

Original Research

Received 30 June 2026

Revised 24 July 2026

Accepted 07 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (16s): 01–24

KEYWORDS:

Pranhita River, Phytoplankton, Phytoplankton diversity indices, Physico-chemical parameters

Integrated Assessment of Water Physico-Chemistry and Algal Diversity in the Pranhita River, Gadchiroli District, Maharashtra, India: A Baseline Study for Ecosystem Health

Ramesh Halami¹, Vyankatesh Ippala² and Nathuji Wadhave²

^{1,2}Raje Dharmarao College of Science Aheri, Gadchiroli, (M.S), India

³N. S. Arts and Science College, Bhadrawati, Chandrapur, (M.S), India

Corresponding Author: Ramesh Halami

Corresponding Author Email: rameshhalami@gmail.com

Email: vyankateshippala01@gmail.com , nswadhawe@gmail.com

ORCID iD: 0009-0000-9308-4263, 0000-0003-3013-3288, 0009-0002-8230-0148

ABSTRACT: Freshwater algae are important components of riverine ecosystems and respond sensitively to changes in physicochemical and hydrological conditions. The present study assessed seasonal variation in algal diversity and abundance and examined their association with physicochemical characteristics of the Pranhita River in Chamorshi and Aheri Tehsils of Gadchiroli District, Maharashtra, India. Three sampling sites, Chaprala (S₁), Wangepalli (S₂) and Devalmari (S₃), were examined during the pre-monsoon, monsoon and post-monsoon seasons of 2025–26. A total of 30 algal taxa belonging to four major classes, Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae, were recorded. Twenty-nine taxa were observed during the pre-monsoon and monsoon seasons, while all 30 taxa were recorded during the post-monsoon season. Quantitative abundance was estimated from 1000 mL whole-water samples and expressed as units per 1000 mL. Total standardized abundance increased from 58,100 units/1000 mL in the pre-monsoon to 148,100 units/1000 mL in the monsoon and 148,400 units/1000 mL in the post-monsoon. Chlorophyceae was the dominant group throughout the study, followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. Prominent taxa included *Pinnularia* sp., *Diatoma* sp., *Spirogyra* sp., *Zygnema* sp., *Oedogonium* sp. and *Cymbella* sp.

Shannon–Wiener, Simpson's, Pielou's evenness and Margalef's richness indices ranged from 1.146–1.178, 0.630–0.647, 0.827–0.850 and 0.252–0.274, respectively. Physicochemical parameters showed marked seasonal variation, with comparatively higher temperature, TDS, EC, hardness, calcium, alkalinity, chloride and BOD during the pre-monsoon period, increased turbidity during the monsoon, and lower temperature with higher dissolved oxygen during the post-monsoon period. Seasonal changes in algal communities appeared to reflect the combined influence of temperature, water movement, turbidity, dissolved substances and oxygen availability. Cyanobacterial taxa were recorded, but cyanotoxins were not analyzed; therefore, their occurrence does not establish toxin contamination or human-health risk. The study provides baseline information for future ecological and water-quality assessments of the Pranhita River.

1. INTRODUCTION

Rivers are dynamic freshwater ecosystems that support diverse biological communities and provide important ecological services. Algae constitute an important biological component of river ecosystems because they contribute to primary production, oxygen generation, nutrient cycling and aquatic food webs. Changes in temperature, water chemistry, flow, light availability, nutrient concentrations and substrate characteristics can influence the composition, abundance and distribution of algal communities. Consequently, algae are widely used in freshwater ecological studies and can provide complementary information to conventional water-quality assessment.

The freshwater algal flora of Maharashtra has been investigated for several decades. Kamat provided an important early account of the algae of Vidarbha, Maharashtra, establishing a foundation for subsequent regional algal investigations [1]. Later studies demonstrated substantial phytoplankton diversity in river systems of eastern Maharashtra. Tijare reported qualitative and quantitative phytoplankton diversity from the Wainganga River near Markandadeo in Gadchiroli District and documented several algal groups occurring in the river system [2]. Cyanobacterial diversity from major rivers of neighbouring Chandrapur District was investigated by Reddy and Chaturvedi, who reported numerous cyanobacterial taxa belonging to several genera [3]. Their investigation of desmids further demonstrated the diversity of freshwater green algae in rivers of Chandrapur District [4]. Scenedesmus and related chlorophycean genera have also been documented from riverine habitats of the region by Dhumal et al. [5].

Regional surveys have continued to add information concerning the distribution of freshwater algae. Reddy reported new records of freshwater algae for Maharashtra based on investigations of major rivers of Chandrapur District [6]. Diatom investigations have subsequently demonstrated considerable diversity in the river systems of Chandrapur District, including the Wardha, Wainganga and Painganga rivers [7]. Freshwater algal diversity has also been investigated in other parts of Maharashtra, including the Baramati region, demonstrating the broad distribution of freshwater algal communities within the state [8]. Further investigations by Reddy and Chaturvedi have reported new records of freshwater algae from India and have contributed to understanding the distribution and taxonomic diversity of freshwater algal organisms [9].

The distribution and abundance of algae are strongly influenced by the physical and chemical characteristics of their aquatic environment. Water temperature affects metabolic activity, photosynthesis, growth and reproduction. pH influences physiological processes and nutrient availability, while turbidity affects light penetration. Electrical conductivity and total dissolved solids provide information about ionic and dissolved substances. Dissolved oxygen is related to photosynthetic activity, atmospheric exchange, respiration and organic matter decomposition. Nutrient availability can also strongly influence algal productivity and community structure. Shukla and Sharma investigated correlations among different physicochemical parameters of Wainganga River water and emphasized the importance of considering multiple environmental variables in river-water assessment [10]. Spatial and temporal variation in water quality has also been investigated in the Godavari Basin by Dharmadhikari et al., demonstrating the importance of seasonal changes in river-water characteristics [11]. Physicochemical characteristics of the Wardha River in Chandrapur District have similarly been documented by Mithani et al. [12]. Investigations by Wadhave have provided additional regional information concerning freshwater algal diversity and distribution in Vidarbha [13].

Algae have considerable ecological value because their community structure can reflect environmental conditions. Bellinger and Sigee emphasized the usefulness of freshwater algae for identification and assessment of environmental changes and their application as biological indicators [14]. Standard taxonomic references such as Desikachary's work on Cyanophyta and Prescott's freshwater algal literature remain important sources for identification and classification of freshwater algal taxa [15,16]. Round discussed the ecological interpretation of algae in relation to habitat, environmental conditions and interactions with other ecological factors [17]. Bellinger and Sigee further emphasized the use of algae as indicators of environmental conditions because algal communities can integrate environmental changes over time [18].

Quantitative assessment of algal communities can be supported by ecological indices. Wu et al. investigated the application of phytoplankton-based approaches for assessing the ecological status of river systems [19]. Stevenson et al. highlighted the ecological importance of benthic and attached algae and their responses to nutrients, water flow, substrate and other environmental characteristics [20]. At the same time, biological indices must be interpreted carefully because algal responses vary among different river types and geographical regions.

Cyanobacteria are particularly important in water-quality investigations because some species or strains are capable of producing cyanotoxins. However, the presence of cyanobacteria does not automatically indicate toxin production or a human-health risk. The World Health Organization has emphasized the importance of monitoring cyanobacteria and cyanotoxins in water resources where appropriate [21]. Chorus and Welker provided updated guidance concerning the public-health consequences, monitoring and management of toxic cyanobacteria [22]. The World Health Organization also provides guidance on the management of cyanobacteria in drinking-water supplies and emphasizes appropriate monitoring and risk assessment [23].

Standardized analytical procedures are essential for reliable water-quality investigations. The American Public Health Association, American Water Works Association and Water Environment Federation provide widely accepted procedures for the measurement of physical, chemical and biological water-quality parameters through Standard Methods for the Examination of Water and Wastewater [24]. Diversity indices provide quantitative measures of algal community structure. Shannon and Weaver provided the mathematical basis of the Shannon information measure, which is widely used in ecological diversity analysis [25]. Simpson introduced a measure of diversity based on the probability that two individuals selected from a community belong to the same category [26]. Pielou developed a measure of evenness that evaluates the distribution of individuals among taxa [27].

Recent compilations of freshwater algal diversity have demonstrated the extensive algal flora documented from Maharashtra and emphasized the importance of regional inventories. Baig reported additional information concerning freshwater algal diversity in Maharashtra [28]. Contemporary research by Astuti et al. has also emphasized trait-based and community-level approaches to the use of freshwater microalgae as bioindicators [29]. Nevertheless, Lange, Townsend and Matthaai highlighted that the application of periphyton and algal indices requires careful consideration of habitat conditions and the ecological characteristics of individual river systems [30].

