



Assessing sediment diatoms for water quality index in the protected wetlands of Vettangudi Bird Sanctuary, India

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Introduction

Assessing water characteristics through key quality parameters is essential for understanding the ecological health of rangeland resources and forms a critical foundation for effective freshwater pond monitoring. Aquatic plant organisms, particularly phytoplankton—primary producers that include blue-green algae, green algae, diatoms, desmids, and euglenoids—significantly influence the chemical composition of water, a key determinant of productivity. Among these, diatoms and microflora are recognized as essential primary producers and serve as critical indicator species, providing valuable insights into the ecological health of inland freshwater pools (Lougheed et al., 2015).

Biomonitoring ponds by analyzing the assemblages of microflora and microfauna is an essential tool for assessing pond health, as these assemblages are strongly influenced by pollutant loads. Understanding the potential role of diatom algae in regulating water quality is particularly important in ponds with high levels of biological interaction. This knowledge is fundamental for developing effective management guidelines and ensuring the sustainability of freshwater wetland ecosystems.

The time-dependent hypersensitivity of diatoms to environmental changes (Stevenson, 2014) underscores the importance of thoroughly understanding the complex relationships between physico-chemical water quality parameters, thereby enabling more effective assessment of pond conditions. In the present experimental pond, avian diversity was identified as a significant biotic interaction affecting the pond ecosystem (Mahesh et al., 2018).

Although numerous studies have explored diatom diversity in relation to water quality in freshwater wetlands, there remains a significant knowledge gap concerning biotic interactions, particularly allocauthous pollution, and their impact on water quality as indicated by diatom presence in ephemeral ponds. To address this gap, the present investigation aimed to relate the physical conditions and chemical composition of pond substrata to the presence of diatoms, recognized indicators of water quality parameters.

Water samples were collected from three adjoining temporary ponds within the Vettangudi Bird Sanctuary, Sivagangai District, Tamil Nadu, India, to achieve this objective.

Study area

The Vettangudi Bird Sanctuary (latitude 10° 06.57'N, longitude 78° 30.81'E) encompasses three temporary drainage ponds: Vettangudipatty, Chinna Kollukudipatty, and Periya Kollukudipatty. For this study, the Periya Kollukudipatty (PKD) pond was selected as the experimental site. The sanctuary is in the villages of Vettangudipatty and Kollukudipatty within Thiruppathur Taluk, Sivagangai District, Tamil Nadu, India. The PKD pond hosts many migratory birds annually, primarily between November and February. Additionally, it serves multiple purposes for local communities, including domestic use, irrigation through channel systems, collection of fuelwood, minor forest products, and cattle grazing during the summer when the ponds dry up.

Methodology

Water samples were collected from three randomly selected points in the experimental pond between November 2013 and March 2014. Sampling was conducted at 06:00 hours during each collection period using clean plastic bottles. The samples were then transported to the laboratory for further analysis. Sampling and analytical procedures followed the standard methods outlined by Beutler et al. (2005). The pH of the water was measured using a pH meter (Elico, India), and water temperature was recorded immediately after sampling. Total Dissolved Solids (TDS), conductivity and dissolved oxygen (DO) were analyzed using a water analyzer kit (Systronics, Model No. 371).

Bulk water samples were filtered through a phytoplankton net with a mesh size of 45 microns and preserved using 4% formalin and Lugol's iodine solution. Diatom species were identified and photographed using a Euromex light microscope (Holland) at 1000× magnification. At least 500 valves per slide were counted and identified to the species level. Special hyrax mounts were used to prepare slides, and the morphological structures of the diatoms were observed under the microscope. Species identification was carried out based on the manuals by Anand (1988) and Karthick et al. (2013).

Results and Discussion

The physico-chemical condition of water determines the planktonic status of an aquatic ecosystem. The analyzed water quality parameters (Table 1) clearly indicate a gradual increase in alkalinity from January 2014 toward the end of the sampling period. This increase was accompanied by a deterioration in water quality, as evidenced by elevated levels of total dissolved solids (TDS), salinity, acidity, and alkalinity. Notably, higher dissolved oxygen (DO) levels were observed during January, February, and March 2014, which can be attributed to the inflow of fresh rainwater replenishing the pond. Diatom algae-produced oxygen is known to facilitate the bacterial degradation of polycyclic aromatic hydrocarbons (PAHs), phenolics, and organic solvents in benthic environments. However, as organic nutrient levels in water bodies increase, DO tends to decline (Manral and Khudsar, 2013). Additionally, the aggregation of microalgae and diatoms during this period likely contributed to reduced DO levels.

