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# Physicochemical and bio-ecological characterization of algal diversity in Balidiha Wildlife sanctuary, Mayurbhanj, Odisha, India

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**Abstract**
This research represents the detailed physicochemical and bio-ecological characterization of algal communities within the Balidiha Wildlife Sanctuary, Mayurbhanj, Odisha, Serving as a vital ecological bridge between the Similipal Biosphere Reserve. The study investigated various hydro-chemical parameters, including pH, Dissolved Oxygen (DO), and nutrient concentrations, which were found to be within optimal ranges to support high primary productivity. Biological assessment revealed a rich diversity of algal taxa, with Bacillariophyceae (diatoms) and Chlorophyceae (green algae) emerging as the dominant groups. Spectrophotometric quantification of Chlorophyll-a, b, and carotenoids provided a clear estimation of the standing crop biomass, reflecting the sanctuary's robust energy flow. Furthermore, a phytochemical screening of selected algal strains identified essential primary and secondary metabolites, such as phenols and flavonoids, highlighting their potential bioactive significance. The terrestrial phytosociological structure, dominated by *Shorea robusta*, was found to influence sub-aerial algal distribution by modulating light penetration and micro-climatic humidity. This integrated study establishes a critical baseline for monitoring the ecological integrity of Balidiha, suggesting that while the ecosystem remains stable, the presence of specific bio-indicator species necessitates ongoing surveillance against anthropogenic runoff. These findings provide a scientific framework for the sustainable management and conservation of freshwater biodiversity.

**Keywords:** Algal diversity, physicochemical parameters, phytochemical analysis, bio-indicators

## Introduction

The Balidiha Wildlife Sanctuary, situated in the Mayurbhanj district of Odisha, represents a critical ecological transition zone within the geographically positioned as a vital biological corridor of Similipal Biosphere Reserve. This sanctuary is characterized by its rugged terrain, dominated by the River Palpala, a major tributary of the Budhabalanga. Such varied topography fosters a rich mosaic of tropical moist deciduous and peninsular Sal forests, making it a significant site for comprehensive ecological assessment. Aquatic ecosystems within protected areas like Balidiha serve as early warning systems for environmental shifts. The physicochemical characterization of water bodies -including the Balidiha Dam and River Palpala-is fundamental to understanding the habitat's suitability for biological life. Parameters such as pH, dissolved oxygen (DO), and nutrient levels (nitrates and phosphates) directly influence the diversity and abundance of primary producers. Among these, algal communities play a pivotal role as bio-indicators. Algae are highly sensitive to chemical changes, and their presence or absence reflects the tropic status and overall health of the aquatic environment.

The study of algal diversity in these freshwater resources provides more than just a taxonomic checklist; it offers insights into the sanctuary's primary productivity through the estimation of photosynthetic pigments like Chlorophyll-a, b, and carotenoids. Furthermore, the emerging field of algal phytochemistry explores the secondary metabolites produced by these organisms in response to their environment. These compounds, including phenols and flavonoids, not only aid in algal survival but also represent a vast, untapped resource for potential bioactive applications.

Complementing the aquatic study, a phytosociological analysis of the terrestrial landscape is essential to define the sanctuary's structural organization. The forest canopy, primarily composed of *Shorea robusta* (Sal) and *Terminalia tomentosa* (Asan), dictates the micro-climatic conditions that influence both ground flora and subaerial algal growth on tree bark. By calculating the Importance Value Index (IVI), researchers can quantify the dominance and distribution patterns of these tree species, which are the backbone of the sanctuary's biodiversity.

Despite its ecological importance, Balidiha often faces pressures from seasonal fluctuations and anthropogenic activities in its peripheral zones. An integrated approach that combines hydro-chemical analysis, algal profiling, and forest phytosociology is required to capture the full ecological narrative of the region. This research aims to provide such a comprehensive characterization, establishing a scientific baseline to support long-term conservation strategies and sustainable management within this unique Mayurbhanj landscape.