The Pranhita River is an important river system of central India and forms part of the Godavari drainage system. The river supports diverse aquatic habitats including flowing-water areas, rocky substrates, submerged surfaces and river margins. Despite its ecological importance, detailed seasonal information on algal diversity and abundance in the Chamorshi and Aheri Tehsil regions remains comparatively limited. The present investigation was therefore undertaken to document the diversity, distribution and abundance of algae in selected stretches of the Pranhita River; compare algal abundance among pre-monsoon, monsoon and post-monsoon periods; determine the contribution of major algal groups; identify relatively abundant taxa; calculate Shannon–Wiener, Simpson, Pielou and Margalef diversity measures; characterize the seasonal physico-chemical profile of the river; and interpret the ecological relationship between water-quality conditions and algal communities, including the occurrence of cyanobacteria and its relevance to environmental and human-health monitoring.

2. STUDY AREA

The study was carried out in selected stretches of the Pranhita River located in Chamorshi and Aheri Tehsils of Gadchiroli District, Maharashtra, India. Three sampling sites were selected to represent different local habitat conditions.

Figure 1. Map Showing the Sampling Sites along the Pranhita River, Gadchiroli District, Maharashtra



Table 1. Sampling Sites of the Pranhita River

Site	Location	Coordinates	General characteristics
S ₁	Chaprala	20.184872°N, 79.994797° E	Near Chaprala Wildlife Sanctuary; moderate flow
S ₂	Wangepalli	19.8000°N, 80.2000° E	Broader riverbed; agriculture-adjacent shoreline
S ₃	Devalmari	20.1895°N, 79.9990° E	Rocky substrate pockets; high epilithic growth

The selected sites differ in flow characteristics, substrate conditions and surrounding land use. Such differences may influence the development of planktonic, benthic and attached algal communities.

3. METHODOLOGY FOR COLLECTION AND QUANTITATIVE ESTIMATION OF ALGAL ABUNDANCE

3.1 Sampling Period

Algal sampling was carried out during three seasonal periods in 2025-26:

Pre-monsoon: March–May

Monsoon: June–September

Post-monsoon: October–February

The physico-chemical seasonal profile was considered using three broader seasonal windows:

Summer: March–May

Monsoon: June–September

Winter: October–February

Because these two datasets use slightly different seasonal windows, their comparison is interpreted as seasonal ecological context rather than as an exact date-matched statistical correlation.

3.2 Collection of Algal Samples

Samples were collected from river water and, where available, from submerged or attached algal growth at the selected sampling sites. Water samples were collected approximately 10–15 cm below the water surface using clean 1-L sampling bottles or a Van Dorn sampler. For qualitative examination, additional samples were collected using a plankton net with a mesh size of approximately 20–25 µm. For quantitative analysis, three replicate 1-L (1000 mL) whole-water samples were collected from each sampling site during each sampling period.

Attached algal material was collected from suitable submerged surfaces using a clean scalpel or soft brush. Where quantitative estimation of attached algae was required, a known area of the substrate was sampled and the collected material was suspended in a known volume of filtered sample water.

All samples were labeled with the sampling site, date, season, and replicate number. Samples intended for quantitative analysis were preserved immediately with Lugol's iodine solution at approximately 1 mL per 100 mL of sample. After approximately 24 h, formalin was added to obtain a final concentration of 2–4% for long-term preservation, where required. Qualitative samples were preserved in 4% formalin and transported to the laboratory for microscopic examination.

3.3 Quantitative Collection, Concentration, Dilution and Enumeration of Algae

For quantitative analysis, each replicate consisted of a 1000 mL (1 L) whole-water sample collected directly from the river. The entire sample was carefully transferred into a clean graduated measuring cylinder and allowed to settle undisturbed for approximately 48 h. Following sedimentation, the supernatant was slowly removed by siphoning, taking care not to disturb the settled algal material. The remaining algal suspension was concentrated to a known final volume of 20 mL.

Before subsampling, the concentrated suspension was gently and thoroughly mixed to obtain a relatively uniform distribution of algal units. When the concentration of algal material was too high for reliable microscopic enumeration, an aliquot of the concentrate was diluted with filtered sample water to obtain a countable density. For example, 1 mL of concentrated sample was diluted to a final volume of 10 mL. The dilution factor (D_f) was calculated as:

$$D_f = \frac{V_f}{V_i}$$

where V_f is the final volume after dilution (mL) and V_i is the volume of concentrated sample used for dilution (mL). Thus, dilution of 1 mL of concentrate to 10 mL gives a dilution factor of 10. Where serial dilution was performed, the overall dilution factor was calculated by multiplying the individual dilution factors:

$$D_{f_{total}} = D_{f_1} \times D_{f_2} \times D_{f_3} \times \dots \times D_{f_n}$$

A 1-mL aliquot of the concentrated or appropriately diluted sample was transferred to a Sedgewick–Rafter counting chamber and examined under a compound microscope. Initial observations were made at $40\times$ magnification, while higher magnification was used when necessary for detailed taxonomic identification and confirmation of morphological characteristics. At least 10 microscopic fields or a minimum of 300 countable algal units were examined for each replicate, depending on sample density and the availability of countable units.

Algal units were counted according to their morphological organization. Unicellular forms were recorded as individual cells, whereas colonial and coenobial forms were recorded as colonies or coenobia, respectively. Filamentous taxa such as *Ulothrix*, *Oedogonium* and *Spirogyra* were recorded as filaments. Where cell-based abundance was required, the number of cells was estimated using the mean number of cells per filament obtained from representative observations. *Vaucheria* was recorded as a filament or standardized filament length because it is a siphonous, coenocytic alga characterized by multinucleate cytoplasm and the absence of regular transverse septa.

The abundance of each taxon was expressed as algal units per 1000 mL of original river water. The standardized abundance was calculated using:

$$N = \frac{C \times V_c \times D_f}{(V_a \times V_o)} \times 1000$$

where,

N = algal abundance expressed as units per 1000 mL of original river water

C = number of algal counting units observed in the counting chamber

V_c = final volume of concentrated sample (mL)

D_f = dilution factor, where applicable

V_a = volume of sample examined in the counting chamber (mL)

V_o = original volume of river-water sample (mL).

In the present study, V_c was 20 mL, V_a was 1 mL, and V_o was 1000 mL. Therefore, for an undiluted sample, the abundance was calculated by accounting for the concentration of the original 1000-mL sample into 20 mL and the 1-mL volume examined in the counting chamber. When dilution was necessary, the appropriate dilution factor was incorporated into the calculation.

For example, if C algal units were counted in 1 mL of the 20-mL concentrate without further dilution, the estimated abundance in the original 1000-mL river-water sample

$$N = C \times 20$$

Thus, a count of 25 units in the 1-mL aliquot corresponded to an estimated abundance of 500 units per 1000 mL of original river water. If the aliquot had first been diluted tenfold, the corresponding value would be multiplied by the appropriate dilution correction.

All replicate samples were processed using the same concentration, dilution and enumeration procedure. The resulting values were expressed on a common basis of units per 1000 mL of original river water, allowing quantitative comparison of algal abundance among sampling sites and seasons.

3.4 Microscopic Examination

The samples were examined using a compound microscope. Preliminary scanning was carried out at $40\times$ magnification, while detailed identification and enumeration were performed at $100\times$ and $400\times$ magnification. Oil-immersion magnification ($1000\times$) was used where necessary for small or morphologically critical specimens.

Algal specimens were identified on the basis of their morphological characteristics using standard taxonomic literature and relevant regional references [15,16]. Taxonomic names were checked against recognized algal databases and recent taxonomic literature wherever necessary.

The conventional term “Cyanophyceae” is retained in the present study because it corresponds to the classification used in the original dataset. In modern taxonomic systems, organisms traditionally placed under Cyanophyceae are generally treated as cyanobacteria.

3.5 Classification of Algal Groups

The recorded algae were grouped into four major classes:

1. Chlorophyceae
2. Bacillariophyceae
3. Cyanophyceae
4. Euglenophyceae

The classification was maintained consistently with the taxonomic framework used for the original dataset.

A taxonomic note is required for *Vaucheria*, because it is a coenocytic alga currently placed in Xanthophyceae rather than Chlorophyceae. If *Vaucheria* is retained within the Chlorophyceae category in the original dataset, this classification should be explicitly mentioned as a limitation or taxonomic caveat. Any discrepancy between taxa listed in tables and those represented in figures should likewise be clarified in the relevant table or figure legend.