Table 1: Water quality variables, analyzed from the water samples, collected from the PKD pond surface water during the water availability period (November 2013 to March 2014). Values are mean ± SE; (n=3)

Sampling months	pH	DO (ppm)	TDS (ppm)	Salinity (ppt)	Conductivity (µS)	Acidity (mg/l)	Alkalinity (mg/l)
Nov-13	7.07 ±0.04	7.68 ±0.01	241.7±0 .6	0.14±0	133±0.21	14.67±1.1	79.33±0.37

Dec-13	7.29 ±0.04	5.87 ±0.01	115.7±0. 2	0.13±0	218±0.51	12±0.9	139.33±0.67
Jan-14	8.87 ±0.02	7.77 ±0.04	760± 0.6	0.81±0	1410±1.4	35.33±2.3	34.03±0.83
Feb-14	8.75 ±0.02	7.8 ±0.05	1630± 1.4	1.71±0	2970±1.6	40.67±1.2	85.33±1.4
Mar-14	8.94 ±0.01	8.73 ±0.03	1580± 1.21	2.07±0	3520±3.5	43.33±1.2	91.33±0.2

A high TDS level is indicative of eutrophication in aquatic systems, often resulting from increased nutrient inputs, such as excreta from migratory birds sheltering in the pond during the study period. This eutrophic state was further confirmed by the presence of pollution indicator microalgae species, including *Cosmarium contractum*, *Lepocinlis sphagnophila*, *Spirogyra webri*, and *Oscillatoria okeni*.

Data analysis revealed monthly variations in total diatom cell counts and species diversity at the Vettangudi Bird Sanctuary Pond (VTG pond). Of the 32 species identified across 20 genera of phytoplankton, including diatoms and microalgae, 20 species belonged to Bacillariophyceae, 8 to Chlorophyceae, 5 to Cyanophyceae, and 2 to Euglenophyceae. The pond's nutrient loading, primarily driven by the migratory bird population, classifies it as dystrophic. Pond physico-chemical properties, including elevated organic matter, CO₂ levels, and high pH, were responsible for supporting specific phytoplankton communities (Jena et al., 2013).

The dominance of Bacillariophyceae was attributed to the alkaline pH conditions. This finding aligns with studies by Shetty and Gulimane (2023). The presence of *Spirogyra sp.* further confirms the eutrophic nature of the experimental pond, consistent with observations by Adesalu and Nwankwo (2008). Additionally, the occurrence of *Lepocinlis sphagnophila* indicates high levels of organic pollution, while *Cosmarium contractum var. minutum* reflects neutral pH conditions, suggesting the existence of pure water environments within the pond.

Throughout the sampling periods, poor water quality was evident from both physical and chemical analyses, supported by the presence of pollution-indicating species such as *Spirogyra webri*. This species thrives in lentic environments, forming thick mats on the pond surface, which deplete oxygen levels and lead to anaerobic conditions. Cyanophycean species such as *Anabaena torulosa* were also observed, with their intercalary heterocysts facilitating nitrogen fixation.

The results highlight the importance of linking species occurrence and diversity indices to water quality parameters. The findings have broader implications for temporal and spatial wetland management and can inform the development of rangeland conservation guidelines for fragile freshwater ecosystems. The preference and tolerance of microalgae assemblages for specific habitats are largely dependent on the physicochemical characteristics of the aquatic environment, outcompeting other algal groups in such conditions.

The alkaline range detected during the study (Table 1) aligns with findings by Vijay Baskar et al. (2009), which suggest that alkaline conditions promote phytoplankton proliferation. The presence of *Chlamydomonas macrosphaera*, *Chlorella vulgaris*, and *Phormidium tenue* indicates polluted water conditions, while *Pithophora oedogonia* (a Chlorophyceae member) forms thick algal mats on stagnant water surfaces. Additionally, *Amphora coffeaeformis* is known to accumulate herbicides like mesotrione (Valiente Moro et al., 2012). The increased conductivity levels observed during the study were likely due to nutrient enrichment from migratory avian populations (Khanthong et al., 2023), consistent with observations at the PKD pond.

