Research Notes

Anthropogenic pressure and freshwater ecosystem health: A comparative study of a common pond and a temple pond in Kerala

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Received: 12/06/2025; Revised: 24/06/2025; Accepted: 26/06/2025; Published: 01/07/2025

Abstract

This study presents a comparative analysis of the water quality and ecological status of a common eutrophic pond and a well-maintained temple pond in Kilimanoor, Kerala, India. A range of physicochemical and biological parameters were analysed to evaluate the extent of environmental stress and ecosystem health in each water body, following standard protocols. Results showed that the common pond was significantly degraded, with high turbidity and poor availability of dissolved oxygen (DO), accompanied by high biological oxygen demand (BOD) and chemical oxygen demand (COD). The pond's surface was heavily infested with *Salvinia* spp., and algal diversity was low, dominated by pollution-tolerant species like *Oscillatoria, Chlorella,* and *Nitzschia*. Primary productivity was minimal, and fish diversity was limited. In contrast, the temple pond exhibited healthier conditions: clean water, low salinity, relatively high DO, and reduced BOD and COD. Biological assessments revealed a diverse algal community, absence of invasive flora, and a stable fish population, including *Aplocheilus lineatus* and frequent sightings of predatory birds, suggesting a robust food web. The study concludes that anthropogenic activities and poor management practices severely impact water quality and biodiversity in small freshwater ecosystems. The findings underscore the urgent need for regular monitoring, pollution control, and community-based conservation efforts to restore and sustain aquatic habitats.

Keywords: Anthropogenic impact, aquatic biodiversity, aquatic pollution, community-based conservation, ecology, ecosystem, freshwater microflora, pond eutrophication.

Introduction

Freshwater ponds are indispensable ecological entities that serve as biodiversity hotspots and provide crucial ecosystem services such as groundwater recharge, nutrient cycling, flood regulation, and climate moderation.[1-3] These lentic water bodies also function as natural habitats for a range of aquatic organisms, including plankton, macroinvertebrates, fish, and amphibians, and form an integral part of the landscape mosaic in many tropical and subtropical regions. In Kerala, a state in southwestern India known for its rich hydrological and biological diversity, ponds hold additional socio-cultural significance. They are routinely used for domestic purposes, agricultural irrigation, and ritualistic functions, particularly if located in temple precincts.[4,5]

However, the ecological health of these freshwater systems is increasingly under threat due to rapid urbanization, unregulated domestic and agricultural waste discharge, sand mining, and land-use changes.[6,7] Small water bodies such as ponds, owing to their limited size, volume and low flushing capacity, are particularly vulnerable to eutrophication, a phenomenon characterized by excessive nutrient enrichment, particularly nitrogen and phosphorus, which leads to harmful algal blooms, oxygen depletion, and subsequent biodiversity loss.[8,9] Eutrophication has been widely documented in Kerala's inland water bodies, including the Vembanad and Ashtamudi lakes, and smaller ponds in rural and peri-urban settings.[10, 11]

Studies conducted in Kerala, by Kiran,[12] and Sabu *et al*.,[13] have highlighted the disparity in water quality between community ponds exposed to anthropogenic disturbances and temple ponds that are relatively protected. Temple ponds often have restricted access and are maintained for religious purity, which inadvertently aids in preserving better water quality and ecological integrity.[14] In contrast, common ponds frequently suffer from direct anthropogenic inputs like laundry waste, livestock bathing, and agricultural runoff, leading to increased organic load and microbial contamination.[15,16] A growing body of local research emphasizes the need for integrating traditional management systems with scientific monitoring to ensure the sustainability of small freshwater ecosystems. For instance, studies by Rajendran *et al.,*[17] and Harikrishnan *et al*.,[18] advocate for the participatory conservation of temple ponds in Kerala as potential models for decentralized water resource management. Given this background, a preliminary study was undertaken to assess and compare the physicochemical and biological characteristics of two freshwater ponds: a eutrophicated common pond subject to routine anthropogenic stress and a relatively undisturbed temple pond used primarily for ritualistic purposes.

Materials and Methods

The present study was conducted in two freshwater bodies located in Kilimanoor, Kerala: a common pond and a temple pond. The common pond, known as Chittilathu Pond, is situated at Koduvazhannor and spans an area of approximately 4.6 km². It is a eutrophic water body characterized by extensive *Salvinia* cover and frequent anthropogenic disturbances such as bathing and laundering. The pond is located adjacent to agricultural land and has an indirect hydrological connection to a nearby stream. The second study site is a temple pond situated within the Thiruviraloorkkavu Sree Vanadurga Devi Temple premises at Chemmaruthimukku. Covering an area of 6 km², this pond is regularly used for ritualistic purposes, including daily ablutions and special religious ceremonies such as "Arattu." Unlike the common pond, the temple pond is relatively clean and better maintained.