Figure 2. Algal Groups and their Taxonomic Classifications



The microscopic survey revealed a diverse algal assemblage represented by four major groups: Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae. Chlorophyceae comprised a variety of green algae, including *Chlorella*, *Cosmarium*, *Closterium*, *Microspora*, *Oedogonium*, *Scenedesmus*, *Spirogyra*, *Ulothrix*, *Volvox*, *Zygnema*, *Gloeocystis*, *Vaucheria*, and *Cladophora*, showing considerable variation in cellular organization and thallus structure. Bacillariophyceae was represented by *Diatoma*, *Mastogloia*, *Nitzschia*, *Pinnularia*, *Fragilaria*, *Cymbella*, and *Synedra*, which exhibited characteristic siliceous frustules and diverse valve shapes. Cyanophyceae included *Anabaena*, *Microcystis*, *Nostoc*, *Oscillatoria*, *Rivularia*, *Spirulina*, *Scytonema*, and *Anacystis*, displaying unicellular, colonial, filamentous, and heterocystous forms. Euglenophyceae was represented by *Euglena* and *Phacus*, both characterized by elongated or spindle-shaped cells with flexible body forms and

prominent chloroplasts. Together, these groups demonstrate substantial morphological diversity in the algal community and provide evidence of the coexistence of different structural and ecological forms within the studied aquatic environment.

3.6 Quantification and Expression of Algal Abundance

The abundance of algae was determined from the quantitative whole-water samples collected as 1000 mL (1 L) samples. The concentration procedure, counting volume, and dilution factor were incorporated into the calculation to obtain the final abundance per 1000 mL of river water.

No separate conversion from a 10 mL sample was applied to the final dataset. All abundance values presented in the tables and figures therefore represent the estimated number of algal cells, colonies, coenobia, or filaments per 1000 mL of original river water, according to the counting unit used for each taxon.

3.6 Relative Abundance

The relative abundance of each taxon was calculated using:

$$\text{Relative abundance (\%)} = (\text{Abundance of individual taxon} / \text{Total abundance}) \times 100$$

The relative contribution of each major algal group was also calculated using the same principle.

3.8 Presentation of Abundance Data

All quantitative abundance values in the tables and figures are expressed as cells or counting units per 1000 mL of Pranhita river water. Where replicate measurements were available, the results are presented as mean $\pm$ standard deviation (SD). Seasonal and site-wise variations in total abundance and the relative contribution of the major algal groups were subsequently compared.

Table 2.1. Taxonomic Composition of Algal Groups and Taxon at Site-1(Chaprala)

Group	Taxon	Site-1 (Chaprala)		
		Pre- Monsoon	Monsoon	Post- Monsoon
Chlorophyceae	Chlorella sp.	1,000	2,500	1,800
	Cosmarium sp.	900	1,300	1,500
	Closterium sp.	1,000	2,100	1,600
	Microspora sp.	1,000	1,500	1,400
	Oedogonium sp.	800	2,200	2,500
	Scenedesmus sp.	700	2,000	1,800
	Spirogyra sp.	800	2,100	2,800
	Ulothrix sp.	1,000	2,200	2,000
	Volvox sp.	900	1,700	1,200
	Zygnema sp.	800	1,800	2,200
	Gloeocystis sp.	900	1,900	1,600
	Vaucheria sp.	900	2,300	2,000
	Cladophora sp.	—	—	—
Bacillariophyceae	Diatoma sp.	700	2,400	2,800
	Mastogloia sp.	800	1,900	1,800
	Nitzschia sp.	1,000	2,600	3,000
	Pinnularia sp.	1,000	2,800	3,200
	Fragilaria sp.	—	—	—
	Cymbella sp.	—	—	—
	Synedra sp.	0	0	1,200
	Anabaena sp.	—	—	—
	Microcystis sp.	—	—	—
	Nostoc sp.	—	—	—

Cyanophyceae	Oscillatoria sp.	–	–	–
	Rivularia sp.	–	–	–
	Spirulina sp.	–	–	–
	Scytonema sp.	–	–	–
	Anacystis sp.	–	–	–
Euglenophyceae	Euglena sp.	–	–	–
	Phacus sp.	–	–	–

Table 2.2. Taxonomic Composition of Algal Groups and Taxon at Site-2 (Wangepalli)

Group	Taxon	Site-2 (Wangepalli)		
		Pre- Monsoon	Monsoon	Post- Monsoon
Chlorophyceae	Chlorella sp.	600	1,600	1,400
	Cosmarium sp.	700	1,800	2,000
	Closterium sp.	800	1,900	1,800
	Microspora sp.	600	1,500	1,600
	Oedogonium sp.	900	1,800	2,200
	Scenedesmus sp.	1,000	2,200	2,000
	Spirogyra sp.	1,100	2,200	2,600
	Ulothrix sp.	600	1,700	1,800
	Volvox sp.	700	1,900	1,500
	Zygnema sp.	1,000	2,200	2,500
	Gloeocystis sp.	900	2,100	1,800
	Vaucheria sp.	900	1,700	1,800
	Cladophora sp.	500	1,400	2,200
Bacillariophyceae	Diatoma sp.	1,000	2,700	3,200
	Mastogloia sp.	–	–	–
	Nitzschia sp.	–	–	–
	Pinnularia sp.	700	2,700	3,000
	Fragilaria sp.	900	3,200	3,600
	Cymbella sp.	1,000	3,200	3,800
	Synedra sp.	0	0	1,500
Cyanophyceae	Anabaena sp.	700	2,000	1,600
	Microcystis sp.	800	2,300	1,800
	Nostoc sp.	1,000	2,600	2,200
	Oscillatoria sp.	900	1,800	1,500
	Rivularia sp.	800	2,200	1,800
	Spirulina sp.	900	2,500	2,000
	Scytonema sp.	700	2,400	1,800
	Anacystis sp.	700	2,200	1,600
Euglenophyceae	Euglena sp.	800	1,900	1,400
	Phacus sp.	1,000	2,600	1,800

Table 2.3. Taxonomic Composition of Algal Groups and Taxon at Site-3 (Devalmari)

Group	Taxon	Site-3 (Devalmari)		
		Pre- Monsoon	Monsoon	Post- Monsoon
Chlorophyceae	Chlorella sp.	800	1,900	1,600
	Cosmarium sp.	1,000	2,600	2,200
	Closterium sp.	–	–	–
	Microspora sp.	800	2,200	2,000
	Oedogonium sp.	1,000	2,900	3,200
	Scenedesmus sp.	800	2,500	2,400
	Spirogyra sp.	1,000	2,900	3,500
	Ulothrix sp.	900	2,200	2,200
	Volvox sp.	700	1,800	1,400
	Zygnema sp.	1,000	3,000	3,400
	Gloeocystis sp.	1,000	2,600	2,000
	Vaucheria sp.	1,000	2,500	2,200
	Cladophora sp.	–	–	–
Bacillariophyceae	Diatoma sp.	900	2,500	3,000
	Mastogloia sp.	–	–	–
	Nitzschia sp.	–	–	–
	Pinnularia sp.	1,100	3,000	3,500
	Fragilaria sp.	1,000	2,700	3,200
	Cymbella sp.	1,200	3,200	4,000
	Synedra sp.	0	0	1,800
Cyanophyceae	Anabaena sp.	500	1,600	1,400
	Microcystis sp.	800	1,700	1,500
	Nostoc sp.	900	2,200	2,000
	Oscillatoria sp.	1,000	2,000	1,600
	Rivularia sp.	700	2,200	1,600
	Spirulina sp.	1,000	2,300	1,800
	Scytonema sp.	800	1,600	1,400
	Anacystis sp.	–	–	–
Euglenophyceae	Euglena sp.	800	2,000	1,500
	Phacus sp.	1,000	2,400	1,800

3.8 Taxonomic Composition

A total of 30 algal taxa belonging to four major groups were recorded.

Table 3. Taxonomic Composition of Algae

Algal group	Number of taxa	Percentage of total taxa
Chlorophyceae	13	43.33
Bacillariophyceae	7	23.33
Cyanophyceae	8	26.67
Euglenophyceae	2	6.67
Total	30	100.00

Chlorophyceae represented the largest taxonomic group with 13 taxa, followed by Cyanophyceae with 8 taxa, Bacillariophyceae with 7 taxa and Euglenophyceae with 2 taxa.

Twenty-nine taxa were recorded during pre-monsoon and 29 during monsoon. All 30 taxa were recorded during post-monsoon because *Synedra* sp. was recorded during this period.

