell, straight frustule, formerly Synedra ulna

Taxonomic Classification

Table 2: Taxonomic Classification of all species (Phylum, Class, Order, Family, Genus)

Species Name	Phylum	Class	Order	Family	Genus
Oscillatoria sp.	Cyanobacteria	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	Oscillatoria
Oscillatoria limnetica	Cyanobacteria	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	Oscillatoria
Lyngbya sp.	Cyanobacteria	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	Lyngbya

chlorella sp.	Chlorophyta	Trebouxiophyceae	Chlorellales	Chlorellaceae	Chlorella
Chlorella vulgaris	Chlorophyta	Trebouxiophyceae	Chlorellales	Chlorellaceae	Chlorella
chlamydomonas sp.	Chlorophyta	Chlorophyceae	Chlamydomonadales	Chlamydomonadaceae	Chlamydomonas
Chlamydomonas reinhardtii	Chlorophyta	Chlorophyceae	Chlamydomonadales	Chlamydomonadaceae	Chlamydomonas
spirogyra sp.	Charophyta	Zygnematophyceae	Zygnematales	Zygnemataceae	Spirogyra
spirogyra sp. (zygospore)	Charophyta	Zygnematophyceae	Zygnematales	Zygnemataceae	Spirogyra
zygnema sp.	Charophyta	Zygnematophyceae	Zygnematales	Zygnemataceae	Zygnema
mougeotia sp.	Charophyta	Zygnematophyceae	Zygnematales	Zygnemataceae	Mougeotia
closterium sp.	Charophyta	Zygnematophyceae	Desmidiales	Closteriaceae	Closterium
oedogonium sp.	Chlorophyta	Chlorophyceae	Oedogoniales	Oedogoniaceae	Oedogonium
microspora floccose	Chlorophyta	Chlorophyceae	Microsporales	Microsporaceae	Microspora
Navicula sp.	Bacillariophyta	Bacillariophyceae	Naviculales	Naviculaceae	Navicula
Nitzschia sp.	Bacillariophyta	Bacillariophyceae	Bacillariales	Bacillariaceae	Nitzschia
Tabellaria sp.	Bacillariophyta	Bacillariophyceae	Fragilariales	Tabellariaceae	Tabellaria
Tabellaria flocculosa	Bacillariophyta	Bacillariophyceae	Fragilariales	Tabellariaceae	Tabellaria
Ulnaria ulna	Bacillariophyta	Bacillariophyceae	Fragilariales	Fragilariaceae	Ulnaria

Comparative Analysis

Tangi Dam

Tangi Dam exhibited a moderate diversity of algal species with a balanced representation from all three major groups: cyanobacteria, green algae, and diatoms. Dominant taxa included *Oscillatoria sp.*, *Chlorella sp.*, *Chlamydomonas sp.*, *Spirogyra sp.*, and diatoms such as *Navicula* and *Nitzschia*. The presence of *Chlorella vulgaris* and *Navicula* indicates a nutrient-rich but relatively stable environment. The absence of more sensitive or specialized taxa suggests that while the habitat supports moderate diversity, it may experience moderate nutrient loading or turbidity.

Punjar Stream

Punjar Stream showed the highest diversity among all sampling sites, containing a wide range of green algae, diatoms, and cyanobacteria. There were species like *Zygnema sp.*, *Mougeotia sp.*, *Chlamydomonas*, *Tabellaria*, *Ulnaria ulna*, and *Nitzschia*. The coexistence of more tolerant species like *Oscillatoria limnetica* and sensitive species like Tabellaria flocculosa and Zygnema indicates that there was some differences in the water's quality, with some areas with more organic matter and others being cleaner.

Rumly Stream

Oscillatoria sp., Chlamydomonas, and Spirogyra predominated in Rumly Stream, which had the least variety of algae. Rumly Stream's low algae diversity shows nutrient enrichment or disturbed environments, which may be the results of agricultural activities like sedimentation and runoffs. The lack of sensitive species like desmids and some diatoms indicates that the oxygen deficient or eutrophic environment prevented the emergence of specialized forms.

Bari Imam

The Bari Imam site was found to be the richest in terms of algal complexity and diversity of morphological form, with 19 species being recorded, including *Microspora floccosa*, *Oedogonium sp.*, *Zygnema*, and *Spirogyra* zygospores. For the ecological significance of the Site, the variety of green algae, cyanobacteria, and recorded diatoms is most representative. The microhabitat seems to have remained the least disturbed, possibly due to less disturbance and clear water. This is proved by the presence of *Spirogyra* conjugation and the occurrence of other complex formations.

Bara Dari

Bara Dari also showed a high species richness, especially for green filamentous algae and diatoms. The dominant species observed were *Mougeotia sp.*, *Zygnema sp.*, *Microspora*, and *Tabellaria flocculosa*. The occurrence of both tolerant and sensitive species, such as *Lyngbya*, indicates varying water quality, possibly because of nutrient enrichment from different land use activities. The presence of filamentous green algae, such as *Spirogyra* and *Mougeotia*, indicates good oxygenation and light penetration.