Water samples were collected from both ponds using clean, sterilized containers and transported to the laboratory for analysis of physicochemical factors and biological studies. Standard analytical protocols recommended by the American Public Health Association (APHA)[19] were followed for analyses of physical, chemical, and biological parameters.

Physical parameters primarily assessed at the site included colour and odour of water. Water temperature was measured *in situ* using a standard mercury thermometer and pH was recorded on-site using a digital pH meter. Turbidity was assessed using a Secchi disc. Electrical conductivity, an indicator of ionic concentration, was measured using a conductivity meter and expressed in µS/cm.

Chemical parameters examined included total hardness, total dissolved solids (TDS), total suspended solids (TSS), salinity, dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD). Total hardness was determined through complexometric titration using ethylenediaminetetraacetic acid (EDTA) and Eriochrome Black T as an indicator. TDS was estimated gravimetrically by evaporating a known volume of sample and estimating the amount of residue. TSS was measured by filtering a known volume of water through a pre-weighed filter paper, followed by drying and reweighing. Salinity was determined by argentometric titration using potassium chromate as an indicator and silver nitrate as the titrant. DO was estimated using the Winkler's iodometric method, while BOD was calculated as the difference in DO levels between the initial sample and that incubated for five days at 20°C. COD was determined by the dichromate reflux method, followed by titration with sodium thiosulphate.

Biological assessments included estimation of primary productivity, phytoplankton diversity and identification of aquatic flora, and ichthyofauna. Primary productivity was estimated using the light and dark bottle method. Net and gross productivity values were derived based on changes in DO. Unicellular algae were identified microscopically and confirmed with the help of taxonomic experts. Aquatic flora was categorized based on morphological traits observed in the field. Fish samples were collected using cast nets with minimal disturbance to the habitat, preserved in 15% formalin, and identified using standard taxonomic keys.

Observations and Results

The present study examined the physicochemical and biological characteristics of two freshwater ponds: Site I (a eutrophicated common pond) and Site II (a relatively pristine temple pond).

Physical Parameters

Colour and odour: Site I water appeared somewhat yellowish and emitted a distinct foul odour. In contrast, site II water was almost clear and lacked any characteristic odour.

Temperature: Water temperatures showed diurnal variation, reaching a minimum in the early morning and a maximum around noon. Site I recorded an average temperature of 27 °C (range: 25–30 °C), whereas site II averaged slightly higher at 28 °C (range: 26–31 °C).

pH: The average pH was 7.6 in site I and 8.2 in site II. Both ponds showed a diurnal increase in pH.

Turbidity: Secchi disc readings indicated higher turbidity in site I (30.5 cm), compared to 48.5 cm in site II, supporting the observation of greater suspended particulate matter in the eutrophicated pond.

Electrical Conductivity: Conductivity was higher in site I (84.9 µS/cm) than in site II (44.6 µS/cm).

Hardness: Total hardness levels were 25 mg/L in site I and 15 mg/L in site II.

Total Dissolved Solids (TDS) and Total Suspended Solids (TSS): TDS was found to be 1 mg/L in site I and 0.5 mg/L in site II. TSS values were 3 mg/L for Site I and 1.5 mg/L for Site II.

Salinity: Salinity in site I was markedly higher at 4.86 ppt compared to 1.02 ppt in site II.

Chemical Parameters

Dissolved Oxygen (DO): DO levels were critically low in site I at 2 mg/L. The oxygen level was relatively high in site II, measuring 12 mg/L.

Biological Oxygen Demand (BOD): BOD level was higher in site I (5 mg/L). Site II recorded a lower BOD of 1 mg/L.

Chemical Oxygen Demand (COD): Site I showed elevated COD values (7.7 mg/L); site II recorded a COD value of 4 mg/L.

Biological Parameters

Primary Productivity: Gross primary productivity (GPP) in site I was 0.2 mg/L and in site II this was 1.8 mg/L. Net primary productivity (NPP) was negative in both ponds, the values recorded being -0.375 mg/L and -0.188 mg/L in site I and site II respectively.

Aquatic Biota

Macroflora: The water surface at site I was completely covered with *Salvinia* spp., whereas site II lacked such vegetation, and its water surface appeared clear.