3.9 Seasonal Total Algal Abundance

Table 4. Seasonal Total Algal Abundance

Season	Abundance Site-1 (Chaprala)	Abundance Site-2 (Wangepalli)	Abundance Site-3 (Devalmari)	Total abundance (units/1000 mL)
Pre-monsoon	14,200	22,200	21,700	58,100
Monsoon	33,300	58,300	56,500	148,100
Post-monsoon	34,400	57,800	56,200	148,400
Total	81,900	138,300	134,400	354,600

The total algal abundance increased considerably from pre-monsoon to monsoon. It increased from 58,100 units/1000 mL to 148,100 units/1000 mL and remained almost unchanged during post-monsoon at 148,400 units/1000 mL.

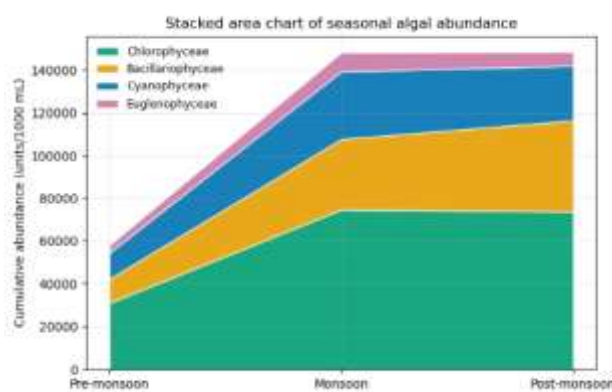
Thus, the highest total abundance was recorded during post-monsoon, closely followed by monsoon.

3.10 Seasonal Abundance of Major Algal Groups

Table 5. Seasonal Abundance of Major Algal Groups

Algal group	Pre-monsoon	Monsoon	Post-monsoon
Chlorophyceae	31,000	74,700	73,700
Bacillariophyceae	11,300	32,900	42,600
Cyanophyceae	12,200	31,600	25,600
Euglenophyceae	3,600	8,900	6,500
Total	58,100	148,100	148,400

Figure 3. Stacked Area Chart: Seasonal Abundance of Major Algal Groups



Chlorophyceae recorded the highest abundance during all three seasons. Its abundance increased from 31,000 units/1000 mL during pre-monsoon to 74,700 units/1000 mL during monsoon and remained high at 73,700 units/1000 mL during post-monsoon.

Bacillariophyceae increased from 11,300 units/1000 mL during pre-monsoon to 32,900 units/1000 mL during monsoon and 42,600 units/1000 mL during post-monsoon.

Cyanophyceae increased from 12,200 units/1000 mL during pre-monsoon to 31,600 units/1000 mL during monsoon, followed by a decrease to 25,600 units/1000 mL during post-monsoon.

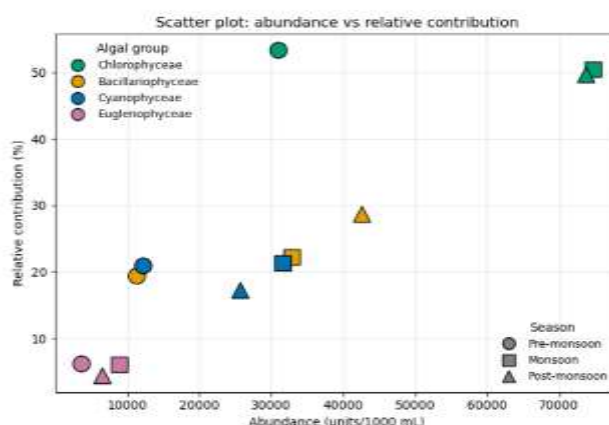
Euglenophyceae remained comparatively low in abundance, with values of 3,600, 8,900 and 6,500 units/1000 mL during pre-monsoon, monsoon and post-monsoon, respectively.

3.11 Relative Contribution of Major Algal Groups

Table 6. Relative Contribution of Major Algal Groups

Algal group	Pre-monsoon (%)	Monsoon (%)	Post-monsoon (%)
Chlorophyceae	53.36	50.44	49.66
Bacillariophyceae	19.45	22.21	28.71
Cyanophyceae	21.00	21.34	17.25
Euglenophyceae	6.20	6.01	4.38

Figure 4. Scattered Plot: Abundance vs Relative Contribution



Chlorophyceae contributed more than 49% of total abundance during each season. Its relative contribution decreased slightly from 53.36% during pre-monsoon to 49.66% during post-monsoon.

Bacillariophyceae showed the greatest increase in relative contribution, rising from 19.45% during pre-monsoon to 28.71% during post-monsoon.

Cyanophyceae contributed 21.00% during pre-monsoon, 21.34% during monsoon and 17.25% during post-monsoon.

Euglenophyceae contributed the smallest proportion during all three seasons.

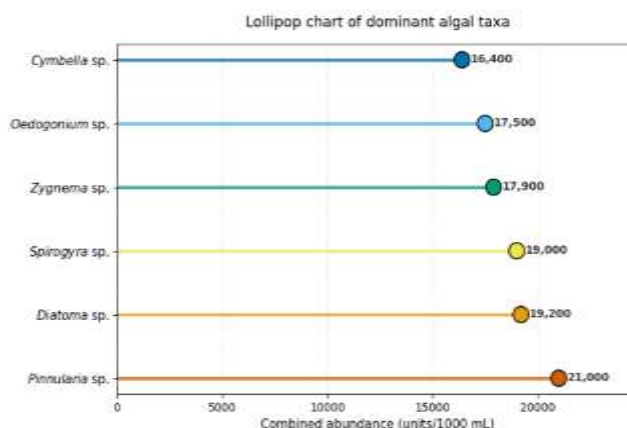
3.12 Dominant and Abundant Taxa

Several taxa showed comparatively high combined abundance across the three seasons.

Table 7. Relatively Abundant Algal Taxa

Taxon	Combined abundance (units/1000 mL)
Pinnularia sp.	21,000
Diatoma sp.	19,200
Spirogyra sp.	19,000
Zygnema sp.	17,900
Oedogonium sp.	17,500
Cymbella sp.	16,400

Figure 5. Lollipop Chart of Dominant Algal Taxa



Pinnularia sp. recorded the highest combined abundance among the listed taxa, followed by Diatoma sp. and Spirogyra sp. Zygnema sp., Oedogonium sp. and Cymbella sp. were also comparatively abundant.

The occurrence of diatoms together with filamentous green algae demonstrates the presence of different ecological groups within the river community.

3.13 Spatial Distribution of Algal Abundance

Table 8. Total Algal Abundance at Sampling Sites

Sampling site	Total abundance (units/1000 mL)	Percentage contribution
Chaprala (S1)	81,900	23.10
Wangepalli (S2)	138,300	39.00
Devalmari (S3)	134,400	37.90
Total	354,600	100.00

Wangepalli recorded the highest total algal abundance, accounting for approximately 39.00% of the overall abundance. Devalmari contributed 37.90%, while Chaprala contributed 23.10%.

The higher abundance at Wangepalli and Devalmari may be associated with differences in substrate, flow, nutrient inputs, light availability and surrounding land use. These factors, however, should be considered as possible ecological explanations rather than statistically demonstrated causes.

3.14 Seasonal Taxonomic Richness

Table 9. Seasonal Taxonomic Richness

Season	Number of taxa
Pre-monsoon	29
Monsoon	29
Post-monsoon	30

The highest taxonomic richness was observed during post-monsoon. The difference was small, with only one additional taxon, Synedra sp., recorded during this season.

The relatively stable taxonomic richness indicates that the overall composition of the algal community remained comparatively persistent even though total abundance changed substantially among seasons.