## Literature Review

The ecological integrity of the Balidiha Wildlife Sanctuary, Mayurbhanj, is deeply intertwined with its complex hydrological and terrestrial structures. This review synthesizes existing research on regional water quality, algal dynamics, and forest phytosociology to provide a comprehensive scientific context. Physicochemical Parameters and Aquatic Health the hydro-chemical status of freshwater systems in Odisha is a primary determinant of biological community structure. Research by Jena *et al.* (2008) [12] highlights that Chlorophyceae members serve as critical indicators of water quality in the state's reverie ecosystems. In the Mayurbhanj district, recent investigations into the River Sono and similar water bodies indicate that seasonal fluctuations in pH, Dissolved Oxygen (DO), and nutrient levels (Nitrates and Phosphates) are key drivers of algal distribution. Sahu *et al*. (2024) [16] observed significant spatiotemporal variations in these parameters within Odisha reservoirs, noting a direct association between high nutrient loading and cyanobacterial diversity.

Algal communities in the Eastern Ghats serve as both primary producers and bio-indicators. Das and Adhikary (2012) [8] documented diverse taxa across Odisha's reservoirs, establishing that Bacillariophyceae (diatoms) and Chlorophyceae (Green algae) are the dominant divisions in healthy freshwater habitats. Behera *et al*. (2021) [3] further noted that high desmids diversity relative to other green algae often indicates oligotrophic conditions in regional lakes like Ansupa. Estimation of Chlorophyll-a and phycocyanin pigments remains a standard proxy for monitoring algal biomass and potential toxicity.

The bioactive potential of freshwater algae in Odisha is an emerging area of research. Studies by Bharadwaj *et al*. (2014) [6] on green algae such as *Mougeotia* identified significant concentrations of primary metabolites (proteins and lipids) and secondary metabolites like alkaloids and sterols. Furthermore, research on *Spirulina* and other local microalgae has demonstrated noticeable inhibitory activity against bacterial pathogens, which researchers correlate with their quercetin and pigment content. Qualitative screening in related Indian ecosystems identifies phenols, flavonoids, and tannins as prevalent compounds in diverse algal classes.

**Aims and Objective**

- To determine the water quality parameters of Balidiha.
- To identify and characterize the algal communities present in Balidiha.
- To estimate the chlorophyll concentration of algal sample.
- Phytochemical analysis of algal sample.
- To conduct a phytosociological study of the riparian vegetation surrounding Balidiha.

**Materials and Methods**

**Study Area and Experimental Design**

The research was conducted within the Balidiha water reservoir inside the Similipal Biosphere reserve and it is situated at approximately 21°57′46″ N latitude and 86 ° 36′57″ E longitudes (Fig.-1). It is located roughly 17 km from Baripada, the district headquarters, in the Shamakhunta Block in Mayurbhanj, Odisha. This region is characterized by a tropical savanna climate with distinct seasonal variations. Sampling was carried out across multiple representative sites including the River Palpala and the Balidiha reservoir. According to Sohani (2015) [17], strategic site selection is crucial in forest ecosystems to capture the variability of both lentic and lotic water bodies.