Japan Road

The Japan Road website indicated a moderate diversity of algae, mostly unicellular green algae (*Chlorella*, *Chlamydomonas*), with a few filamentous forms such as *Spirogyra* and *Oedogonium*. The diatoms were found in lower numbers. The presence of the planktonic green algae suggests still or slowly flowing water with moderate nutrient levels. This environment is suitable for small autotrophs, but it is not ideal for more sensitive or colonial species.

Miana Thub

The algal flora of Miana Thub was diverse but in proportion, constituting green filamentous algae (*Zygnema, Spirogyra*), diatoms (*Navicula, Nitzschia*), and cyanobacteria such as *Oscillatoria*. The presence of this flora indicates a comparably natural freshwater stream with both attached and motile autotrophs. The reappearance of *Closterium* and *Chlorella* indicates a modest nutrient level and stable pH, which might be because of shaded or partially forested conditions

Table 3: Comparative analysis of algal species across sampling sites

Site	Diversity Level	Dominant Groups	Sensitive Species Present	Pollution Indicators	Ecological Interpretation
Tangi Dam	Moderate	Diatoms	*Chlorella vulgaris*	*Oscillatoria sp.*	Moderate nutrients, slightly eutrophic
Punjar Stream	High	Diatoms	*Zygnema, Tabellaria flocculosa*	*Oscillatoria limnetica*	High diversity, mixed water quality
Rumly Stream	Low	Cyanobacteria,	None	*Oscillatoria sp.*	Eutrophic or disturbed, low species richness
Bari Imam	Very High	Diatoms	*Spirogyra (zygospore), Microspora*	*Oscillatoria limnetica*	Rich, balanced habitat with active reproduction
Bara Dari	High	Diatoms	*Zygnema, Tabellaria flocculosa*	*Lyngbya sp.*	Varied water quality, high light penetration
Japan Road	Moderate	Green algae	*Chlorella vulgaris*	*Oscillatoria sp.*	Still water, planktonic dominance
Miana Thub	Moderate to High	Diatoms	*Zygnema, Closterium*	*Oscillatoria sp.*	Natural stream, moderate nutrient levels

Table 4: Comparative analysis of number of algal species of all sampling site

Aspect	Tangi Dam	Punjar Stream	Rumly Stream	Bari Imam	Bara Dari	Japan Road	Miana thub
Total Species	11	15	7	18	15	10	13
Cyanobacteria Species	2	3	2	3	3	2	2
Green Algae Species	5	6	3	8	7	5	6
Diatom Species	4	6	2	7	5	3	5

Unique Species	0	2	1	3	1	0	1

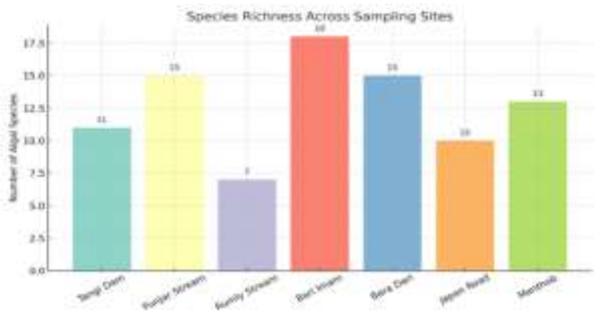

Figure 30: Species richness across different sampling sites

The results are predicated on the relative analysis of the algal leafage observed in the seven brackish spots Tangi Dam, Punjar Stream, Rumly Stream, Bari Imam, Bara Dari, Japan Road, and Miani Thub. The discussion will be predicated on the differences in the species, taxonomic, and morphological aspects of the algae, with conclusions drawn on the implications of the results in relation to the quality of the niche, pollution, and variations in the terrain.

Algal Diversity and Species drollness

Nineteen (19) different algal taxa were set up, including diatoms (*Bacillariophyta*), green algae (*Chlorophyta* and *Charophyta*), and cyanobacteria (blue-green algae). With 18 species recorded, Bari Imam had the most variety of all the spots, followed by Punjar Stream with 15 species, and Bara Dari with 15 species. Only seven different species of algae were set up at Rumly Stream, which had the lowest variety. The vacuity of a variety of microhabitats, light, and nutrient balance may be responsible for the great diversity set up at some of the study locales, including Bari Imam and Punjar Stream. Eutrophic conditions, potentially brought on by sedimentation and dropped flux, may be the cause of Rumly Stream's low variety. The completely randomized analysis of variance performed for algal diversity showed significant variation in algal varieties among all locations (Table 5).