Macrofauna: Site I supported a sparse macrofaunal community, characterized by a limited presence of *Aplocheilus lineatus* (locally known as 'Manathukanni') and a few individuals of *Pethia stoliczkana*. Occasional reptiles such as water snakes and pond crows

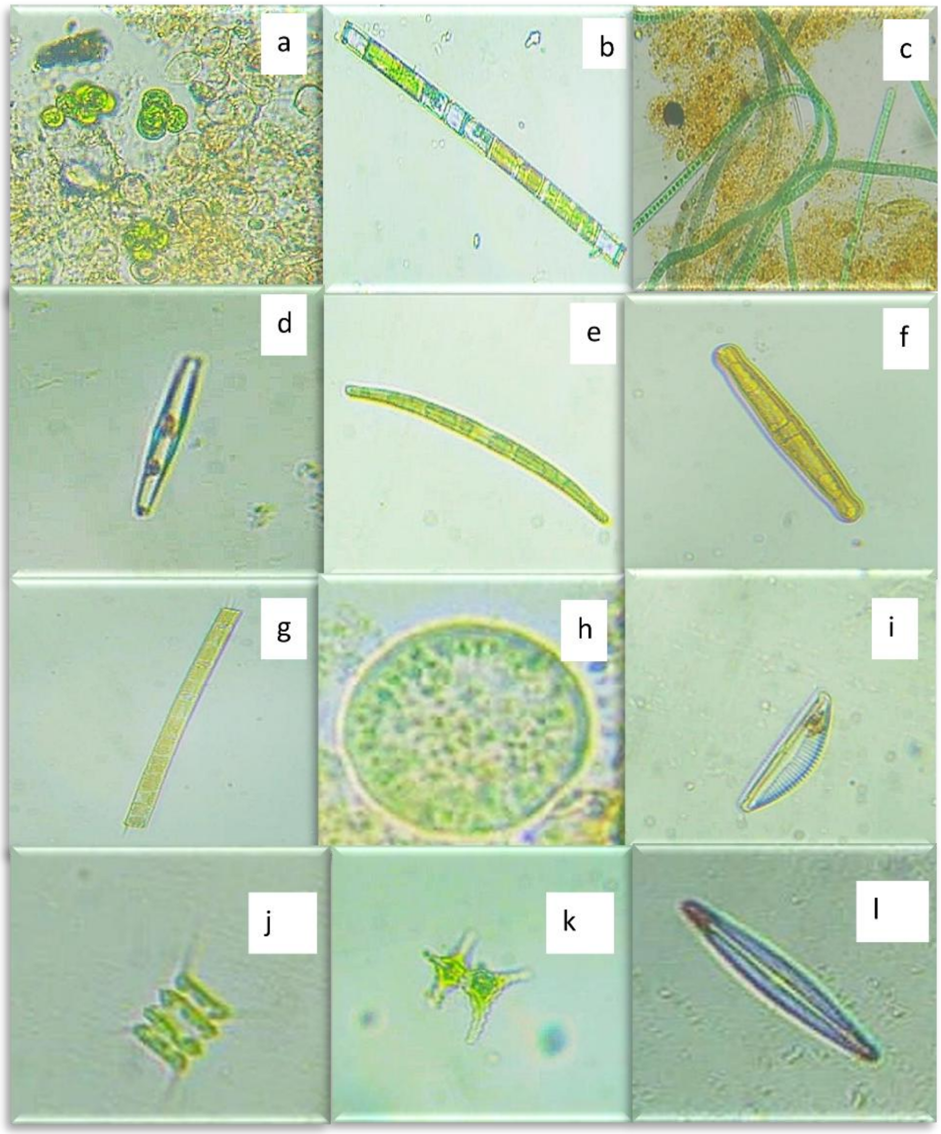

Figure 1: Unicellular algae identified from the study sites. a: *Chlorella,* b: *Spirogyra,* c: *Oscillatoria,* d: *Nitzschia,* e: *Ankistrodesmus,* f: *Navicula,* g: *Zygnema,* h: *Volvox* i: *Amphora,* j: *Scenedesmus,* k: *Staurastrum,* and l: *Frustulia*

were also observed. Site II, however, exhibited a robust population of *Aplocheilus lineatus*. The pond was regularly visited by birds like grey heron, (likely *Ardea cinerea*).

