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Cyanobacterial Diversity from Freshwater Bodies of Murshidabad, West Bengal, India and Assessment of Their Distribution Pattern

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ABSTRACT

Freshwater cyanobacterial population show significant ecological variation formed by environmental gradients. In this systematic study, 32 taxa belonging to 22 genera were recorded from the Kandi subdivision, Murshidabad, West Bengal. The most dominant species was *Phormidium* sp., and different study areas highlighted spatial variations by diversity indices. The maximum values of the Shannon, Margalef, Berger-Parker, and Simpson indices were recorded from different locations separately. Principal component analysis represented maximum variation between EC and TDS (PC1 50.01%). Pearson correlation plots also validate the strong positive correlation between TDS and EC (r = 0.773) and the negative correlation between pH and temperature (r = –0.112). One-sample t-tests demonstrate notable variations against environmental factors, highlighting their impact on the arranging of cyanobacterial colonies. This study provides significant insights into the ecological association of cyanobacteria, highlighting the significance of physicochemical variability in supporting biodiversity and informing conservation approaches for aquatic habitats.

Keywords Cyanobacteria, Diversity, Murshidabad, Physicochemical analysis, PCA.

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INTRODUCTION

Cyanobacteria are an oxygen producing significantly diverse prokaryotic group present in a variety of aquatic environments. Seasonal and regional fluctuation physicochemical parameters such as temperature, nutrient level, availability of light were influenced the cyanobacterial community. Due to anthropogenic activities were also influenced the growth of cyanobacteria, which often leads to formed harmful cyanobacterial blooms (HCB) and these HCBs impacted

water quality, aquatic food chains, and human health (Gobler *et al.* 2024).

The principal component analysis is also useful in cyanobacterial diversity to know the relationship among the environmental parameter, such as temperature, electrical conductivity (EC), pH, and total dissolved solids (TDS) (Chavan and Devarajan 2026). In addition, cyanobacteria encompass species showed significant biotechnological potential. Such as biofertilization, bioremediation, food industry, pharmaceutical (Dudeja *et al.* 2025).

Although this potential existed, there were still few comprehensive descriptions of cyanobacterial diversity and lack essential information for ecological monitoring and water resource management. Systematic surveys were conducted by various workers in West Bengal (Banerjee *et al.* 2020, Dey and Chakraborty 2020, Debnath and Dey 2021, Mallick *et al.* 2025). In Murshidabad district, a thorough study of cyanobacterial diversity was done by Pal and Santra (Pal *et al.* 1986).

It was an attempt to make out the cyanobacterial biodiversity across Kandi subdivision belonging to the Murshidabad district. This researchS provided the revised baseline information of cyanobacterial community and environmental parameters that can aid future ecological, biotechnological studies in Murshidabad.

MATERIALS AND METHODS

Study Area

Kandi subdivision covers an area of approximately 1,200.76 km with coordinates of 23° 57′ 0″ N latitudes and 88° 1′ 48″ E longitudes. The study was carried out throughout the subdivision, and a study area map (Fig. 1A-1C, Table 1) was generated using Q Gis software.

Collection, isolation, purification, identification and preservation

Cyanobacteria samples were collected from various freshwater bodies (Fig. 2A-2D) in the Kandi subdivision of Murshidabad district. Collected samples were examined under a Carl Zeiss Primo Star microscope. Pure cultures of the isolates were obtained using the agar method and maintained in BG-11 medium. The incubation temperature was kept at 28 ± 2°C, and continuous white light irradiation at 25–30 µmol m^{-2} s^{-1} was also maintained (Rippka *et al.* 1979, Kaushik 1987).

Traditional morphometric approaches were used for identification following the standard monographs (Desikachary 1959, Komárek and Anagnostidis 1999, 2005, Komárek J. 2013).

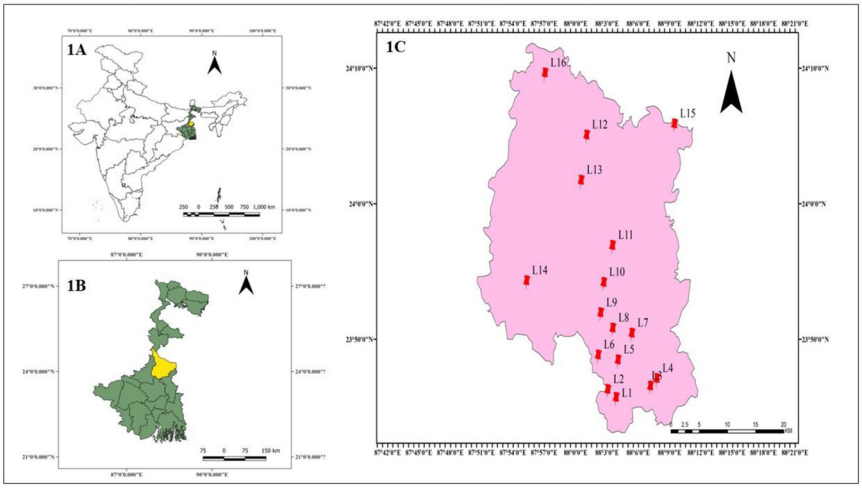


Fig. 1 A- Represents West Bengal in India; **1B-** Represents Kandi subdivision, District Murshidabad in West Bengal Map; **1C-** Represents study area along with collection site location.

Table 1. Diversity indices of cyanobacterial communities across 16 sampling locations in Kandi subdivision Murshidabad District, West Bengal, India. Values include Shannon diversity index (H'), Simpson's index (1–D), Margalef richness index (d), and Berger–Parker dominance index (d), with corresponding geographic coordinates (latitude and longitude) for each site. [L= Location].