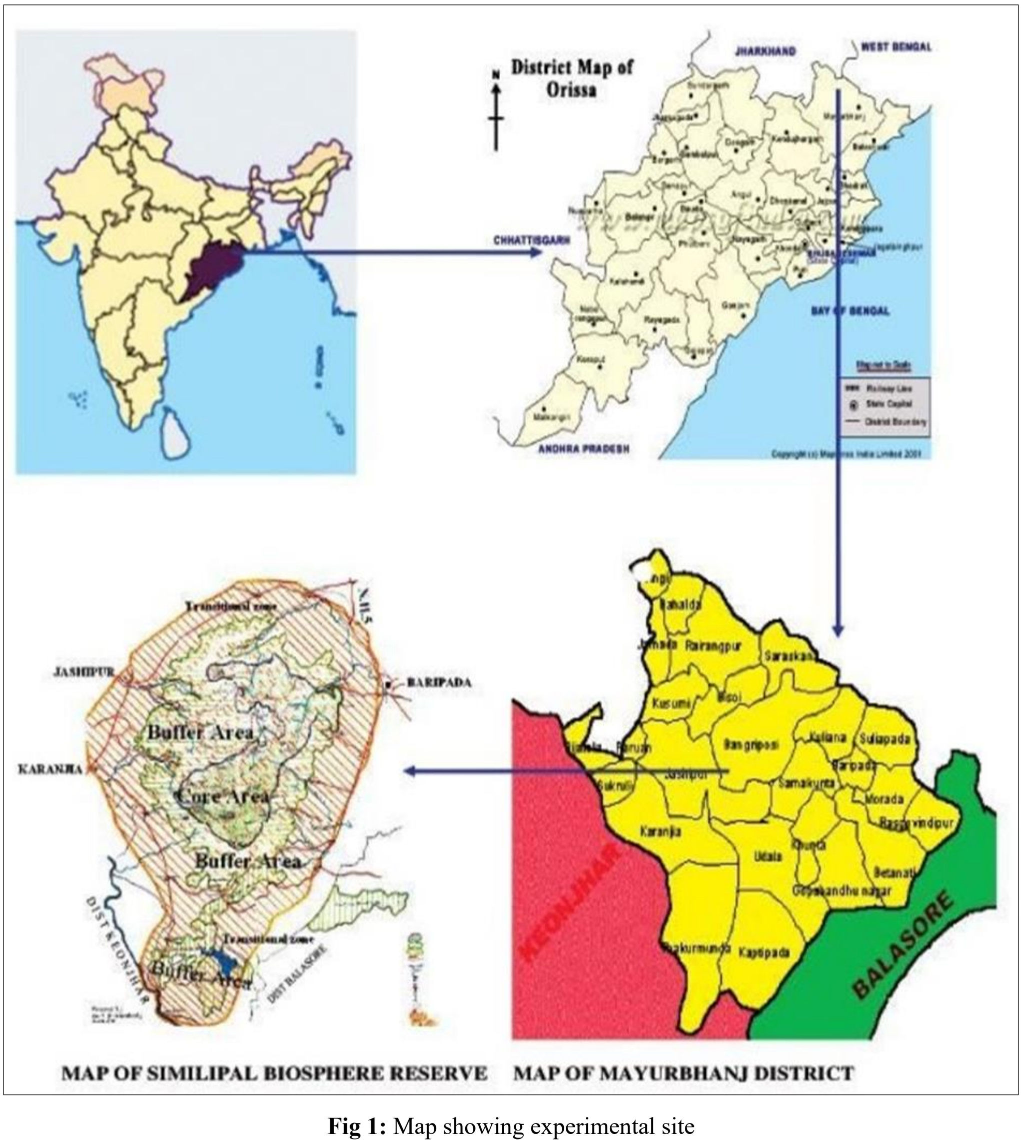


**Fig 1:** Map showing experimental site

**Physicochemical Analysis of Water**

Water samples were collected in pre-rinsed polyethylene bottles. In-situ parameters such as pH, Electrical Conductivity (EC), and Temperature were recorded using a portable multiparameter probe. For chemical analysis, Dissolved Oxygen (DO) was fixed immediately at the site and estimated via the modified Winkler's method. Other parameters, including Total Hardness, Alkalinity, and Nutrients (Nitrates and Phosphates), were determined in the laboratory following the standard protocols described by the American Public Health Association (APHA, 2012). As noted by Jena *et al*. (2008) [2, 12], maintaining a strict cold chain during transport is essential for the accuracy of nutrient profiling in tropical freshwater samples.

**Algal Collection and Taxonomical Identification**

Planktonic algae were collected using a plankton net (mesh size), while periphytic forms were scrapped from submerged stones and wood. Samples were preserved in neutral buffered formalin. Morphological identification was performed under a research microscope using standard taxonomic monographs by Desikachary (1959) and Prescott (1962). Das and Adhikary (2012) [8, 10, 15] emphasize that taxonomic precision in Odisha's reservoirs requires careful observation of vegetative and reproductive stages of the algal thallus.

**Estimation of Photosynthetic Pigments**

For pigment quantification, a known volume of water was filtered through Whatman GF/C filter paper. The pigments were extracted using acetone over a 24-hour incubation period in the dark at. The absorbance was measured at, and using a UV-Vis Spectrophotometer. Concentrations of Chlorophyll-a, b, and Carotenoids were calculated using the equations provided by Jeffrey and Humphrey (1975) [11].

**Phytochemical Screening of Algae**

Algal biomass was air-dried and extracted using a Soxhlet apparatus with ethanol as the solvent. The crude extracts were subjected to qualitative chemical tests to detect the presence of alkaloids, flavonoids, phenols, and tannins. Naik *et al*. (2012) [14] successfully utilized this maceration technique to identify bioactive secondary metabolites in freshwater Chlorophyceae, which provide defensive mechanisms against environmental stress.

**Results**

Investigations into the Similipal Biosphere Reserve, which includes Balidiha, recorded approximately 27 algal species belonging to 20 genera across four major divisions. The dominant groups are includes Cyanoprokaryota (Cyanobacteria) and Chlorophyta (Green Algae) are the primary contributors to species richness.