3.15 Diversity Indices

Shannon–Wiener (H'):

$$H' = - \sum p_i \ln p_i$$

$$p_i = \frac{n_i}{N}$$

Simpson (1 - D):

$$1 - D = 1 - \sum p_i^2$$

Pielou evenness (J):

$$J = \frac{H'}{\ln S}$$

Margalef richness (d):

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

where,

n_i = abundance of the i th taxon

N = Total abundance

S = Number of taxa

H' = Shannon – Wiener index

J = Pielou evenness

d = Margalef richness

Total abundance of major algal groups shown in table .5

For Pre-monsoon:

Total abundance of major algal groups (N) = 58,100 and Number of groups (S) = 4

Table 10. Phytoplankton Diversity Indices during Pre-monsoon

Major algal group	Abundance (n_i)	$p_i = \frac{n_i}{N}$	p_i^2	$p_i \ln p_i$
Chlorophyceae	31,000	0.53356	0.28469	-0.33518
Bacillariophyceae	11,300	0.19449	0.03783	-0.31845
Cyanophyceae	12,200	0.20998	0.04409	-0.32772
Euglenophyceae	3,600	0.06196	0.00384	-0.17234
Total	58,100	1.00000	0.37045	-1.15369

Shannon–Wiener (H'):

$$H' = - \sum p_i \ln p_i$$

$$H' = -(-1.15369) = 1.15369 \approx 1.154$$

Simpson (1 - D):

$$1 - D = 1 - \sum p_i^2$$

$$1 - D = 1 - 0.37045 = 0.62955 \approx 0.630$$

Pielou evenness (J):

$$J = \frac{H'}{\ln S}$$

$$J = \frac{1.15369}{\ln 4}$$

$$\ln 4 = 1.38629$$

$$J = \frac{1.15369}{1.38629} = 0.8322 \approx 0.832$$

Margalef richness (d):

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

$$d = \frac{4 - 1}{\ln 58,100}$$

$$\ln 58,100 = 10.96992$$

$$d = \frac{3}{10.96992} = 0.2735 \approx 0.274$$

For Monsoon:

Total abundance of major algal groups (N) = 148,100 and Number of groups (S) = 4

Table 11. Phytoplankton Diversity Indices during Monsoon

Major algal group	Abundance (n _i)	$p_i = \frac{n_i}{N}$	p_i^2	$p_i \ln p_i$
Chlorophyceae	74,700	0.50439	0.25441	-0.34525
Bacillariophyceae	32,900	0.22215	0.04935	-0.33421
Cyanophyceae	31,600	0.21337	0.04553	-0.32958
Euglenophyceae	8,900	0.06009	0.00361	-0.16896
Total	148,100	1.00000	0.35290	-1.17800

Shannon–Wiener (H'):

$$H' = -\sum p_i \ln p_i$$

$$H' = -(-1.17800) = 1.17800 \approx 1.178$$

Simpson (1 - D):

$$1 - D = 1 - \sum p_i^2$$

$$1 - D = 1 - 0.35290 = 0.64710 \approx 0.647$$

Pielou evenness (J):

$$J = \frac{H'}{\ln S}$$

$$J = \frac{1.17800}{\ln 4}$$

$$\ln 4 = 1.38629$$

$$J = \frac{1.15369}{1.38629} = 0.8498 \approx 0.850$$

Margalef richness (d):

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

$$d = \frac{4 - 1}{\ln 148,100}$$

$$\ln 148,100 = 11.90565$$

$$d = \frac{3}{11.90565} = 0.2520 \approx 0.252$$

For Post-monsoon:

Total abundance of major algal groups (N) = 148,400 and Number of groups (S) = 4

Table 12. Phytoplankton Diversity Indices during Post-monsoon

Major algal group	Abundance (n _i)	$p_i = \frac{n_i}{N}$	p_i^2	$p_i \ln p_i$
Chlorophyceae	73,700	0.49663	0.24664	-0.34760
Bacillariophyceae	42,600	0.28706	0.08241	-0.35830
Cyanophyceae	25,600	0.17251	0.02976	-0.30311
Euglenophyceae	6,500	0.04380	0.00192	-0.13703
Total	148,400	1.00000	0.36073	-1.14604

Shannon–Wiener (H′):

$$H' = - \sum p_i \ln p_i$$

$$H' = -(-1.14604) = 1.14604 \approx 1.146$$

Simpson (1 - D):

$$1 - D = 1 - \sum p_i^2$$

$$1 - D = 1 - 0.36073 = 0.63927 \approx 0.639$$

Pielou evenness (J):

$$J = \frac{H'}{\ln S}$$

$$J = \frac{1.17800}{\ln 4}$$

$$\ln 4 = 1.38629$$

$$J = \frac{1.15369}{1.38629} = 0.8498 \approx 0.850$$

Margalef richness (d):

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

$$d = \frac{4 - 1}{\ln 148,400}$$

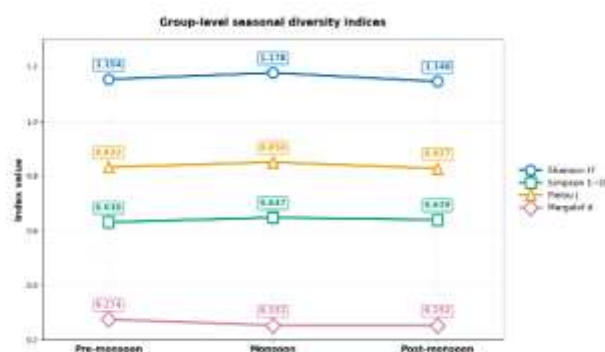
$$\ln 148,400 = 11.90767$$

$$d = \frac{3}{11.90767} = 0.2519 \approx 0.252$$

Table 13. Seasonal Diversity Indices

Diversity measure	Pre-monsoon	Monsoon	Post-monsoon
Shannon–Wiener (H')	1.154	1.178	1.146
Simpson (1 – D)	0.630	0.647	0.639
Pielou evenness (J)	0.832	0.850	0.827
Margalef richness (d)	0.274	0.252	0.252

Figure 6. Group Level Seasonal Diversity Indices



When the diversity indices were calculated using the four major algal groups as the units of analysis, the Shannon–Wiener index showed relatively limited seasonal variation, ranging from 1.146 to 1.178, with the maximum value recorded during monsoon. Simpson diversity ranged from 0.630 to 0.647 and also showed only minor seasonal variation. Pielou evenness values ranged from 0.827 to 0.850, indicating a relatively even distribution of abundance among the four major algal groups. Margalef richness was highest during pre-monsoon at 0.274 and remained nearly unchanged during monsoon and post-monsoon at 0.252. These group-level values indicate that the algal community was distributed among Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae rather than being concentrated entirely in a single group, although Chlorophyceae remained the dominant group throughout the study.

4. SEASONAL PHYSICO-CHEMICAL PROFILE

The physico-chemical characteristics of the Pranhita River showed pronounced seasonal variation. The measured parameters included water temperature, pH, turbidity, total dissolved solids, electrical conductivity, dissolved oxygen, biochemical oxygen demand, total hardness, calcium, total alkalinity and chlorides.

Table 14. Average Seasonal Physico-chemical Characteristics of the Pranhita River at the Sampling Sites

Parameter	Unit	Summer (March–May)	Monsoon (June–September)	Winter (October–February)
Water temperature	°C	32.0–36.0	26.0–29.0	20.0–24.0
pH	—	7.9–8.4	7.2–7.6	7.6–8.0
Turbidity	NTU	<8	>70	<15
TDS	mg/L	280–350	120–160	180–240
EC	μS/cm	450–550	190–260	290–380
Dissolved oxygen	mg/L	5.2–6.0	6.5–7.2	7.0–7.8
BOD	mg/L	2.5–3.2	1.2–1.8	1.5–2.2

Total hardness	mg/L	180–220	80–110	120–160
Calcium (Ca ²⁺)	mg/L	65–80	30–45	45–60
Total alkalinity	mg/L	170–210	70–95	110–150

Water temperature was highest during summer, ranging from 32.0 to 36.0°C. During monsoon it decreased to 26.0–29.0°C and reached 20.0–24.0°C during winter. Temperature is an important environmental factor because it influences metabolic processes, photosynthesis and algal growth.

The pH was moderately alkaline during summer, ranging from 7.9 to 8.4. During monsoon, it decreased to 7.2–7.6 and increased again to 7.6–8.0 during winter. The monsoon decrease can be associated with the influence of rainfall and dilution.

Turbidity showed the strongest seasonal change. Values remained below 8 NTU during summer but increased to more than 70 NTU during monsoon and decreased to below 15 NTU during winter. High monsoon turbidity indicates increased suspended material associated with rainfall, runoff and soil erosion. Turbidity can affect algal communities by reducing light penetration.

TDS ranged from 280–350 mg/L during summer, decreased to 120–160 mg/L during monsoon and increased to 180–240 mg/L during winter. The summer increase may reflect concentration of dissolved substances under comparatively low-flow conditions, while monsoon rainfall produces a dilution effect.

Electrical conductivity followed a similar pattern. EC was 450–550 µS/cm during summer, 190–260 µS/cm during monsoon and 290–380 µS/cm during winter. The similar seasonal trends of TDS and EC indicate changes in the concentration of dissolved ionic substances.

Dissolved oxygen ranged from 5.2–6.0 mg/L during summer, 6.5–7.2 mg/L during monsoon and 7.0–7.8 mg/L during winter. The highest DO was observed during winter. Lower water temperature generally favours greater oxygen solubility, while turbulence and mixing can also increase oxygenation.