Study Site	Latitude	Longitude	Shannon (H')	Simpson (1-D)	Margalef (d)	Berger-Parker (d)
L1	23°45'35.08"N	88° 3'50.62"E	2.567046	0.088	4.349345	0.16
L2	23°46'10.09"N	88° 3'1.85"E	2.740403	0.073881	4.950513	0.129032
L3	23°46'25.19"N	88° 7'7.72"E	2.38889	0.1	3.67189	0.15
L4	23°46'58.57"N	88° 7'44.87"E	2.773718	0.072917	5.349186	0.166667
L5	23°48'21.28"N	88° 4'1.50"E	2.539367	0.086777	4.205701	0.136364
L6	23°48'43.22"N	88° 2'7.88"E	2.506662	0.096953	4.415103	0.210526
L7	23°50'19.49"N	88° 5'21.54"E	2.835134	0.065398	5.345536	0.103448
L8	23°50'42.09"N	88° 3'31.31"E	2.397267	0.111111	3.941505	0.238095
L9	23°51'49.64"N	88° 2'21.90"E	2.630033	0.084184	4.501524	0.178571
L10	23°54'4.17"N	88° 2'39.04"E	2.553237	0.08642	4.497691	0.166667
L11	23°56'47.45"N	88° 3'29.76"E	2.934536	0.059688	5.719993	0.121212
L12	24° 4'58.97"N	87°52'40.92"E	2.588573	0.079585	4.58843	0.117647
L13	24° 1'35.90"N	88° 0'29.77"E	2.891439	0.061394	5.532927	0.096774
L14	23°54'11.63"N	87°55'16.50"E	2.303488	0.111111	3.692694	0.2
L15	24° 5'45.50"N	88° 9'26.30"E	2.84146	0.065398	5.345536	0.137931
L16	24° 9'30.91"N	87°57'2.23"E	2.960034	0.061224	5.886021	0.119048

Analysis of Physicochemical Properties of Water Samples

Cyanobacterial diversity and abundance were regulated by multiple physicochemical factors (Table 2), including temperature, pH, total dissolved solids (TDS), and electrical conductivity (EC) of aquatic environments (Amorim *et al.* 2020).



Fig. 2 A-D. Represents photographs of different habitats.

Table 2. Physicochemical characteristics of water across 16 sampling sites in Kandi subdivision, Murshidabad District, West Bengal, India. Values are expressed as mean ± standard deviation for pH, temperature (°C), total dissolved solids (TDS, mg/L), and electrical conductivity (EC, µS/cm). The dataset highlights spatial variation in physicochemical parameters influencing cyanobacterial diversity.

Study Sites	Mean pH	Mean Temperature (°C)	Mean TDS (mg/L)	Mean EC (µs/cm)
L1	7.607± 0.247	28.02 ± 1.82	532.5 ± 86.088	616.25 ± 102.881
L2	7.532 ± 0.242	28.755 ± 2.503	479.003 ± 37.41	736.5 ± 102.441
L3	7.612 ± 0.241	27.555 ± 2.657	421.75 ± 88.728	746.5 ± 76.617
L4	7.425 ± 0.193	28.942 ± 3.057	365.5 ± 72.5	477.25 ± 80.132
L5	7.8 ± 0.22	28.075 ± 2.001	363.25 ± 33.633	589 ± 36.359
L6	7.515 ± 0.192	30.05 ± 4.287	360.25 ± 46.692	528 ± 41.024
L7	7.555 ± 0.153	30.257 ± 3.61	384.25 ± 71.775	577.25 ± 29.84
L8	7.71 ± 0.285	30.085 ± 3.153	530.25 ± 85.109	1218.75 ± 180.376
L9	7.732 ± 0.262	28.61 ± 2.303	425.5 ± 54.71	790.25 ± 60.089
L10	7.785 ± 0.125	28.697 ± 1.673	477.25 ± 82.91	759.725 ± 70.218
L11	7.832 ± 0.278	28.662 ± 2.36	363.75 ± 59.149	587.5 ± 45.113
L12	7.487 ± 0.138	29.022 ± 3.474	509.25 ± 89.141	934.25 ± 79.647
L13	7.537 ± 0.297	29.68 ± 2.937	401.25 ± 68.536	654.75 ± 60.647
L14	7.62 ± 0.139	28.612 ± 2.221	392 ± 60.477	588 ± 33.948
L15	7.767 ± 0.277	30.435 ± 3.73	540.75 ± 66.001	1371.25 ± 117.854
L16	7.575 ± 0.371	28.282 ± 2.61	416.25 ± 82.034	745.25 ± 75.433

Shannon–Wiener Diversity Index (H′)

The Shannon–Wiener index is commonly used in the studies of phytoplankton and cyanobacteria. It considers both species richness and evenness, rendering it responsive to alterations in community structure.

$$H' = -\sum (pi \ln pi)$$

where pi is the proportion of individuals in the i^{th} species. Increased cyanobacterial diversity and a more balanced species distribution are indicated by higher Shannon index values, whereas dominance by one or a small number of taxa is indicated by lower values (Shannon 1948).

Simpson's Diversity Index (D)

Simpson's index measures the probability that two randomly selected individuals in a sample are members of the same species. Rather than richness, it emphasizes species domination.

$$D = \sum pi^2$$

Simpson diversity is commonly expressed as 1−D or 1 / D. where N is the total number of species and pi is the relative abundance of observed species. A high Simpson dominance score in cyanobacterial communities indicates blooms and reduced community stability (Simpson 1949).

Margalef's Richness Index (d)

Species evenness has not significantly affected Margalef's index, which primarily shows species richness.

$$d = \frac{S - 1}{\ln N}$$

where, "N" = total count of individual and "S" = species count. Margalef's index is useful for evaluating richness across locations or seasons in cyanobacteria research. Reduced values are typical of eutrophic systems dominated by a few bloom-forming species, whereas higher values reflect greater cyanobacterial species diversity, commonly observed in oligotrophic or mesotrophic environments (Margalef 1957).

Berger–Parker Dominance Index (d)

The relative abundance of the most common species in a population is measured by the Berger-Parker index.

$$d = \frac{N\ Max}{N}$$

where the total number of individuals and the number of individuals is represented by "N" and "Nmax",

respectively. Elevated Berger-Parker values in cyanobacterial communities indicate significant dominance by species that produce toxins or create blooms, indicating environmental pressure and ecological imbalance (Berger and Parker 1970).

One-sample t-test

To differentiate between an unknown population mean and a specific value one -sample t-test is used as a statistical hypothesis test.

$$t = \frac{\bar{x} - \mu}{sI\sqrt{n}}$$

$\bar{x}$ =Sample mean, μ= Hypothesized population mean, s= Sample standard deviation, n=sample size.

Multivariate Analysis

It is used to study the relationship between cyanobacterial diversity and physicochemical properties of aquatic ecosystems (Rangra *et al.* 2024). Principal Component Analysis (PCA) represents simplified interrelationships among diversity indices, species composition, and physicochemical variables (Sharma *et al.* 2024).

