Journal of Phytomedicine and Botany
Volume: 1, Issue: 1, 2026 (July-December), Pages: 1-5
ISSN: 3144-3494; DOI: https://doi.org/10.68589/jpb/sc/1.2.2026.1-5
Short Communication

Phytoplankton Diversity, Antibacterial and Bio-indicator Properties of Microalgae in the Jaikwadi Wetland Ecosystem, Paithan

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Received: 2 August 2026 / Accepted: 7 October 2026 / Published: 23 November 2026

Background: This short communication evaluates phytoplankton composition, bio-indicator metrics, and phytomedical potential in the Ramsar-recognized Jaikwadi Reservoir (Nathsagar Lake), Maharashtra.

Methods: A total of 48 microalgal species across four classes (Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae) were identified. Palmer's Algal Index was used to assess organic pollution. Crude methanolic extracts of isolated *Chlorella vulgaris* strains were screened for total phenolic content and in-vitro antibacterial activity.

Results: Palmer's Algal Index revealed severe organic pollution at town-adjacent sampling sites (Station IV score: 24), driven by Cyanophyceae blooms (*Microcystis aeruginosa* and *Oscillatoria* spp.) during pre-monsoon periods. Screening crude methanolic extracts of isolated *Chlorella vulgaris* strains demonstrated notable total phenolic content (42.5 ± 3.1 mg GAE/g) and in-vitro antibacterial activity against *Staphylococcus aureus* (14.2 ± 1.1 mm zone of inhibition).

Conclusion: These findings highlight the dual role of wetland microalgae as ecological health indicators and bioactive bio-resources for pharmacognosy.

Keywords: *phytoplankton, palmer index, microalgae, antibacterial activity, phytomedicine*

Introduction

Freshwater wetlands serve as crucial ecological indicators of environmental health and nutrient dynamics in semi-arid regions (Mitsch & Gosselink, 2015). The Jaikwadi Reservoir (Nathsagar Lake), constructed across the Godavari River near Paithan in Maharashtra, represents one of Western India's largest freshwater wetland ecosystems. Despite its designation as a Ramsar site of international importance, increasing anthropogenic pressures, agricultural runoff, and untreated domestic effluents subject the reservoir to seasonal nutrient loading and localized water quality degradation (Patil & Ghorade, 2011; Potadar & Nannaware, 2022). Phytoplankton communities, primarily represented by Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae, form the base of aquatic food webs and respond rapidly to changes in physico-chemical water parameters (Palmer, 1969; Reynolds, 2006). Because individual taxa exhibit distinct tolerance thresholds to organic enrichment, community structure analysis provides a reliable biological index of trophic status (Anand & Perumal, 2006; Suryawanshi et al., 2026). Beyond ecological monitoring, indigenous freshwater microalgae synthesize diverse secondary metabolites, including polyphenols, fatty acids, and pigments with documented

antioxidant and antimicrobial activities (Verdelho Vieira et al., 2025). However, integrated studies linking spatial bio-indicator assessments with the pharmacognosic evaluation of native algal isolates from Nathsagar Lake remain limited. This short communication presents preliminary findings on microalgal diversity, organic pollution indices, and the antibacterial potential of *Chlorella vulgaris* isolated from the Jaikwadi catchment.

Materials and Methods

Seasonal water and plankton sampling were carried out across four designated stations in Jaikwadi Reservoir: Station I (Inflow Zone), Station II (Deep Pelagic Zone), Station III (Littoral Zone), and Station IV (Anthropogenic Stress Zone near Paithan town). Physico-chemical parameters (water temperature, pH, Secchi disk transparency, dissolved oxygen [DO], five-day biochemical oxygen demand [BOD5], nitrates, and orthophosphates) were analyzed following standard protocols (American Public Health Association [APHA], 2017). Phytoplankton samples were collected by filtering 50 L of surface water through a 25 µm mesh bolting silk plankton net, preserved immediately in 1% Lugol's iodine solution, and enumerated using a Sedgwick-Rafter counting chamber under a compound optical research microscope (Trivedy & Goel, 1986). Taxonomic identification was carried out using standard regional and freshwater algal monographs (Anand & Perumal, 2006). Palmer's (1969) Algal Genus Pollution Index was computed to classify organic pollution levels across stations. For phytomedical screening, unialgal cultures of *Chlorella vulgaris* were isolated via serial dilution and agar plating on BG-11 medium, incubated at 25 ± 1°C under a 16:8 h light-dark photoperiod (3000 lux). Harvested biomass was shade-dried, powdered, and extracted with 80% methanol using continuous orbital shaking for 24 h, followed by centrifugation at 4000 rpm and rotary evaporation. Total phenolic content (TPC) was quantified spectrophotometrically via the Folin-Ciocalteu assay and expressed as milligrams of gallic acid equivalents per gram of dry weight (mg GAE/g DW). Free radical scavenging activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay across concentrations ranging from 10 to 200 µg/mL to determine the half-maximal inhibitory concentration (IC50). In-vitro antibacterial activity was evaluated against *Staphylococcus aureus* (ATCC 25923) using the Kirby-Bauer disk diffusion method (Saifullah et al., 2016). Standardized bacterial suspensions adjusted to the 0.5 McFarland turbidity standard (approximately 1.5 × 10^8 CFU/mL) were uniformly swabbed onto sterile Mueller-Hinton agar plates. Sterile Whatman No. 1 filter paper disks (6 mm diameter) were impregnated with 20 µL of crude methanolic algal extract (100 mg/mL dissolved in 10% dimethyl sulfoxide [DMSO]), air-dried aseptically, and placed onto the inoculated agar surface. Standard chloramphenicol disks (30 µg) served as the positive control, while disks loaded with 10% DMSO served as the negative control. Plates were pre-diffused at 4°C for 30 min and incubated at 37°C for 24 h. Antimicrobial efficacy was determined by measuring the diameter of clear inhibition zones (in mm) around each disk in triplicate (Figure 3A).