BOD was highest during summer, ranging from 2.5–3.2 mg/L, and decreased to 1.2–1.8 mg/L during monsoon. Winter values ranged from 1.5–2.2 mg/L. The higher summer BOD indicates greater oxygen demand during the warmer low-flow period.

Total hardness ranged from 180–220 mg/L during summer, decreased to 80–110 mg/L during monsoon and increased to 120–160 mg/L during winter. Calcium followed a similar seasonal pattern, ranging from 65–80 mg/L in summer, 30–45 mg/L during monsoon and 45–60 mg/L during winter.

Total alkalinity ranged from 170–210 mg/L during summer, decreased to 70–95 mg/L during monsoon and increased to 110–150 mg/L during winter. Chloride concentration similarly decreased from 35–50 mg/L during summer to 12–20 mg/L during monsoon and increased to 22–32 mg/L during winter.

Overall, summer was characterized by higher temperature, TDS, EC, BOD, hardness, calcium, alkalinity and chloride concentration. Monsoon was characterized by high turbidity and dilution of several dissolved constituents, while winter showed lower temperature, lower turbidity and higher dissolved oxygen.

5. METHODOLOGICAL BASIS FOR PHYSICO-CHEMICAL ANALYSIS

5.1 Central Water Commission Framework

The sampling and monitoring framework may be interpreted in the context of river monitoring approaches used within the Godavari sub-basin. Physical characteristics such as temperature, pH, conductivity and dissolved oxygen are commonly important components of river-water monitoring.

5.2 APHA/AWWA/WEF Standard Methods

Laboratory analysis of water-quality parameters follows standard analytical principles described in Standard Methods for the Examination of Water and Wastewater [24].

The major analytical approaches include:

- DO: Winkler titration or appropriate electrometric method
- BOD: five-day incubation at 20°C

- Total hardness: EDTA titrimetric method
- Calcium: EDTA titrimetric method
- Alkalinity: acid-base titration
- Chloride: argentometric titration using standard silver nitrate

These standardized approaches facilitate comparison among sampling periods and locations.

5.3 Pollution-Control Monitoring Context

River-water monitoring by state pollution-control agencies can provide additional information concerning long-term changes in water quality. Monitoring networks associated with the Maharashtra Pollution Control Board and Telangana State Pollution Control Board are relevant to the wider Wardha–Wainganga–Pranhita river system.

6. RELATIONSHIP BETWEEN PHYSICO-CHEMICAL CONDITIONS AND ALGAL DIVERSITY

The seasonal physico-chemical profile provides an important environmental context for understanding the observed algal patterns. Algal communities respond to several environmental variables simultaneously, and no single parameter can normally explain all changes in algal abundance.

During summer and pre-monsoon, water temperature was comparatively high, ranging from 32.0 to 36.0°C. TDS, EC, hardness, calcium, alkalinity, chloride and BOD were also comparatively high. During the corresponding pre-monsoon algal sampling period, total algal abundance was 58,100 units/1000 mL.

During monsoon, water temperature decreased to 26.0–29.0°C and turbidity increased to more than 70 NTU. At the same time, TDS, EC, hardness, calcium, alkalinity and chloride decreased substantially, while dissolved oxygen increased. Despite the high turbidity, total algal abundance increased to 148,100 units/1000 mL.

This apparent contrast indicates that algal abundance was not controlled by turbidity alone. Monsoon flow can redistribute nutrients, algal cells and organic material and can modify substrate conditions. Furthermore, the present sampling included algae associated with submerged and attached substrates, which may remain present even under increased suspended sediment conditions.

During post-monsoon, turbidity decreased considerably, while TDS, EC and other dissolved constituents increased from monsoon levels. Dissolved oxygen remained comparatively high. The algal abundance reached 148,400 units/1000 mL, the highest seasonal value, and taxonomic richness increased to 30 taxa.

Bacillariophyceae showed particularly strong post-monsoon representation. Its abundance increased from 11,300 units/1000 mL during pre-monsoon to 32,900 units/1000 mL during monsoon and 42,600 units/1000 mL during post-monsoon. This pattern may be associated with relatively clearer water, improved light penetration and suitable submerged substrates following the monsoon.

Table 15. Average Seasonal Comparison of Physicochemical and Algal Characteristics at the Sampling Sites

Parameter	Pre-monsoon / Summer	Monsoon	Post-monsoon / Winter context
Water temperature (°C)	32.0–36.0	26.0–29.0	20.0–24.0
pH	7.9–8.4	7.2–7.6	7.6–8.0
Turbidity (NTU)	<8	>70	<15
TDS (mg/L)	280–350	120–160	180–240
EC (µS/cm)	450–550	190–260	290–380
DO (mg/L)	5.2–6.0	6.5–7.2	7.0–7.8
BOD (mg/L)	2.5–3.2	1.2–1.8	1.5–2.2
Total algal abundance	58,100	148,100	148,400
Number of taxa	29	29	30

The seasonal comparison demonstrates that algal abundance changed substantially while taxonomic richness remained comparatively stable. This suggests that environmental conditions affected the quantity of algal biomass or abundance more strongly than the overall presence or absence of taxa.

Because the physicochemical seasonal dataset and algal dataset do not have identical sampling windows and site-specific paired observations, direct Pearson or Spearman correlation coefficients cannot be calculated reliably from the information currently available. The relationships described here should therefore be interpreted as ecological associations rather than statistically established correlations.

7. RELATIONSHIP BETWEEN INDIVIDUAL PHYSICO-CHEMICAL PARAMETERS AND ALGAL COMMUNITIES

7.1 Water Temperature

Temperature influences algal metabolism, photosynthesis and reproduction. The highest temperatures occurred during summer, while winter had the lowest temperatures. Chlorophyceae remained abundant across all seasons, indicating that the dominant taxa were capable of persisting across a wide temperature range.

7.2 pH

The river remained neutral to moderately alkaline during all seasonal periods. Such conditions can support diverse freshwater algal communities. The reduction in pH during monsoon coincided with strong changes in river hydrology.

7.3 Turbidity

Turbidity was exceptionally high during monsoon. High suspended material can reduce light penetration and affect photosynthetic organisms. However, total algal abundance increased during monsoon, indicating that the algal community was probably influenced by several additional factors, including flow, nutrient redistribution and attached habitats.

7.4 TDS and Electrical Conductivity

TDS and EC were highest during summer and lowest during monsoon. Their parallel seasonal patterns suggest dilution during the rainy period and concentration of dissolved substances during lower-flow conditions.

7.5 Dissolved Oxygen

DO was lowest during summer and highest during winter. The increase in DO during monsoon and winter coincided with increased algal abundance compared with pre-monsoon. However, the relationship should not be interpreted as direct causation because DO is affected by temperature, turbulence, photosynthesis and organic matter decomposition.

7.6 BOD

BOD was highest during summer. Higher BOD indicates greater oxygen demand associated with biodegradable material. The lower monsoon BOD occurred simultaneously with strong dilution.

7.7 Hardness, Calcium and Alkalinity

Hardness, calcium and alkalinity showed their highest values during summer and lower values during monsoon. These parameters contribute to the chemical environment in which algal communities develop and may influence species composition through nutrient and ionic availability.

7.8 Chlorides

Chloride concentration decreased markedly during monsoon and increased during winter. The pattern is consistent with dilution during increased river discharge followed by concentration as discharge decreases.

8. INTEGRATED RELATIONSHIP BETWEEN WATER QUALITY, ALGAE AND HUMAN HEALTH

The algal community of the Pranhita River contains several groups of ecological importance. Chlorophyceae was the dominant group, while Bacillariophyceae increased substantially during post-monsoon. Cyanophyceae represented approximately one-fifth of the total algal abundance during pre-monsoon and monsoon.

The recorded cyanobacterial taxa included *Anabaena*, *Microcystis*, *Nostoc*, *Oscillatoria*, *Rivularia*, *Spirulina*, *Scytonema* and *Anacystis*.

Cyanobacteria are important in water-quality monitoring because some species and strains can produce cyanotoxins. However, the presence of cyanobacterial taxa alone does not establish toxin production. Toxin production is dependent on species or strain characteristics and environmental conditions. No cyanotoxin measurements were included in the present investigation.

Therefore, the recorded cyanobacteria should be interpreted as an ecological observation rather than evidence of toxic contamination.