Data Analysis

For data analysis and graph development python (version 3.12.12), 'scikit-learn' package is used to run the PCA analysis.

RESULTS AND DISCUSSION

Identification of isolated organism

A systematic study showed a total of 32 organism belongs to belongs 22 genera were documented [Photo plate 1 (A-X) & Photo plate 2(A-H), Table 3], *Phormidium* was the most dominant genera with 4 species. In recent studies, it had been found that *Phormidium* can tolerate a wide range of physicochemical conditions (Kalita and Baruah 2023). Detailed taxonomic description was mentioned in supplementary file (Supplementary file).

Diversity analysis

The analysis showed varying levels of diversity and dominance patterns across the study sites. The grouped bar chart of all indices (Fig. 3, Table 1) visually confirmed that the Shannon and Margalef indices values tend to be higher in some locations than others, which revealed that those study sites were richer, with a more even distribution of species populations. In this study, location 8 showed the maximum Berger-Parker index value (0.238), indicating greater dominance by a single species. *Oscillatoria subbrevis* and *Phormidium* sp. were the most dominant organisms across the location (Fig. 4). Location 16 had the highest Shannon diversity index

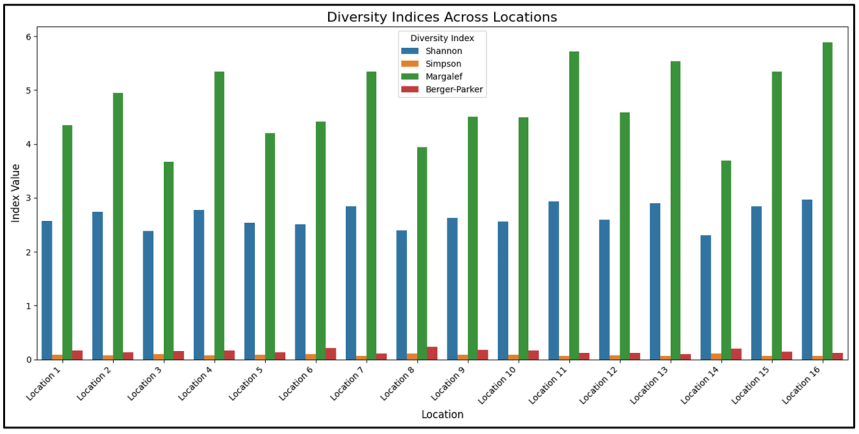


Fig. 3. Comparative analysis of cyanobacterial diversity indices across 16 sampling locations.