Table 5. Descriptive Statistics for the Diversity in Algal Species in (A) Islamabad and (B) Kahuta (A)

Sr. No.	Location	Standard Deviation (+,-)	SE Mean	Minimum	Maximum
01	Bara Dari	2.5820	1.2910	1.0000	7.0000
02	Bari Imam	2.6300	1.3150	3.0000	8.0000
03	Japan Road	2.0817	1.0408	0.0000	5.0000

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(B)

Sr. No.	Location	Standard Deviation (+,-)	SE Mean	Minimum	Maximum
01	Punjar Stream	2.0616	1.0308	2.0000	6.0000
02	Rumly Stream	0.8165	0.4082	1.0000	3.0000
03	Tangi Dam	2.2174	1.1087	0.0000	5.0000
04	Miana Thub	2.3805	1.1902	1.0000	6.0000

Table 6. Completely Randomized AOV for Number

Source	DF	SS	MS	F	P
Algal	3	89.250	29.7500	17.1	0.00
Error	24	41.714	1.7381		
Total	27	130.964			

Group-wise Distribution Patterns:

Nearly all locales included cyanobacteria, including *Oscillatoria sp*., *Oscillatoria limnetica*, and *Lyngbya sp*., which were markers of eutrophic conditions and organic pollution. Their extensive presence indicates that nutrient vacuity is moderate to high throughout the slice spots.

Green algae, especially filamentous algae like *Spirogyra sp*., *Zygnema sp*., *Mougeotia sp*., and unicellular algae like *Chlamydomonas* and *Chlorella spp*., were the most current group. The high proportion of green algae indicates significant light penetration and dissolved oxygen vacuity, particularly in cloudy water bodies like Bari Imam and Miana Thub. Their reproductive features analogous as *Spirogyra* zygospores and diversity also point to optimal growth conditions and seasonal exertion.

Other diatoms, analogous as *Navicula*, *Nitzschia*, *Tabellaria*, and *Ulnaria*, were also vastly represented. Diatoms were set up at every position, particularly in Punjar, Bara Dari, and Tangi. This indicates stable substrata and variable water rates. Sensitive species like *Tabellaria flocculosa* were present in clean water spots, whereas tolerant species like *Nitzschia* were present in all water spots.

Site-wise Ecological Implications:

• Tangi levee showed moderate diversity, suggesting moderate nutrient situations. It hosted common green algae and diatoms, but demanded more sensitive forms.

• Punjar Stream demonstrated high diversity withco-circumstance of tolerant (*Oscillatoria*) and sensitive (*Zygnema*, *Tabellaria*) species, inferring spatial diversity and shifting water quality.

• Rumly Stream had limited diversity, indicating environmental stress, presumably due to low flux or pollution.

• Bari Imam, with its rich algal leafage, including reproductive and social stages, reflected a balanced, fairly perturbed submarine niche.

• Bara Dari also showed high diversity, with filamentous and social taxa suggesting light-rich conditions and periodic nutrient inputs.

• Japan Road displayed moderate diversity dominated by unicellular algae, indicating still or leisurely- moving water with planktonic dominance.

• Miana thub showed a amalgamation of diatoms and filamentous green algae, which is reflective of natural aqueduct conditions with stable homes and moderate nutrients.

Indicator Species and Environmental Assessment:

The concurrence of bio-index species analogous as *Tabellaria flocculosa*, *Nitzschia*, and *Oscillatoria limnetica* provides important details on particular ecological conditions at the spots

- *Oscillatoria limnetica* is reflective of pollution or a high organic content.
- *Nitzschia sp.* is a tolerant species, indicating eutrophied or disturbed waters.
- *Tabellaria flocculosa*, together with *Zygnema*, is characteristic of clean, well- oxygenated waters.

This demonstrates that the algae at these spots could be useful in biomonitoring and water quality analysis

Conclusion:

The findings of the present study are briefly described below:

• The presence of green algae of Chlorophyta and Charophyta has been observed in all the areas that indicated dominance in the forms of *Spirogyra*, *Zygnema*, and *Mougeotia*, signifying high photosynthesis activity, favorable light intensity, and moderate nutrient levels.

• The presence of cyanobacteria, i.e., *Oscillatoria sp*. and *Lyngbya sp.*, has been observed in all the areas that indicated the process of eutrophication and enrichment of organic matter.

• The presence of diatoms like *Navicula, Nitzsche, Tabellaria*, and *Ulnaria* has been observed in all areas that indicated the presence of clean and polluted water.

• Bari Imam has been observed as the most diverse area in terms of algal diversity that indicated the presence of 18 species of algae, including reproductive structures like *Spirogyra* zygospore.

Ecological Implications

The algal communities present are of great use in understanding the ecological health of the sites under study. Dominance of *Oscillatoria limnetica* and *Nitzsche* suggests that some of the sites under study are subjected to organic enrichment, perhaps because of fertilizers used in agricultural activities or sewage discharge. Conversely, the presence of such sensitive organisms as *Zygonema* and *Tabellaria floccules* suggests the presence of cleaner and less disturbed sites in the Punjar Stream, Bari Imam, and Bara Dari.

Contribution to Biodiversity Records

The study contributes to the baseline documentation of freshwater algal biodiversity in lesser-studied areas of Islamabad and Kahuta. It also demonstrates the utility of algae, particularly filamentous green algae and diatoms, as biological indicators for water quality assessment.

Recommendations

- Regular monitoring of these water bodies using algae as bio-indicators is recommended to assess any signs of eutrophication or ecological disturbances.

- Molecular identification techniques should be used in future studies for verification and extension of species identification.

- Quantitative ecological indices and physico-chemical parameters of water should be used for better ecological analysis.

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