Results

Across the sampling period, 48 phytoplankton species belonging to 34 genera were recorded: Chlorophyceae (19 species, 39.6%), Bacillariophyceae (14 species, 29.2%), Cyanophyceae (10 species, 20.8%), and Euglenophyceae (5 species, 10.4%). Seasonal succession exhibited diatoms (*Navicula*, *Synedra*) and green algae (*Scenedesmus*, *Pediastrum*) dominating post-monsoon months under higher oxygenation and water clarity (Secchi depth up to 68.5 cm at Station II). Conversely, pre-monsoon conditions characterized by elevated water temperatures (>32°C) and high orthophosphate levels (up to 2.45 mg/L at Station IV) promoted cyanobacterial dominance (38.8%), marked by dense blooms of *Microcystis aeruginosa* and *Oscillatoria* spp. (Suryawanshi et al., 2026).

Table 1. Physico-chemical summary, Palmer Index score, and dominant organic bio-indicators across sampling stations in Jaikwadi Reservoir

Station	DO Range (mg/L)	BOD Range (mg/L)	Palmer Index Score & Status	Dominant Organic Bio-Indicators
Station I (Inflow)	5.4 – 7.8	2.8 – 5.2	16 (Probable Pollution)	*Navicula, Nitzschia, Scenedesmus*
Station II (Deep Water)	6.2 – 8.4	1.5 – 3.1	11 (Low Pollution / Mesotrophic)	*Navicula, Synedra, Cyclotella*
Station III (Littoral)	5.1 – 7.5	3.1 – 6.4	19 (Probable Pollution)	*Microcystis, Scenedesmus, Anabaena*
Station IV (Urban Stress)	3.8 – 6.1	5.8 – 11.4	24 (Severe Organic Pollution)	*Microcystis, Oscillatoria, Euglena*

Assessment using Palmer's Algal Pollution Index confirmed severe organic enrichment at Station IV (score 24 > 20), directly linked to municipal sewage inflows and domestic runoff from Paithan town (Palmer, 1969; Yannawar et al., 2014).

Pollution-tolerant taxa including *Microcystis*, *Oscillatoria*, *Euglena*, and *Nitzschia* served as reliable indicators of progressing eutrophication along the littoral margins, as illustrated in Figure 1.