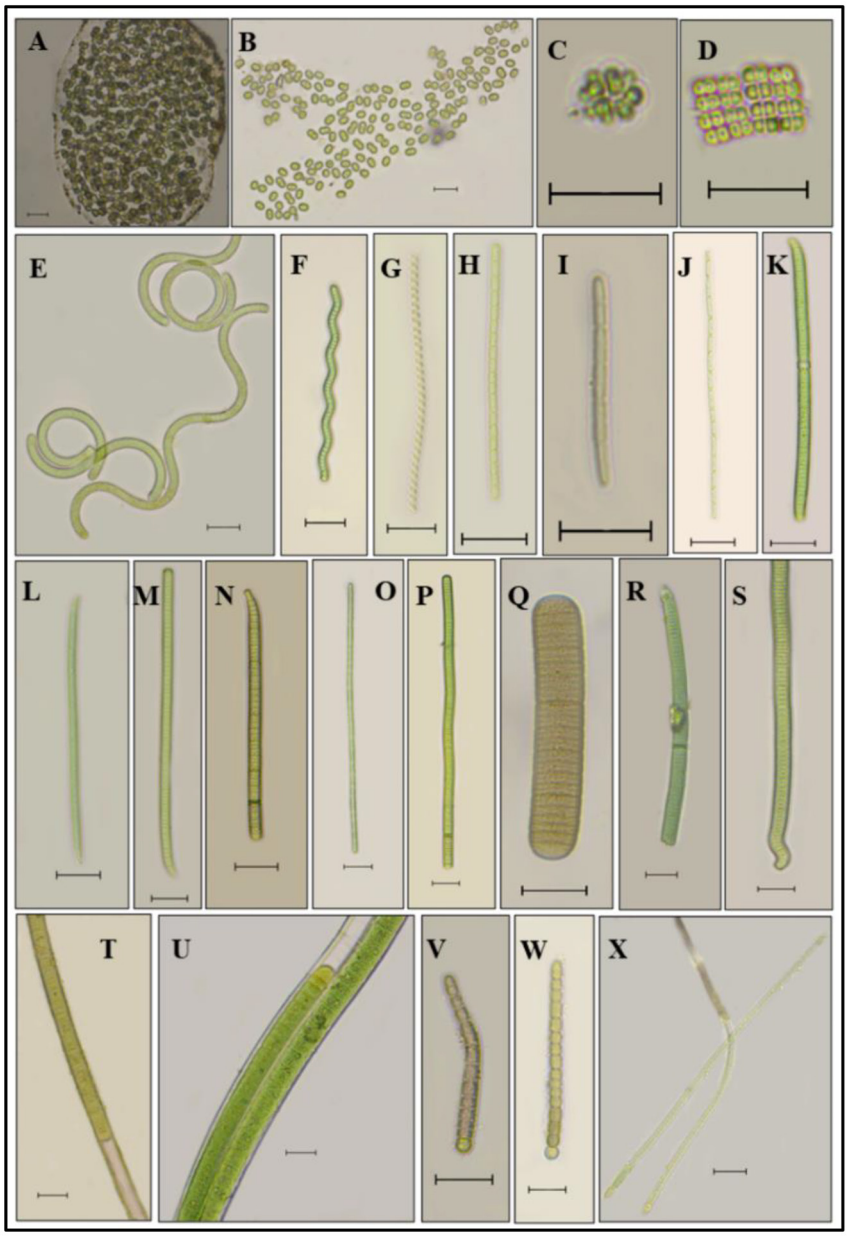


Photo plate 1. A. *Microcystis smithii* Komárek & Anagnostidis; **B**. *Cyanobacterium minervae* (J.J. Copeland) Komárek; **C.** *Gomphosphaeria aponina* Kützing; **D**. *Merismopedia glauca* (Ehrenberg) Kützing; **E**. *Limnospira indi*ca (Desikachary & Jeeji-bai) Nowicka-Krawczyk; **F.** *Arthrospira balkrishnanii* N.D. Kamat; **G**. *Spirulina major* Kutzing ex Gomont; **H**. *Pseudanabaena catenata* Lauterborn; **I.** *Pseudanabaena voronichinii* Anagnostidis; **J**. *Jaaginema gracile* Anagnostidis & Komárek; **K**. *Phormidium breve* (Kützing ex Gomont) Anagnostidis & Komárek; **L**. *Phormidium acula* (Brühl & Biswas) Anagnostidis & Komárek; **M**. *Kamptonema formosum* (Bory ex Gomont) Strunecký; **N.** *Phormidium uncinatum* Gomont; **O**. *Anagnostidinema amphibium* (Gomont) Strunecký, Bohunická, J.R. Johansen & Komárek; **P.** *Phormidium* sp.; **Q**. *Oscillatoria subbrevis* var. major (G.S. West) Umezaki & Watanabe; **R.** *Oscillatoria ornata* Kützing ex Gomont; **S.** *Oscillatoria anguina* Bory ex Gomont; **T**. *Lyngbya* sp.; **U.** *Lyngbya martensiana* Meneghini ex Gomont; **V.** *Calothrix marchica* var. intermedia C.B. Rao; **W.** *Rivularia aquatica* De Wildeman; **X.** *Cylindrospermum mikhailovskoense* f. minus Elenkin; each scale bar is 10μm.

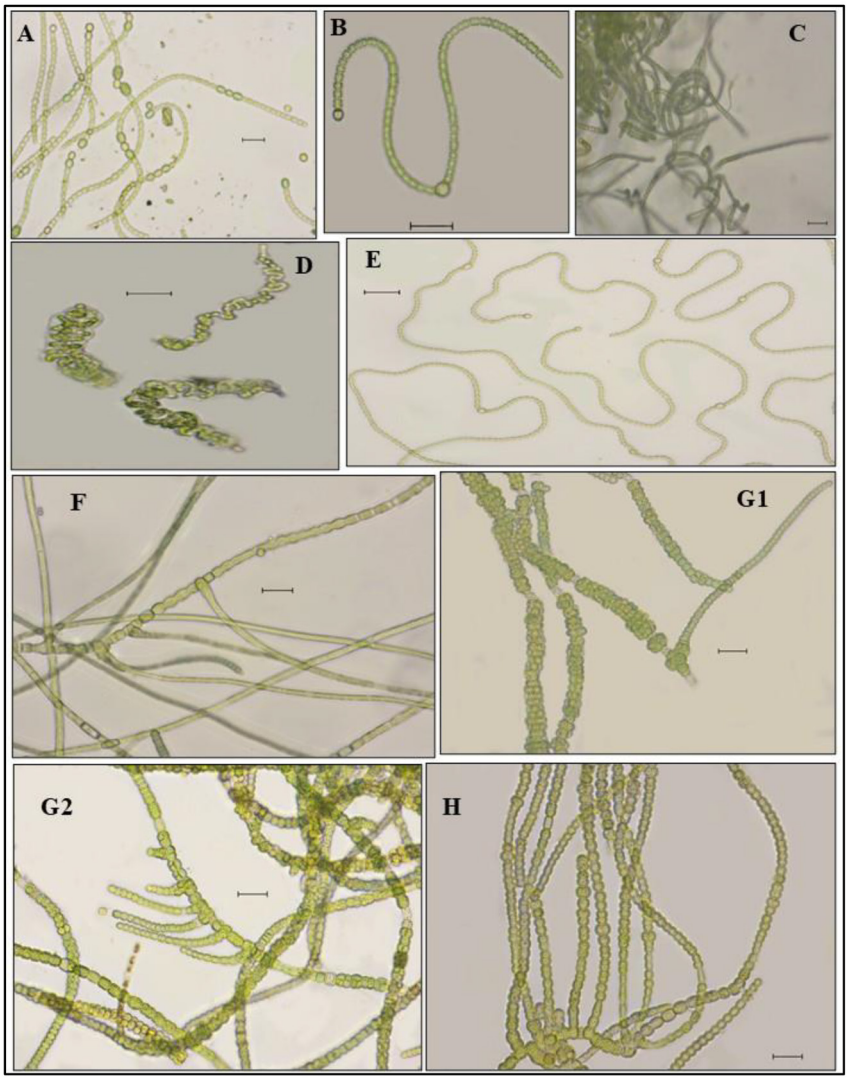


Photo plate 2. A. *Anabaena sphaerica* Bornet & Flahault; **B.** *Anabaena carmichaeli*i Cronberg & Komárek; **C.** *Anabaenopsis magna* J.H. Evans; **D.** *Nostoc punctiforme* f. populorum (Geitler) Hollerbach; **E.** *Nostoc commune* Vaucher ex Bornet & Flahault; **F.** *Hapalosiphon welwitschii* West & G.S. West; **G1 & G2.** *Westiellopsis prolifica* Janet; **H.** *Fischerella muscicola* Gomont; each scale bar is 10 µm.

and Margalef richness index, with values of 2.960 and 5.886, respectively. Location 14 had a comparatively low Simpson index (Table 1), i.e., 0.111, indicating greater evenness and less dominance. The highest Berger-Parker dominance index was recorded at L8 (Table 1), with a value of 0.238. These findings are similar to prior research, which indicates that substrate type and microhabitat variation significantly impact cyanobacterial diversity (Dubey 2023).

Multivariate Analysis of Environmental Variables

Analysis of Principal Components of Environmental PC1 and PC2 accounted for 50.1% and 27.8%, respectively, and together accounted for 77.9% of the overall variance (Fig. 5). PC1 showed notable positive loadings for total dissolved solids (TDS) and electrical conductivity (EC). It was revealed that a dominant ionic gradient influences site variation. In PC2, mean

Table 3. Represents isolated organism arranged in taxonomic order.