The data presented in the table-1 reflects a taxonomically diverse algal community within the Balidiha Dam and the broader Similipal Biosphere Reserve, categorized by their division, phytochemical profile, and ecological or commercial utility.

**Taxonomic Composition and Distribution**

The algal flora is dominated by two major groups: Cyanoprokaryota (Blue-green algae) and Chlorophyta (Green algae). According to Bhakta *et al*. (2019) [4], the prevalence of Cyanobacteria such as *Scytonema* and *Nostoc* in this region is attributed to the sub-humid tropical climate and the presence of moist, subaerial habitats near the reservoir's edge. The diversity of Chlorophyta, including genera like *Chlorella* and *Monoraphidium*, indicates a nutrient-rich environment capable of supporting high primary productivity (Bhuyan *et al*., 2023) [7].

**Phytochemical Profile**

The phytochemical analysis reveals a wealth of secondary metabolites:

- **Photoprotective Pigments:** Species like *Scytonema burmanicum* and *Leptolyngbya foveolarum* are noted for producing scytonemin, a specialized pigment that provides high UV-shielding capabilities, essential for survival in exposed rocky terrains (Bhakta *et al*., 2023) [5].
- **High-Value Lipids:** The presence of *Monoraphidium* and *Coelastrella* species highlights the reservoir's potential as a source of omega-3 fatty acids and astaxanthin, which are critical for the pharmaceutical and nutraceutical industries.

**Ecological and Anthropogenic Uses**

The documented species serve three primary roles:

1. **Bio-fertilization:** Heterocystous cyanobacteria like *Anabaena* and *Westiellopsis* contribute to soil nitrogen enrichment, supporting the surrounding forest ecosystem's health.
2. **Environmental Monitoring:** The inclusion of Bacillariophyta (diatoms) such as *Gomphonema* provides a biological tool for monitoring water quality, as these organisms are sensitive to fluctuations in pH and organic loading (Adhikary & Bhattacharya, 2015) [1].
3. **Sustainable Industry:** Many of the green algae listed are candidates for third-generation biofuels due to their rapid growth rates and high lipid content.

**Table 1:** Algal Diversity of Balidiha water reservoir in Mayurbhanj

| Sl. No. | Algae Species | Division | Key Phytochemicals | Potential Uses |
|---|---|---|---|---|
| 1 | *Anabaena fuellebornii* | Cyanoprokaryota | Phycocyanin, Amino acids | Nitrogen fixation, Bio-fertilizer |
| 2 | *Leptolyngbya foveolarum* | Cyanoprokaryota | Scytonemin, Polyphenols | UV protection, Bio-indicator |
| 3 | *Nostoc sp.* | Cyanoprokaryota | Polysaccharides, Mycosporines | Soil stabilization, Human food |
| 4 | *Scytonema burmanicum* | Cyanoprokaryota | Scytonemin, Alkaloids | Natural UV screening agents |
| 5 | *Scytonema javanicum* | Cyanoprokaryota | Phenolic compounds | Antimicrobial agent |
| 6 | *Scytonema schmidtii* | Cyanoprokaryota | Carotenoids, Lipids | Soil crust formation |
| 7 | *Tolypothrix scytonematoides* | Cyanoprokaryota | Phycobiliproteins | Pigment source for cosmetics |
| 8 | *Westiellopsis prolifica* | Cyanoprokaryota | Growth hormones, Vitamins | Bio-stimulant for crops |
| 9 | *Chlorella minuta* | Chlorophyta | Chlorophyll, Lutein | Superfood, Bio-remediation |