Where river water is used for drinking, recreation or domestic activities, cyanobacterial monitoring may be relevant because toxin-producing blooms can create public-health concerns under appropriate environmental conditions. WHO guidance emphasizes monitoring and management of cyanobacteria and cyanotoxins in relevant water resources [21–23].

Table 16. Algal Groups and Their Ecological Relevance

Algal group	Major ecological significance
Chlorophyceae	Primary production; responds to light, nutrients and temperature
Bacillariophyceae	Important benthic and planktonic algae; useful in ecological assessment
Cyanophyceae	Important primary producers; some taxa may produce cyanotoxins
Euglenophyceae	Can occur in nutrient-rich or organically influenced freshwater habitats

The human-health interpretation of the present study should therefore remain precautionary and evidence-based. The data demonstrate the occurrence of cyanobacteria but do not demonstrate toxin contamination or a direct health risk.

9. ECOLOGICAL SIGNIFICANCE OF THE RECORDED ALGAE

The recorded algal community represents an important biological component of the Pranhita River. Chlorophyceae formed the largest group in terms of both taxonomic richness and abundance.

Bacillariophyceae represented an important component of the community and showed an increase in abundance during post-monsoon. Diatoms are frequently associated with submerged surfaces and can respond to changes in water chemistry, flow and substrate characteristics.

Cyanobacteria represented a persistent component of the community. Their occurrence demonstrates that the river provides environmental conditions capable of supporting a diverse cyanobacterial assemblage.

Euglenophyceae occurred at comparatively low abundance. The occurrence of euglenoid algae may be associated with nutrient and organic conditions in some freshwater environments, although specific interpretation requires taxon-level and physicochemical information.

The high Pielou evenness values indicate that the community was relatively evenly distributed. This is consistent with the high Shannon–Wiener and Simpson diversity values observed in the three sampling periods.

10. DISCUSSION

The present study documented 30 algal taxa belonging to four major groups in selected stretches of the Pranhita River. Chlorophyceae represented the largest taxonomic group, followed by Cyanophyceae, Bacillariophyceae and Euglenophyceae. The findings are broadly consistent with previous investigations of freshwater algal communities in Vidarbha and neighbouring districts [1–13].

Total algal abundance showed a pronounced seasonal increase, from 58,100 units/1000 mL during pre-monsoon to 148,100 units/1000 mL during monsoon and 148,400 units/1000 mL during post-monsoon. Thus, the major seasonal variation was observed in abundance rather than in taxonomic richness. The relatively stable number of taxa across seasons indicates that

most taxa persisted throughout the study period, while the post-monsoon increase in richness resulted from the additional occurrence of *Synedra* sp.

Chlorophyceae dominated the algal community throughout the study period. Its abundance increased from 31,000 units/1000 mL during pre-monsoon to 74,700 units/1000 mL during monsoon and remained high during post-monsoon at 73,700 units/1000 mL. The predominance of Chlorophyceae may be associated with the availability of suitable light, nutrients and habitats within the river. However, because paired species-specific environmental measurements were not available, a single environmental factor cannot be identified as the principal driver of this pattern.

Bacillariophyceae showed the most pronounced increase in relative contribution, from 19.45% during pre-monsoon to 28.71% during post-monsoon. The increase in diatom abundance may be associated with seasonal changes in water clarity, flow conditions and the availability of suitable submerged substrates. Such relationships should, however, be interpreted cautiously in the absence of direct statistical relationships between diatom abundance and individual environmental variables.

Cyanophyceae increased in absolute abundance from pre-monsoon to monsoon but declined during post-monsoon. Its relative contribution also decreased from 21.34% during monsoon to 17.25% during post-monsoon. This seasonal pattern indicates that cyanobacterial abundance varied considerably with changing environmental conditions, although the available data do not allow a specific factor to be identified as responsible for the observed variation.

The relatively high turbidity recorded during the monsoon is an important feature of the physicochemical profile. Turbidity exceeding 70 NTU can reduce light penetration and consequently modify the underwater photosynthetic environment. However, the simultaneous increase in total algal abundance indicates that turbidity alone does not explain the seasonal dynamics of the algal community. The inclusion of attached and submerged algal habitats in sampling is relevant in this context because attached algae may persist on available substrates despite changes in suspended sediment concentrations. In addition, monsoon flow may redistribute nutrients and algal propagules within the river system.

The seasonal physicochemical pattern showed higher TDS, EC, hardness, calcium, alkalinity and chloride concentrations during summer, followed by marked decreases during the monsoon, which may be associated with rainfall-related dilution. Similar seasonal variations in physicochemical parameters have been reported from central Indian river systems [10–12]. Dissolved oxygen increased during the monsoon and reached its highest values during winter. Lower water temperature during winter generally increases oxygen solubility, while turbulence and enhanced atmospheric exchange during periods of increased flow may also contribute to higher dissolved oxygen concentrations.

The diversity indices showed remarkable stability despite substantial differences in total algal abundance. At the level of the four major algal groups, Shannon–Wiener diversity ranged from 1.146 to 1.178, Simpson diversity from 0.630 to 0.647, Pielou evenness from 0.827 to 0.850 and Margalef richness from 0.252 to 0.274. These values indicate a relatively even distribution of abundance among the major algal groups.

The stability of the diversity and evenness indices despite the large increase in total abundance suggests that seasonal changes affected the overall abundance of the algal community more strongly than its proportional structure. Thus, the increase in algal abundance was not restricted exclusively to a single major algal group.

Spatially, the highest total abundance was recorded at Wangepalli, followed by Devalmari and Chaprala. Differences among sampling sites may be associated with local environmental and habitat characteristics, including substrate availability, flow conditions and surrounding land use. However, these factors should be considered potential explanations rather than established causes unless supported by site-specific statistical analyses.

The results support the ecological value of algae as complementary biological indicators of aquatic environmental conditions [14,18–20]. Nevertheless, interpretation of algal communities should take into account local habitat characteristics, sampling design, seasonal variability and taxonomic composition [30].

The algal diversity recorded in the Pranhita River can be considered within the broader context of freshwater algal studies conducted in Maharashtra. Kamat's work on Vidarbha provided an early foundation for understanding the regional algal flora [1]. Tijare's investigation of the Wainganga River documented substantial phytoplankton diversity in Gadchiroli District [2].

Studies conducted in Chandrapur District have reported cyanobacteria, desmids, Scenedesmus and related chlorophycean algae, new records of freshwater algae and considerable diatom diversity [3–7]. These investigations indicate that river systems of eastern Maharashtra support diverse freshwater algal communities.

The present study contributes additional information from the Pranhita River, particularly from the Chamorshi and Aheri Tehsil regions. The documentation of 30 taxa and their seasonal abundance provides useful baseline information for future ecological and biomonitoring studies in the region. Direct numerical comparison with earlier studies should nevertheless be made cautiously because sampling periods, habitat types, sampling effort, taxonomic resolution and analytical methods may differ among investigations.

Algal communities respond to environmental changes and can therefore provide useful biological information about aquatic ecosystems. Diatoms are frequently used in water-quality assessment because their distribution can respond to pH, conductivity, nutrient availability and other environmental variables. Green algae may respond to changes in light, nutrients and temperature, whereas cyanobacteria may become abundant under particular environmental conditions. Euglenoid algae can also provide information about nutrient enrichment and organic conditions in certain aquatic habitats.

The present study recorded all four major algal groups and demonstrated seasonal differences in their abundance. The relatively high diversity and evenness values indicate a diverse and relatively even algal community. Biological indicators are particularly informative when interpreted together with physicochemical observations. The physicochemical data obtained in the present study provide environmental context for the observed algal patterns; however, direct statistical relationships between algal abundance and individual physicochemical parameters would require matched site-specific measurements collected on the same sampling dates.

11. CONCLUSION

The present investigation documented substantial algal diversity and pronounced seasonal variation in algal abundance in selected stretches of the Pranhita River in Chamorshi and Aheri Tehsils of Gadchiroli District, Maharashtra. A total of 30 algal taxa belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae were recorded.

Chlorophyceae was the dominant algal group throughout the study, while Bacillariophyceae showed a marked increase in abundance and relative contribution during post-monsoon. Total algal abundance increased from 58,100 units/1000 mL during pre-monsoon to 148,100 units/1000 mL during monsoon and 148,400 units/1000 mL during post-monsoon. Wangepalli recorded the highest overall algal abundance among the three sampling sites.

The Shannon–Wiener, Simpson and Pielou indices showed high and relatively stable values across seasons, indicating a diverse and relatively evenly distributed algal community. Margalef richness was highest during pre-monsoon and increased again during post-monsoon.