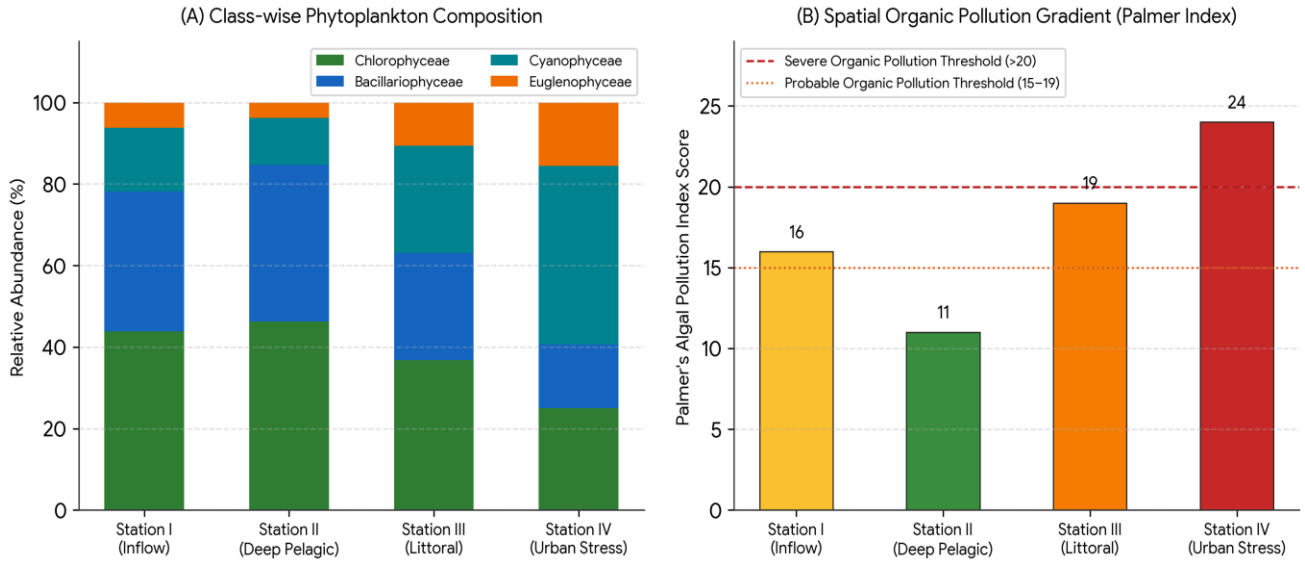

Figure 1. Spatial variation in (A) class-wise relative abundance (%) of phytoplankton communities and (B) Palmer's Algal Organic Pollution Index scores across the four sampling stations of Jaikwadi Reservoir.

Phytomedical screening of crude methanolic extracts from isolated *Chlorella vulgaris* strains yielded a total phenolic content of 42.5 ± 3.1 mg GAE/g dry weight and an IC50 DPPH radical scavenging value of 68.4 µg/mL. In the disk diffusion assay, the methanolic extract produced clear in-vitro antibacterial inhibition zones of 14.2 ± 1.1 mm against *Staphylococcus aureus* (ATCC 25923), compared to 22.4 ± 0.8 mm for the chloramphenicol positive control and no inhibition (0.0 mm) for the 10% DMSO negative control (Figure 2A; Figure 3). These results align with recent evaluations demonstrating that polyphenolic fractions and lipophilic metabolites in *Chlorella* disrupt Gram-positive bacterial cell wall integrity (Fassi Fihri R et al., 2024, Verdelho Vieira et al., 2025).

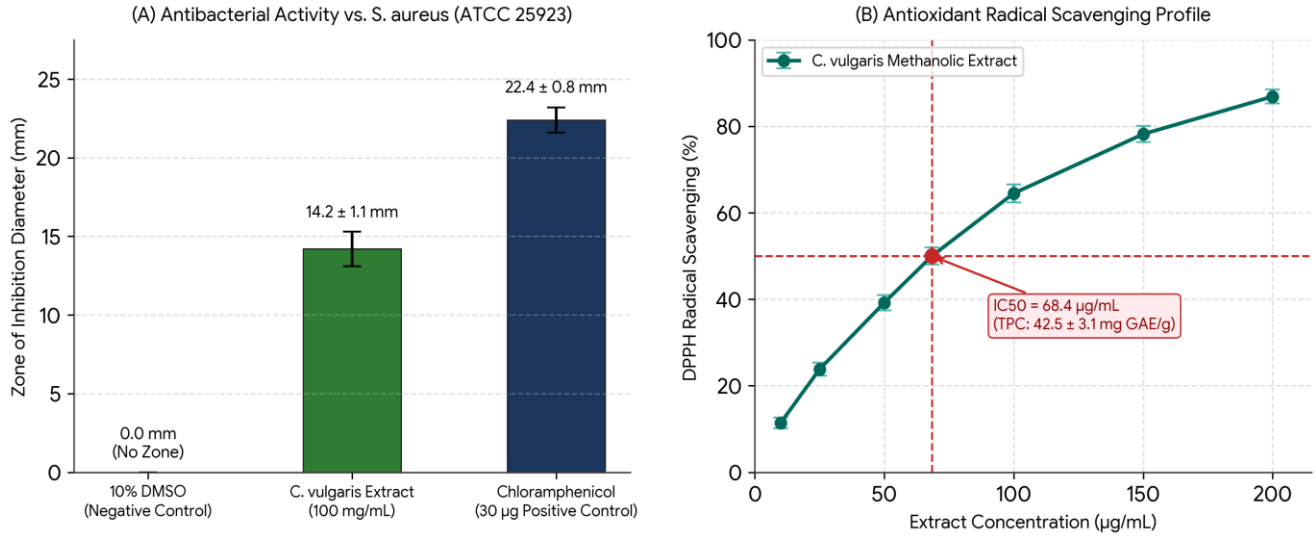

Figure 2. Phytomedical bioactivity of crude methanolic extracts from isolated *Chlorella vulgaris*: (A) in-vitro antibacterial zones of inhibition against *Staphylococcus aureus* (ATCC 25923) compared with controls, and (B) dose-dependent DPPH radical scavenging profile showing the IC50 threshold.