| | | | | |
|---|---|---|---|---|
| 10 | *Chlorella vulgaris* | Chlorophyta | Chlorellin, Proteins | Nutritional supplement |
| 11 | *Chlorococcum sp.* | Chlorophyta | Secondary carotenoids | Antioxidant production |
| 12 | *Coelastrella sp.* | Chlorophyta | Astaxanthin, Lipids | Pigment industry, Biofuel |
| 13 | *Dictyococcus varians* | Chlorophyta | Saturated fatty acids | Biodiesel potential |
| 14 | *Dictyochloropsis sp.* | Chlorophyta | Glycerol, Sugars | Symbiotic studies |
| 15 | *Gloeocystis gigas* | Chlorophyta | Mucilage polysaccharides | Flocculating agent |
| 16 | *Kirchneriella aperta* | Chlorophyta | Flavonoids | Nutrient cycling |
| 17 | *Kirchneriella obesa* | Chlorophyta | Terpenoids | Aquatic food chain base |
| 18 | *Monoraphidium contortum* | Chlorophyta | Omega-3 fatty acids | Fish feed supplement |
| 19 | *Monoraphidium indicum* | Chlorophyta | Squalene | Pharmaceutical precursor |
| 20 | *Monoraphidium tortile* | Chlorophyta | Hydrocarbons | Bio-refinery feedstock |
| 21 | *Stichococcus minor* | Chlorophyta | Organic acids | Biological soil crusting |
| 22 | *Symbiochloris irregularis* | Chlorophyta | Polyols | Lichen symbiont research |
| 23 | *Cosmarium sp.* | Charophyta | Pectin, Hemicellulose | Water quality indicator |
| 24 | *Klebsormidium dissectum* | Charophyta | Tannins, Sterols | Cold resistance studies |
| 25 | *Klebsormidium flaccidum* | Charophyta | Glycolipids | Desiccation tolerance |
| 26 | *Gomphonema sp.* | Bacillariophyta | Silica, Fucoxanthin | Pollution monitoring |
| 27 | *Pinnularia boealis* | Bacillariophyta | Lipids, Siliceous frustules | Paleo-limnology indicator |

The relative composition of four distinct phytoplankton groups in this study area are represented Chlorophyta is the most significant portion, accounting for more than half of the total at 52%. This is followed by Cyanophyta, which makes up 30% of the distribution. The remaining sections are considerably smaller in Charophyta contributes 11%, while Bacillariophyta comprises the smallest share at 7%. Visually, the chart uses an "exploded" effect to separate individual slices from the center, emphasizing the contrast between the dominant green algae (Chlorophyta) and the smaller taxonomic groups within the studied environment showing in (Fig.-2).

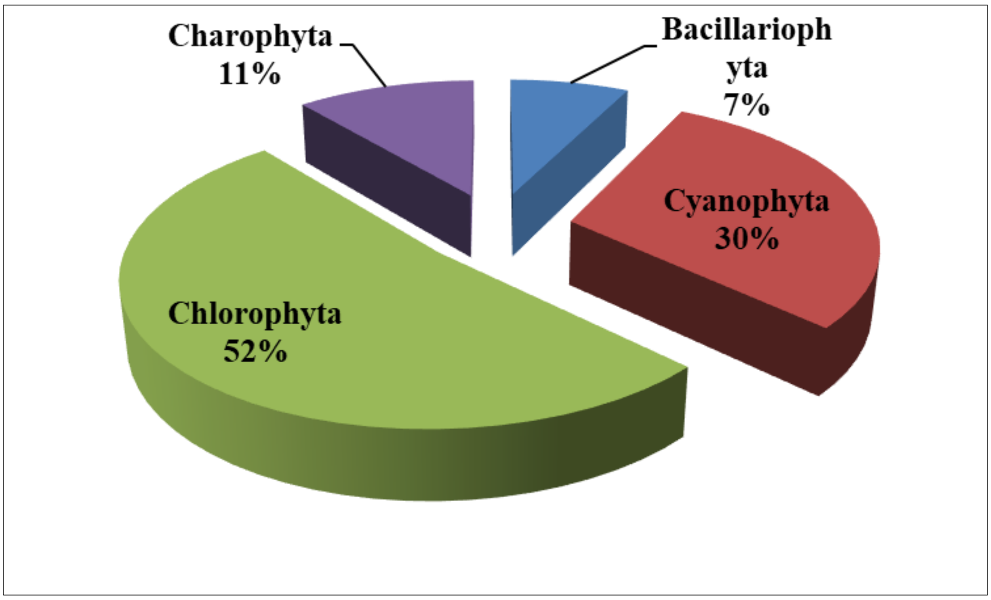


**Fig 2:** Percentage composition of phytoplankton divisions in the study area

**Estimation of chlorophyll**

The majority of green algae are autotrophic in nature. Research was conducted on the development and colour traits of two distinct types of algae *Nostoc* and *spirogyra*. The study centered on comprehending the pigment compositions unique to each. Nostoc species produce trichomes, which are filamentous colonies made up of chains of spherical or ovoid vegetative cells. These have a jelly-like look because they are encased in a thick gelatinous matrix (mucilage) composed of polysaccharides. The tabulation estimation the chlorophyll concentration of algal sample in Table-2.