The physico-chemical profile showed clear seasonal variation. Summer was characterized by higher temperature, TDS, EC, BOD, hardness, calcium, alkalinity and chloride concentrations. Monsoon was characterized by very high turbidity and lower concentrations of several dissolved constituents, while winter showed lower temperature and higher dissolved oxygen.

The seasonal algal patterns indicate that community abundance was influenced by multiple environmental factors rather than by a single physicochemical parameter. The high algal abundance during monsoon despite increased turbidity suggests the importance of hydrological processes, nutrient redistribution, attached habitats and substrate conditions.

Cyanobacterial taxa including *Anabaena*, *Microcystis*, *Nostoc*, *Oscillatoria*, *Rivularia*, *Spirulina*, *Scytonema* and *Anacystis* were recorded. Their occurrence is relevant to ecological and water-quality monitoring, but it does not demonstrate cyanotoxin contamination or a direct human-health risk because toxin analysis was not conducted.

Overall, the study provides baseline information on algal diversity, abundance, seasonal distribution and physico-chemical characteristics of the Pranhita River. The combined biological and environmental observations demonstrate the value of algae as a complementary component of river ecosystem monitoring.

ACKNOWLEDGEMENTS

The authors acknowledge the Maharashtra Pollution Control Board and Telangana State Pollution Control Board for their river-water monitoring activities, which provide valuable information for understanding long-term changes in water quality within the wider Wardha–Wainganga–Pranhita river system.

AUTHOR CONTRIBUTIONS

Ramesh Halami: Conceptualization, Investigation, Field Sampling, Laboratory Analysis, Data Collection, Methodology, Data Curation, Formal Analysis, Visualization, and Writing—Original Draft.

Vyenkatesh Ippala: Phytoplankton index calculation, data analysis, data processing, and figure generation.

Nathuji Wadhawe: Supervision, Methodology, Taxonomic Identification, Writing—Review & Editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study because the research involved environmental water and algal samples and did not involve human participants, animals, or human-derived materials.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

- [1] Kamat, N.D., 1975. Algae of Vidarbha, Maharashtra. *Journal of the Bombay Natural History Society* 72(2), 450–476.
- [2] Tijare, R.V., 2020. Qualitative and quantitative study of phytoplankton of River Wainganga near Markandadeo, Dist. Gadchiroli (M.S.). *Environment Conservation Journal* 21(3), 43–49. <https://doi.org/10.36953/ECJ.2020.21305>
- [3] Reddy, B.M., Chaturvedi, A., 2018. Study of cyanobacterial diversity from the major rivers of Chandrapur district, Maharashtra. *Phykos* 48(1), 36–45.
- [4] Reddy, B.M., Chaturvedi, A., 2017. Desmids from the rivers of Chandrapur district, Maharashtra. *NeBIO* 8(1), 25–34.
- [5] Reddy, B.M., Chaturvedi, A., 2015. Scenedesmus and related genera in riverine system of Chandrapur district, Maharashtra, India. *Phykos* 45(2), 19–28.
- [6] Reddy, M., 2021. New records of freshwater algae for Maharashtra state: Investigation from the major rivers of Chandrapur district. *NeBIO* 12(2).
- [7] Reddy, B.M., 2024. Diatom diversity at Chandrapur district, Maharashtra. *BIOINFOLET* 21(1), 132–138. <https://doi.org/10.5958/0976-4755.2024.00043.9>
- [8] Dhumal, S., Chitale, R., Dudhal, A., Wangikar, H., Bankar, P., 2020. Study of freshwater algae from Baramati City area, District Pune. *International Journal of Current Microbiology and Applied Sciences* 9(10), 2933–2937. <https://doi.org/10.20546/ijcmas.2020.910.353>
- [9] Reddy, B.M., Chaturvedi, A., 2017. New records of fresh water algae from India. *Phykos* 47(1), 59–63.
- [10] Shukla, S.K., Sharma, R.K., 2023. Correlation and regression analysis of physicochemical parameters of Wainganga River water in Central India. *J Indian Assoc Environ Manag* 43(1), 11–17. <https://or.niscpr.res.in/index.php/JIAEM/article/view/764>
- [11] Navasakthi, S., Pandey, A., Dandautiya, R., Hasan, M., Khan, M.A., Perveen, K., Alam, S., Garg, R., Qamar, O., 2023. Assessment of spatial and temporal variation in water quality for the Godavari River. *Water* 15(17), 3076. <https://doi.org/10.3390/w15173076>
- [12] Mithani, I., Dahegaonkar, N.R., Shinde, J.S., Tummawar, S.D., 2012. Preliminary studies on physico-chemical parameters of river Wardha, District Chandrapur, Maharashtra. *Journal of Research in Ecology* 1(1), 14–18.

- [13] Wadhawe, N.S., 2014. Cyanophycian algal diversity of Bhadrawati Tahasil paddy soil of Chandrapur District (MS), India. *International Journal of Life Sciences*, Special Issue A2, 112–115.
- [14] Bellinger, E.G., Sigee, D.C., 2010. *Freshwater algae: Identification and use as bioindicators*. Wiley-Blackwell. <https://doi.org/10.1002/9780470689554>
- [15] Desikachary, T.V., 1959. *Cyanophyta*. Indian Council of Agricultural Research, New Delhi, 686 pp.
- [16] Prescott, G.W., 1954. *How to know the fresh-water algae: An illustrated key for identifying the more common fresh-water algae to genus, with hundreds of species named pictured and with numerous aids for their study*. Pictured Key Nature Series.
- [17] Round, F.E., 1981. *The ecology of algae*. Cambridge University Press.
- [18] Bellinger, E.G., Sigee, D.C., 2015. *Algae as bioindicators*. In: *Freshwater Algae: Identification, Enumeration and Use as Bioindicators*. Wiley.
- [19] Wu, N., Schmalz, B., Fohrer, N., 2012. Development and testing of a phytoplankton index of biotic integrity (P-IBI) for a German lowland river. *Ecological Indicators* 13(1), 158–167. <https://doi.org/10.1016/j.ecolind.2011.05.022>
- [20] Stevenson, R.J., Bothwell, M.L., Lowe, R.L. (Eds.), 1996. *Algal ecology: Freshwater benthic ecosystems*. Academic Press, San Diego, CA, 753 pp.
- [21] Chorus, I., Bartram, J. (Eds.), 1999. *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management*. E & FN Spon on behalf of the World Health Organization, London, 416 pp. <https://doi.org/10.1201/9781482295061>
- [22] Chorus, I., Welker, M. (Eds.), 2021. *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management*, 2nd ed. CRC Press. <https://www.who.int/publications/m/item/toxic-cyanobacteria-in-water---second-edition>
- [23] World Health Organization, 2024. *Management of cyanobacteria in drinking-water supplies: Information for regulators and water suppliers*, 2nd ed. World Health Organization, Geneva, 28 pp. <https://www.who.int/publications/i/item/B09130>
- [24] American Public Health Association, American Water Works Association, Water Environment Federation, 2017. *Standard methods for the examination of water and wastewater*, 23rd ed. American Public Health Association, American Water Works Association, Water Environment Federation, Washington, DC. <https://www.wef.org/publications/standard-methods>
- [25] Shannon, C.E., Weaver, W., 1949. *The mathematical theory of communication*. University of Illinois Press, Urbana. https://books.google.com/books/about/The_Mathematical_Theory_of_Communication.html?id=9VYg0gEACAAJ
- [26] Simpson, E.H., 1949. Measurement of diversity. *Nature* 163, 688. <https://doi.org/10.1038/163688a0>
- [27] Pielou, E.C., 1966. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* 13, 131–144. [https://doi.org/10.1016/0022-5193\(66\)90013-0](https://doi.org/10.1016/0022-5193(66)90013-0)
- [28] Baig, A.A., 2025. Diversity of freshwater algae recorded in Maharashtra, India: A comprehensive review (2000–2024). *International Journal of Science Information* 11(4), 92–99. <https://zenodo.org/records/19328071>
- [29] Astuti, S.P., Hashmi, Z., Bilad, M.R., Payus, C.M., Affandi, M., Soegianto, A., 2026. Freshwater microalgae as bioindicators: A review of trait-based advances, ecosystem insights, and biomonitoring innovations. *Environmental Challenges* 22, 101428. <https://doi.org/10.1016/j.envc.2026.101428>
- [30] Lange, K., Townsend, C.R., Matthaei, C.D., 2016. A trait-based framework for stream algal communities. *Ecology and Evolution* 6(1), 23–36. <https://onlinelibrary.wiley.com/doi/10.1002/ece3.1822>