Unicellular Algae: Microscopic analysis revealed observable differences in algal diversity and abundance between the two ponds. Site I had a high density but low diversity of algae, dominated by *Chlorella*, *Spirogyra* and *Oscillatoria* (Figures 1a-c), and diatoms like *Nitzschia*, *Ankistrodesmus* and *Navicula* (Figures 1d-f). Diatom colonies were frequently observed. Alge identified in site II included *Chlorella, Spirogyra, Oscillatoria* and *Navicula* (Figures 1a-c & 1f). It showed higher algal diversity; however thick colonies of algae were absent. Additional taxa identified in site II included *Zygnema*, *Volvox*, *Amphora*, *Scenedesmus*, *Staurastrum*, *Frustulia* (Figures 1g-l), and diatom frustules.

Discussion

The comparative analysis of the common pond (site I) and the temple pond (site II) reveals substantial differences in physicochemical and biological characteristics. The eutrophic state of site I aligns with classic symptoms of nutrient enrichment and ecological degradation reported in similar freshwater ecosystems subjected to uncontrolled human activities. [8,9] The physicochemical parameters of site I showed signs of environmental stress. Elevated electrical conductivity, TDS, and salinity indicate higher ionic content, which may result from domestic activities and agricultural runoff, as similarly observed.[20] The high BOD and low DO in site I reflect reduced self-purification by natural means and higher organic load, typical of eutrophicated waters contributing to oxygen depletion and limiting aerobic biodiversity.[3] In contrast, site II maintained more favourable water quality parameters, suggesting the existence of either natural mechanisms or effective ritual-based management practices that limit pollution influx, a pattern also observed in temple ponds across southern India.[21]

Turbidity and Secchi disc depth values further underscore the reduced transparency in site I, attributed to elevated levels of suspended solids and phytoplankton density. Similar turbidity patterns have been associated with eutrophication and algal blooms in shallow, nutrient-rich waters.[22] In contrast, the lower turbidity and greater transparency observed in site II indicate reduced concentrations of organic and inorganic particulates, potentially enhancing light penetration and supporting photosynthetic activity.

The biological assessments underscore the ecological divergence between the two ponds. The lower gross primary productivity (GPP) in site I suggests that even with high nutrient levels, photosynthesis is impaired, possibly due to light limitation caused by dense *Salvinia* cover—an invasive aquatic plant known to block sunlight and reduce oxygen levels.[23] Negative net primary productivity (NPP) in both ponds, though more severe in site I, indicates high respiration or decomposition rates, a common feature in stagnant, organic-rich waters.[24]

The composition of aquatic flora and fauna also reflects ecosystem health. Dominance of *Salvinia* in site I, a common indicator of eutrophic conditions,[25] contrasts with the open water surface of site II. The sparse ichthyofauna in site I, limited to pollution-tolerant species such as *Aplocheilus lineatus*, is supported by findings from other studies indicating that eutrophicated ponds often exhibit reduced fish diversity.[26] In contrast, the richer biotic community observed in site II, including avian predators like *Ardea cinerea*, signifies a more balanced trophic structure. Algal diversity was visibly higher in site II. The dominance of a few genera in site I, particularly *Chlorella* and *Oscillatoria*, is a typical feature of eutrophic environments, where select species bloom under favourable nutrient conditions.[27] The wider taxonomic range in site II, including *Volvox*, *Scenedesmus* and *Staurastrum*, suggests more stable ecological conditions and lower pollution levels.[28]

The present findings corroborate several of the earlier findings on the critical impact of land-use patterns, hydrological isolation, and cultural practices associated with freshwater ecosystems.[29,30] The temple pond benefits from ritualistic importance and restricted access, likely contributing to its healthier status. Conversely, the common pond is subject to direct anthropogenic disturbances, which may lead to ecological degradation.

Conclusion

This study revealed clear differences in water quality and biodiversity between a eutrophic common pond and a well-maintained temple pond. The common pond showed signs of organic pollution, low dissolved oxygen, high turbidity, and reduced biodiversity,of degraded aquatic systems. In contrast, the temple pond exhibited better water quality, higher primary productivity, and richer aquatic life, reflecting minimal anthropogenic disturbance. These findings underscore the importance of proper management, pollution control, and cultural practices in maintaining freshwater ecosystems. Restoration and community-based conservation are essential to protect such water bodies for ecological and societal benefits.

Acknowledgement
We would like to extend our sincere gratitude to Dr. V. Viji, former Professor of Botany, Government College for Women, Thiruvananthapuram, for her assistance in the identification of algal species.

Financial support and sponsorship
Nil.

Conflicts of interest
The authors declare no competing interests.

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How to cite this article: Bismaya BL, Syamala VS. Anthropogenic pressure and freshwater ecosystem health: A comparative study of a common pond and a temple pond in Kerala. Journal of Experimental Biology and Zoological Studies 2025; 1(2):122-28.