Order	Family	Organism Name
Chroococcales	Microcystaceae	*Microcystis smithii*
	Merismopediaceae	*Merismopedia glauca*
	Gomphosphaeriaceae	*Gomphosphaeria aponina*
	Cyanobacteriaceae	*Cyanobacterium minervae*
Oscillatoriales	Spirulinaceae	*Limnospira indica*
		Arthrospira balkrishnanii
		Spirulina major
	Pseudanabaenaceae	*Pseudanabaena catenate*
		P. voronichinii
		Jaaginema gracile
	Phormidiaceae	*Phormidium breve*
		P. acula
		P. uncinatum
		Phormidium sp.
		Kamptonema formosum
		Anagnostidinema amphibium
	Oscillatoriaceae	*Oscillatoria subbrevis* var. *major*
		O. ornata
		O. anguina
	Lyngbyaceae	*Lyngbya* sp.
	Rivulariaceae	*L. martensiana*
		Calothrix marchica var. *intermedia*
		Rivularia aquatica
Nostocales	Nostocaceae	*Cylindrospermum mikhailovskoense f. minus*
		Anabaena sphaerica
		A. carmichaelii
		Nostoc punctiforme f. populorum
		N. commune
	Anabaenopsidaceae	*Anabaenopsis magna*
Stigonematales	Hapalosiphonaceae	*Hapalosiphon welwitschii*
	Westiellopsidaceae	*Westiellopsis prolifica*
	Fischerellaceae	*Fischerella muscicola*

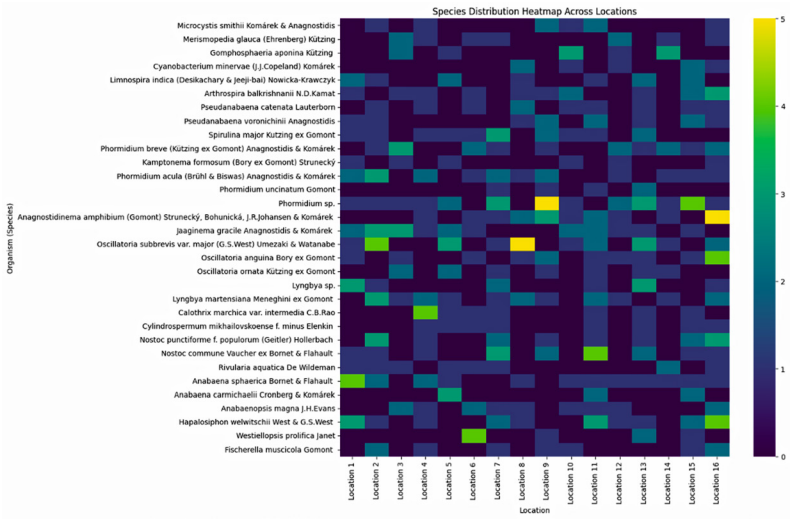


Fig. 4. Species distribution heatmap across 16 sampling locations.

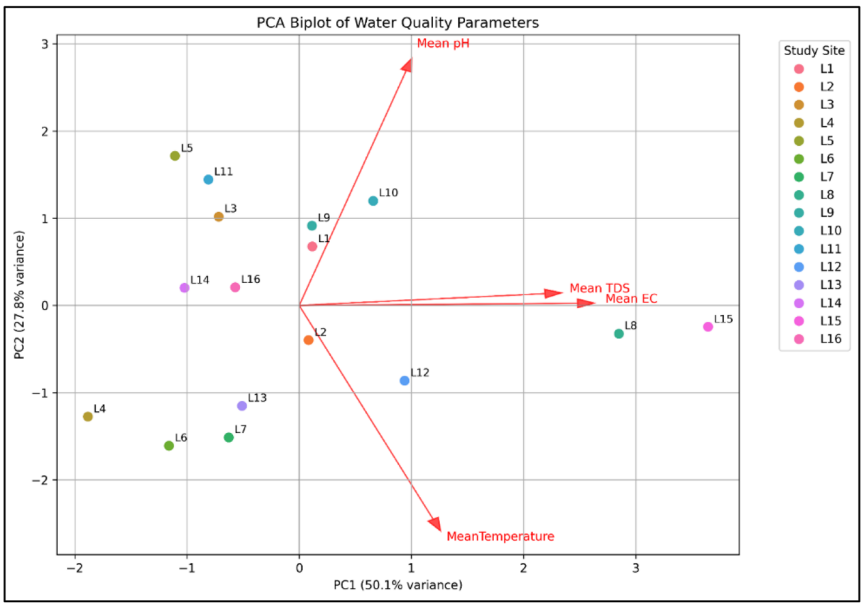


Fig. 5. Represents Principal Component Analysis (PCA) of environmental parameters showing the distribution of 16 sampling locations (L1–L16) grouped into species value clusters (low, medium, high).

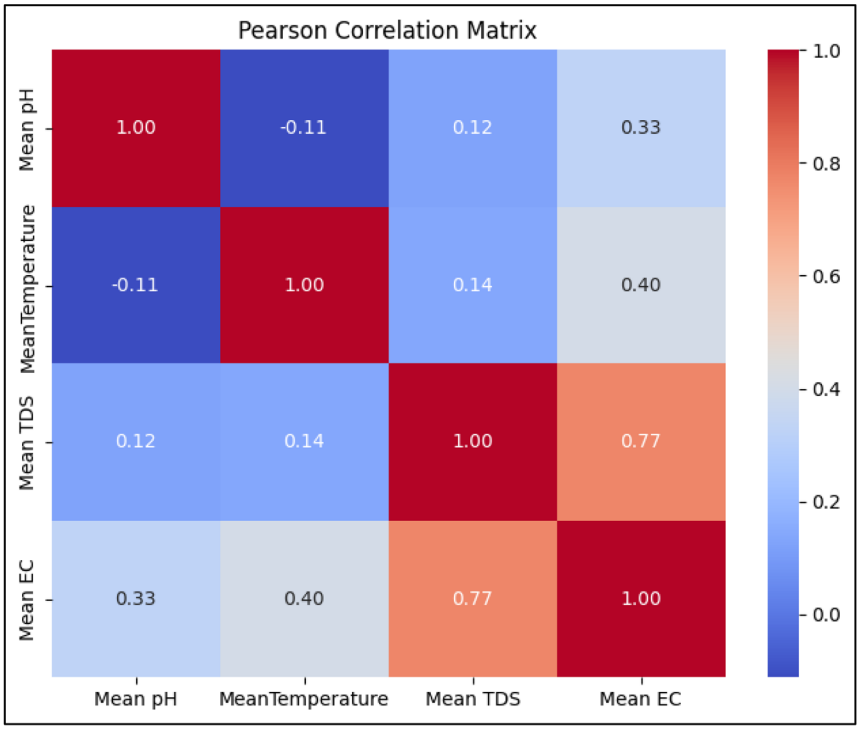


Fig. 6. Pearson correlation matrix of environmental parameters across sampling sites.