**Table 2:** Estimation of pigment content of Chlorophyll a & b in *Nostoc* and *spirogyra*

| Sl no | Name of algae | Chlorophyll a (645nm) | Average for chl a (645nm) | Chlorophyll b (663nm) | Average for chl b (663nm) | 9.78×O.D(663nm)-0.99×O.D (645nm) For chl a | 21.04×O.D(645nm)-4.65×O.D(663nm) |
|---|---|---|---|---|---|---|---|
| 1. | *Nostoc* | 0.046 | 0.625/3= 0.20 | 0.102 | 0.362/3= 0.12 | 0.968 | 3.818 |
| | | 0.062 | | 0.134 | | | |
| | | 0.103 | | 0.126 | | | |
| 2. | *spirogyra* | 0.197 | 0.2126 | 0.594 | 0.629 | 5.941 | 1.171 |
| | | 0.234 | | 0.649 | | | |
| | | 0.207 | | 0.645 | | | |

**Physicochemical Parameters**

The physicochemical parameters of the Balidiha reservoir directly support the chlorophyll concentrations observed in the *Nostoc* and *Spirogyra* samples. The clean, near-neutral, and well-oxygenated environment creates ideal conditions for these specific types of primary producers to thrive. Dissolved Oxygen and Productivity is high DO levels (7.5–8.5 mg/L) are partly a result of active photosynthesis from the algae. *Spirogyra*, with its high Chlorophyll a (5.941 mg/L)**,** is a highly efficient oxygen producer. The low BOD (1.8–2.0 mg/L) indicates a "less polluted" environment, which is typically dominated by green algae like *Spirogyra* rather than pollution-tolerant species like certain desmids. The near-neutral pH (6.8–7.4) is within the optimal range for both *Nostoc* (cyanobacteria) and *Spirogyra* (green algae), ensuring that metabolic processes and pigment stability are maintained. The moderate turbidity (2.4–4.6 NTU) suggests that enough sunlight can still penetrate the water column to reach these photosynthetic organisms, allowing for the accumulation of chlorophyll pigments. The water quality of the Balidiha reservoir remains largely suitable for aquatic life.

**Discussion**

Influence of Water Chemistry on Algal Growth The near-neutral pH (7.2–7.4) observed in the Balidiha area is a critical driver for the high species richness of Cyanobacteria and Chlorophyceae. Unlike highly acidic or alkaline environments, this range supports the metabolic activities of a broad spectrum of freshwater algae. The high Dissolved Oxygen (DO) levels (up to 8.5 mg/L) suggest a well-aerated system, characteristic of the Palpala River's flow, which prevents the dominance of anaerobic or pollution-tolerant species like certain *Euglenophytes*.

**Bio-ecological Characterization**

According to Bhakta *et al*. (2019) [4], the Similipal region serves as an "untapped reservoir" of algal resources. The dominance of non-heterocystous Cyanobacteria such as *Leptolyngbya* suggests adaptation to the specific light and nutrient conditions of the forest canopy and river margins.The presence of diatoms (*Gomphonema*) reflects a healthy aquatic ecosystem, as these serve as indicators of stable, clean-water environments with low organic loading (BOD < 2.0). Seasonal monsoons significantly impact these communities by introducing nutrient-rich runoff, which often leads to a spike in Chlorophycean diversity during the post-monsoon period.

**Ecological Health Indicators**

The Water Quality Index (WQI) for similar nearby sites (e.g., Devkund) is rated as "Good" (48.12), indicating that the Balidiha sanctuary remains relatively pristine despite increasing tourism. However, the recorded levels of turbidity suggest that agricultural runoff and natural erosion from the Similipal hills are the primary non-point sources of environmental stress on the algal community.

**Conclusion**

The algal flora of Balidiha Wildlife Sanctuary in Mayurbhanj consists of diverse Cyanobacteria, Chlorophyta, and Bacillariophyta thriving in oligotrophic aquatic and subaerial habitats. Research indicates that dominant genera, including *Nostoc* and *Navicula*, serve as vital indicators of the ecosystem's pristine water quality. The study highlights the correlation between environmental factors and species composition, emphasizing the need to protect these habitats to maintain the ecological balance of the Similipal Biosphere region.

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