Table 2: Diatoms and microalgae sps. occurrence at the Vettangudi Bird Sanctuary Pond during the experimental period

S. No	Botanical name	Family	Nov 2013	Dec. 2013	Jan. 2014	Feb. 2014	Mar. 2014
1	<i>Achnanthes coarctata var elliptica</i>	Bacillariophyceae					
2	<i>Anabaena torulosa</i>	Cyanophyceae				√	
3	<i>Caloneis intermedia</i>	Bacillariophyceae					
4	<i>Chlamydomonas macrosphaera</i>	Chlorophyceae				√	
5	<i>Chlamydomonas pseudopolypyrenoidea</i>	Chlorophyceae			√		
6	<i>Chlorella vulgaris</i>	Chlorophyceae					
7	<i>Cosmarium contractum var minutum</i>	Chlorophyceae	√				
8	<i>Frustulia saxonica</i>	Bacillariophyceae				√	
9	<i>Lagerheimia quadriseta</i>	Oocystaceae					
10	<i>Lepocinclis sphagnophila</i>	Euglenophyceae			√	√	√
11	<i>Microspora loefgrenii</i>	Chlorophyceae				√	
12	<i>Navicula capitatoradiata</i>	Bacillariophyceae	√				√
13	<i>Navicula cuspidate var ambigua</i>	Bacillariophyceae					
14	<i>Navicula dissipata</i>	Bacillariophyceae				√	
15	<i>Navicula minuscule</i>	Bacillariophyceae	√				
16	<i>Navicula papula</i>	Bacillariophyceae	√			√	√
17	<i>Navicula subhyncocephala</i>	Bacillariophyceae				√	
18	<i>Nitzschia archibaldii</i>	Bacillariophyceae				√	
19	<i>Nitzschia cincta</i>	Bacillariophyceae					
20	<i>Nitzschia kutzinghiana</i>	Bacillariophyceae					
21	<i>Nitzschia palea</i>	Bacillariophyceae					
22	<i>Nitzschia sigma</i>	Bacillariophyceae	√	√	√		
23	<i>Nitzschia tryblionella var levidemis</i>	Bacillariophyceae					
24	<i>Oscillatoria limnotica</i>	Cyanophyceae	√				√
25	<i>Oscillatoria okeni</i>	Cyanophyceae		√	√	√	√
26	<i>Phacus parvulus</i>	Euglenophyceae	√				√
27	<i>Phormidium tenue</i>	Cyanophyceae			√		
28	<i>Pinnularia viridis</i>	Bacillariophyceae					
29	<i>Pithophora oedogonia</i>	Chlorophyceae	√	√	√	√	√
30	<i>Spirogyra webri</i>	Chlorophyceae	√	√	√	√	√
31	<i>Spirulina labyrinthiformis</i>	Cyanophyceae	√	√	√	√	
32	<i>Synedra ula</i>	Bacillariophyceae					

Conclusion

The study of diatom diversity and inventory reveals that the water quality of the PKD pond is deteriorating, as indicated by the analyzed physico-chemical parameters and the observed diatom assemblages. The heavy

pollution and resultant eutrophication at this site are primarily attributed to biotic interactions with migratory birds utilizing the pond ecosystem. However, some moderation of the pollution load was observed due to oxygen emission by diatoms, along with the contribution of Chlorophyceae microalgae, which play a foundational role in the aquatic food chain.

This study highlights the need for further analysis of diatom diversity indices and additional physico-chemical parameters. Such investigations would provide valuable insights to develop specific management guidelines aimed at maintaining water quality, a critical feature in rangeland ecosystems. The sensitivity of algae to changes in water quality makes them valuable bioindicators of the physical and chemical characteristics of aquatic environments. These indicators could also be applied to similar water bodies to aid in the restoration and conservation of dystrophic ecosystems, preserving their ecological integrity.

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