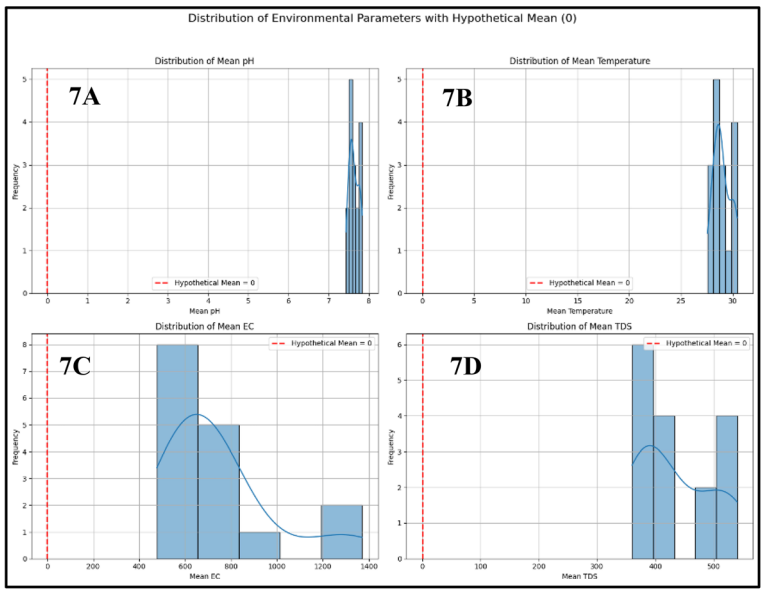


Fig. 7. Distribution of environmental parameters across sampling sites based on one-sample t-test analysis. 7A-Histograms show mean values for pH; 7B-Temperature (°C); 7C-Electrical conductivity (EC, µS/cm); 7D- Total dissolved solids (TDS, mg/L).

temperature (negative loading) and average pH (positive loading), which signified an alkaline temperature gradient. This multivariate analysis concluded that distinguishing locales along these axes highlighted the significance of physicochemical diversity in organizing freshwater habitats. In Pearson's correlation (2008), EC and TDS showed a strong positive association (r = 0.773) as determined by the analysis (Fig. 6), indicating their mutual dependence on dissolved mineral concentration. On the other hand, a negative correlation was found between temperature and pH (r = -0.112). The average pH showed a weak positive correlation with EC and TDS.

Analysis One-sample t-test

Environmental variables such as pH, temperature, EC, and TDS showed significant p-values near zero (Fig. 7A-7D) and the T-statistic values for mean pH, temperature, TDS, and EC were 133.166, 244.981, 26.278, and 12.165, respectively. These were visually confirmed by individual bar graphs.

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REFERENCES

Amorim, C. A., Dantas, Ê. W., & Moura, A. D. N. (2020). Modeling cyanobacterial blooms in tropical reservoirs: The role of physicochemical variables and trophic interactions. *Science of the Total Environment,* 744, 140659. https://doi.org/10.1016/j.scitotenv.2020.140659

Banerjee, S., Singh, A., & Pal, R. (2020). A taxonomic investigation on heterocytous cyanobacteria of West Bengal, India. *Phytomorphology,* 70(3–4), 53–57.

Berger, W. H., & Parker, F. L. (1970). Diversity of planktonic foraminifera in deep-sea sediments. *Science,* 168(3937), 1345–1347.

Kalita, N., Baruah, P. P. (2023). Cyanobacteria as a potent platform for heavy metals biosorption: uptake, responses and removal mechanisms. *Journal of Hazardous Materials Advances,* 11, 100349. https://doi.org/10.1016/j.hazadv.2023.100349

Chavan, V. S., & Devarajan, T. (2026). Diversity and distribution of cyanobacteria in the challenging environment of paddy fields in coastal Karnataka, India. *The Bioscan,* 21(1), 628–637.

Debnath, P., & Dey, H. S. (2021). Diversity of cyanobacteria from freshwater bodies of Krishnagar Sadar subdivision of

Nadia District, West Bengal, India. *Journal of Biodiversity and Environmental Sciences,* 21(5), 190–197.
Desikachary, T. V. (1959). *Cyanophyta.* New Delhi: Indian Council of Agricultural Research.
Dey, H. S., & Chakraborty, S. (2020). Diversity of non-heterocystous filamentous cyanobacteria from freshwater bodies of Bidhannagar, North 24 Parganas, West Bengal. *Asian Journal of Biological and Life Sciences,* 9(3), 386–390.
Dubey, A. (2023) Cyanobacterial Diversity in a Freshwater Ecosystem, *IJEMMASSS*, 51, Volume 05, No. 01(I), pp. 51-55.
Dudeja, C., Masroor, S., Mishra, V., *et al.* (2025). Cyanobacteria-based bioremediation of environmental contaminants: Advances and computational insights. *Discover Agriculture*, 3, 42. https://doi.org/10.1007/s44279-025-00193-9
Gobler, C. J., Drinkwater, R. W., Anthony, A., Goleski, J. A., Famularo-Pecora, A. M. E., Wallace, M. K., Straquadine, N. R. W., & Hem, R. (2024). Sewage- and fertilizer-derived nutrients alter the intensity, diversity, and toxicity of harmful cyanobacterial blooms in eutrophic lakes. *Frontiers in Microbiology*, 15, 1464686. https://doi.org/10.3389/fmicb.2024.1464686
Kaushik, B. D. (1987). *Laboratory methods for blue-green algae.* New Delhi: Associated Publishing Company.
Komárek, J. (2013). *Süßwasserflora von Mitteleuropa, Bd. 19/3: Cyanoprokaryota.* Berlin: Springer Spektrum.
Komárek, J., & Anagnostidis, K. (1999). *Cyanoprokaryota 1. Teil Chroococcales*. Heidelberg: Spektrum Akademischer.
Komárek, J., & Anagnostidis, K. (2005). *Cyanoprokaryota. Süßwasserflora von Mitteleuropa*, Bd. 19/2. Heidelberg: Spektrum Akademischer.
Mallick, T., Debnath, P., & Dey, H. S. (2025). A taxonomic evaluation of freshwater cyanobacteria from Berhampore subdivision of Murshidabad District, West Bengal, India. *Indian Journal of Natural Sciences,* 16(92), October.
Margalef, R. (1957). Information theory in ecology. *Annals of the Royal Academy of Arts and Sciences of Barcelona,* 32(13), 373–449.
Pal, T. K., Adhya, T. K., & Santra, S. C. (1986). Algal flora of Murshidabad District, West Bengal I. A survey from Berhampore and adjoining areas. *Bulletin of the Botanical Society of Bengal,* 40, 33–43.
Pearson's Correlation Coefficient. (2008). In W. Kirch (Ed.), *Encyclopedia of Public Health.* Dordrecht: Springer. https://doi.org/10.1007/978-1-4020-5614-7_2569
Rangra, G. S., Singh, Y., Thapa, K., Khattar, J. I. S., & Singh, D. P. (2024). Spatiotemporal distribution of cyanobacteria in relation to water chemistry of Sutlej River, Punjab (India). *Environmental Monitoring and Assessment,* 196 (10), 937. https://doi.org/10.1007/s10661-024-13011-4
Rippka, R., Deruelles, J., Waterbury, J. B., Herdman, M., & Stanier, R. Y. (1979). Generic assignments, strain histories and properties of pure cultures of cyanobacteria. *Journal of General Microbiology,* 111, 1–61.
Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal,* 27(3), 379–423.
Sharma, R., Patel, S., & Verma, A. (2024). Diversity analysis of cyanobacterial flora from the Tatapani Hot Spring of Chhattisgarh and exploration of their industrially as well as environmentally valuable properties. *Algal Research,* 82, 103653. https://doi.org/10.1016/j.algal.2024.103653
Simpson, E. H. (1949). Measurement of diversity. *Nature,* 163(4148), 688.