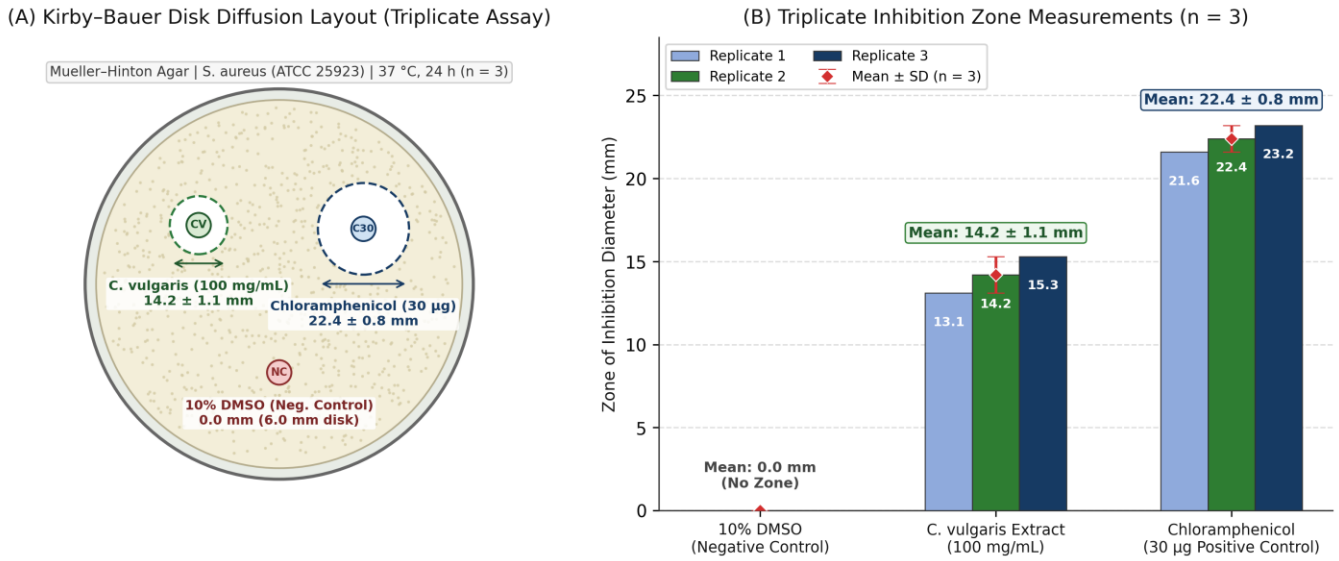

Figure 3. Representative Kirby–Bauer disk diffusion assay and triplicate inhibition zone analysis against *Staphylococcus aureus* (ATCC 25923): (A) standardized 6 mm filter paper disk layout on Mueller–Hinton agar showing comparative clear inhibition zones for *Chlorella vulgaris* methanolic extract (100 mg/mL; 14.2 ± 1.1 mm), chloramphenicol positive control (30 µg; 22.4 ± 0.8 mm), and 10% DMSO negative control (0.0 mm), and (B) replicate-wise measurements (n = 3) alongside mean ± SD values.

Conclusion

Phytoplankton community composition in Jaikwadi Reservoir effectively reflects spatial organic pollution gradients, with cyanobacterial proliferation marking eutrophic stress near urban settlements. Simultaneously, native *Chlorella vulgaris* isolates demonstrate promising antioxidant and antibacterial properties driven by high phenolic yields. Establishing riparian vegetative buffer zones and upgrading municipal wastewater treatment around Paithan are recommended to protect Nathsagar Lake's ecological integrity while supporting sustainable microalgal bioprospecting.

Acknowledgement

The author expresses sincere gratitude to the Director, Gopinathrao Munde National Institute of Rural Development and Research (GMNIRD), and the authorities of Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, for providing laboratory facilities and logistical support during field sampling at Jaikwadi Reservoir.

Author contributions

Rahul Mahamuni: Conceptualization, field sampling, taxonomic identification, laboratory extraction and bioassays, data analysis, manuscript drafting, and final editing.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The author declares that there are no financial, institutional, or personal conflicts of interest associated with this research work or its publication.

Ethics approval

Not applicable. This study involved surface water sampling and in-vitro microbiological screening of indigenous microalgae and did not involve human participants, vertebrate animals, or protected endangered fauna.

AI tool usage declaration

During the preparation and language refinement of this manuscript, the author utilized generative AI assistance strictly for grammatical editing and formatting verification. All scientific data, taxonomic identifications, laboratory measurements, and interpretations were generated, verified, and approved independently by the author, who takes full responsibility for the integrity of the content.

Data availability

The physico-chemical datasets, species checklists, and bioassay measurements generated during the current study are available from the corresponding author upon reasonable academic request.

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