Supplementary file

Taxonomic enumeration of identified organisms

Microcystis smithii Komárek & Anagnostidis, Photo plate 1A
(Retrieved from Komárek & Anagnostidis, 1999, p. 228, fig. 299b)
Description: Colonies more or less spherical, free floating, colony olive-green, cell 4.2µm in diameter.
Habitat: Free floating on pond

Cyanobacterium minervae (J.J. Copeland) Komárek, Photo plate 1B
(Retrieved from Komárek & Anagnostidis, 1999 p. 48, fig. 21)
Description: Colony mucilaginous, cells solitary, almost spherical, pale blue-green, cell 4.1µm broad and 4.5µm long.
Habitat: Brown jelly like colonies attached to the stone

Gomphosphaeria aponina Kützing, Photo plate 1C
(Retrieved from Komárek & Anagnostidis, 1999, p. 221, fig. 290)
Description: Cells olive-green, 4.5µm width and 8µm long, branched radial mucilaginous stalks.
Habitat: Free floating on canal

Merismopedia glauca (Ehrenberg) Kützing, Photo plate 1 D
(Retrieved from Komárek & Anagnostidis, 1999, p. 177, fig. 225)
Description: Colonies made up with 16 cells, oval to spherical, olive-green in colour, closely arranged, 3.2-5.8µm wide.
Habitat: Free floating on pond

Limnospira indica (Desikachary & Jeeji-bai) Nowicka-Krawczyk, Photo plate 1E

(Retrieved from Komárek, 2005, p. 347, fig. 481b)
Description: Trichome spirally coiled, olive-green in colour, cells shorter than wide 6-8µm wide and 2.6µm long.
Habitat: Free floating on pond

Arthrospira balkrishnanii N.D. Kamat, Photo plate 1F
(Retrieved from Komárek, 2005, p. 346, fig. 486)
Description: Trichomes solitary, 3.5-4µm wide, cells shorter than wide,0.8-1.2µm long, apical cell rounded without calyptra.
Habitat: Attached to the mud on paddy field

Spirulina major Kutzing ex Gomont, Photo plate 1G
(Retrieved from Komárek, 2005, p. 148, fig. 173e)
Description: Trichomes pale blue-green, left-handed screw like rotation, 1-2µm wide, distance between spirals 2-2.4µm, apical cell rounded.
Habitat: Attached to the brick

Pseudanabaena catenata Lauterborn, Photo plate 1H
(Retrieved from Komárek, 2005, p. 83, fig. 59a)
Description: Trichome solitary, olive-green in colour, more or less straight, 1.2-2µm wide, cell longer than wide, 2-6µm long, apical cell rounded without areotopes.
Habitat: Attached to the mud

Pseudanabaena voronichinii Anagnostidis, Photo plate 1I
(Retrieved from Komárek, 2005, p. 77, fig. 48d)
Description: Trichome solitary, short, composed of 2-8 cells, cells longer than wide 1-2µm long, 2.5-8µm long, apical cell rounded.
Habitat: Attached to the grass

Jaaginema gracile Anagnostidis & Komárek, Photo plate 1J
(Retrieved from Komárek, 2005, p. 110, fig. 107)
Description: Trichome pale blue-green, 0.7-1µm wide, cells 2-5µm long, apical cell rounded
Habitat: Attached to the mud on paddy field

Phormidium breve (Kützing ex Gomont) Anagnostidis & Komárek, Photo plate 1K
(Retrieved from Komárek, 2005, p. 420, fig. 599c, d)
Description: Trichome bright blue-green in colour, slightly curved at the end, 5-6µm wide, cell 1.5-3µm long.
Habitat: Attached to the cemented wall

Phormidium acula (Brühl & Biswas) Anagnostidis & Komárek, Photo plate 1L
(Retrieved from Komárek, 2005, p. 404, fig. 559)
Description: Trichome solitary, bluish-green, 4-6µm wide, apical cells narrowed, hooked.
Habitat: Attached to the Brick

Kamptonema formosum (Bory ex Gomont) Strunecký, Photo plate 1M
(Retrieved from Komárek, 2005, p. 421, fig. 602b)
Description: Thallus dark blue-green, trichome olive-green, 3.8µm-5µm wide, cell shorter than wide, 2.5-4.6µm long, apical cell obstuse-clonical.
Habitat: Attached to the mud

Phormidium uncinatum Gomont, Photo plate 1N
(Retrieved from Komárek,2005, p. 481, fig. 719c)
Description: Trichome dirty green, 4-5.5µm wide, cell 2-6µm long, apical cell capitate.
Habitat: Attached to the rock

Anagnostidinema amphibium (Gomont) Strunecký, Bohunická, J.R. Johansen & Komárek, Photo plate 1O
(Retrieved from Komárek, 2005, p. 136, fig. 151e)
Description: Trichome almost straight, apical portion slightly bend, trichome 2.8µm wide, cell 0.8-2.4µm long.
Habitat: Attached to the grass

Phormidium sp., Photo plate 1P
Description: Trichome bright blue-green in colour, 3.7-4.1µm wide, apical cell rounded without calyptra.
Habitat: Attached to the mud

Oscillatoria subbrevis var. *major* (G.S. West) Umezaki & Watanabe, Photo plate 1Q
(Retrieved from Komárek, 2005, p. 587, fig. 877a)
Description: Trichome grey, 8.4µm wide, cell shorter than wide, 1.5µm long, apical cell rounded without calyptra.
Habitat: Attached to mud on river bank

Oscillatoria ornata Kützing ex Gomont, Photo plate 1R
(Retrieved from Komárek, 2005, p. 582, fig. 867b)
Description: Trichomes dark blue-green, towards end screw-like coiled, 6.6µm wide, cell 2.1µm long.
Habitat: Attached to the stone on canal

Oscillatoria anguina Bory ex Gomont, Photo plate 1S
(Retrieved from Komárek, 2005, p. 592, fig. 885a)
Description: Trichome bright blue-green, 5.5-6.1µm wide, cell shorter than wide, 1.3-2.5µm long, apical cell sickle like.
Habitat: Attached to stairs on canal

Lyngbya sp., Photo plate 1T
Description: Trichome olive green ,6.1 µm wide, cell 1.40 µm long, apical cell widely rounded without calyptra.
Habitat: Attached to the grass

Lyngbya martensiana Meneghini ex Gomont, Photo plate 1U
(Retrieved from Komárek, 2005, p. 612, fig. 931a)
Description: Trichome olive green ,8.19 µm wide, cell 4.47 µm long, apical cell widely rounded without calyptra.
Habitat: Free floating as a mat on canal

Calothrix marchica var. *intermedia* C.B. Rao, Photo plate 1V
(Retrieved from Komárek,2013, p. 242, fig. 245)
Description: Filaments solitary, 5-6µm wide, not very narrowed towards the end, 4-5.5µm wide at the widened base, heterocyst basal, single, 4.5-5µm wide.
Habitat: Attached to the mud on paddy field

Rivularia aquatica De Wildeman, Photo plate 1W
(Retrieved from Komárek,2013, p.308, fig. 354)
Description: Colonies more or less spherical, dark green, cell 3-5.5µm wide and 5-6µm long, heterocyst spherical.
Habitat: Attached to the grass on stagnant water

Cylindrospermum mikhailovskoense f. *minus* Elenkin, Photo plate 1X
(Retrieved from Komárek,2013, p. 886, fig. 1140)
Description: Thallus mucilaginous, often expanded, blue-green, trichome rarely straight. Cells pale blue-green, slightly barrel-shaped, longer than wide, length 7.35µm and bredth 4.15µm. Heterocyst develops only at one end of trichome, cylindrical, length 7.17µm and bredth 6.14µm. Akinetes cylindrical, solitary length 13.40µm.
Habitat: Attached to the stone on paddy field

Anabaena sphaerica Bornet & Flahault, Photo plate 2A
(Retrieved from Komárek,2013, p.796, fig. 992a)
Description: Cell barrel-saphed,5-6µm wide, heterocyst intercalary, solitary, 6-7µm in diameter, Akinetes attached both sides of the heterocyst, 12-18µm long.
Habitat: Free floating on Canal as a tuff-like structure

Anabaena carmichaelii Cronberg & Komárek, Photo plate 2B
(Retrieved from Komárek,2013, p.752, fig. 931b)
Description: Trichome solitary, free-floating, cells cylindrical to barrel-shaped, 3.5-3.8µm wide, heterocyst up to 4µm in diameter.
Habitat: Attached to the mud on paddy field

Anabaenopsis magna J.H. Evans, Photo plate 2C
(Retrieved from Komárek,2013, p.787, fig. 983h)
Description: Trichome screw like coiled, blue-green in colour, cells cylindrical 5.7µm in diameter, heterocyst spherical, 6.1µm in diameter.
Habitat: Attached to the mud

Nostoc punctiforme f. *populorum* (Geitler) Hollerbach, Photo plate 2D

(Retrieved from Komárek,2013, p. 963, fig. 1254a)
Description: Colonies perfectly spherical, bluish-green, cells barrel-shaped, 4-6.7µm wide, heterocyst spherical or slightly oval shaped, 6-7µm in diameter, akinete was not formed.
Habitat: Free floating as colony on canal

Nostoc commune Vaucher ex Bornet & Flahault, Photo plate 2E
(Retrieved from Komárek,2013, p. 979, fig. 1273d)
Description: Colonies visible, cells shortly barrel-shaped, pale olive green, 3-3.5µm wide and 4-4.3µm long, heterocyst almost spherical, 4.5-5.2µm wide and 5.21µm long, akinete was not found.
Habitat: Attached to the stone as jelly-like substances

Hapalosiphon welwitschii West & G.S. West, Photo plate 2F
(Retrieved from Komárek,2013, p.525, fig. 646)
Description: Filamentous than other algae, sheath very narrow, cells rounded, barrel-shaped, in branches 7.90µm, bredth of cell 5. 75µm. Heterocyst cylindrical, length 8.47µm and bredth 5.91µm.
Habitat: Attached to the grass on river bank

Westiellopsis prolifica Janet, Photo plate 2G1 & G2
(Retrieved from Komárek,2013, p.585, fig. 707)
Description: Thallus forming blackish-green, green or yellow-green. Main filaments usually richly branched, monoseriate, terminal parts of branches often narrowed. Cells in main trichome barrel-shaped up to almost spherical or slightly elongated, length 6.0µm and bredth 5.91µm. Heterocyst various shape, spherical up to irregular-rounded, length 5.81µm and bredth 5.59µm.
Habitat: Attached to the mud on canal

Fischerella muscicola Gomont, Photo plate 2H
(Retrieved from Komárek,2013, p.566, fig. 688a)
Description: Main filament creeping, torulous, 10-12µm wide, branches lateral, 6-7µm wide, cell almost spherical, hormogonia 4µm wide.
Habitat: Attached to mud