The Biobrio ISSN : 2393-9508 e-ISSN: 2582-4902
An International Quarterly Journal of Life Sciences
Website: www.thebiobrio.in SJIF: 8.525
13(1&2): 1867-1872, 2026

Seasonal variation in physico-chemical characteristics and water quality assessment of selected freshwater ponds of Samastipur, Bihar

Rahul Kumar*
University Department of Zoology, B.R.A.Bihar University, Muzaffarpur, Bihar, India

Received : 26th May, 2026 ; Accepted : 26th June, 2026
DOI:- https://doi.org/10.5281/zenodo.21772317

ABSTRACT

The present investigation was carried out to evaluate the seasonal variation in physicochemical characteristics and water quality status of two freshwater ponds located in and around Samastipur district of Bihar, India. Monthly water samples were collected from July 2021 to June 2023 from Pusa Pond and Khairi Pond. Important limnological parameters such as water temperature, transparency, pH, dissolved oxygen, free carbon dioxide, alkalinity, hardness, chloride, sulphate, phosphate, nitrate, BOD, and COD were analysed following standard methods. The study revealed marked seasonal fluctuations in water quality parameters between the two ponds. Pusa Pond exhibited comparatively better water quality with higher dissolved oxygen and transparency, while Khairi Pond showed elevated nutrient concentration, BOD, and COD due to anthropogenic activities and domestic waste discharge. Monsoon season caused dilution of several parameters whereas summer season showed increased concentration of nutrients and alkalinity. The study indicates that increasing anthropogenic pressure is deteriorating pond ecosystems and continuous monitoring is necessary for conservation and sustainable management of freshwater resources.

Key Words - Limnology, Physico-chemical parameters, Pond ecosystem, Water quality, Samastipur, Bihar

***Corresponding author :** rk009699@gmail.com

INTRODUCTION

Freshwater ecosystems are crucial natural reservoirs that maintain local climate stability, support rich biodiversity, facilitate aquaculture, and provide indispensable resources for human livelihoods. Ponds, as essential lentic ecosystems, play a vital role in maintaining regional ecological balance, aiding groundwater recharge, and sustaining aquatic biological productivity.

However, in recent decades, rapid urbanization, untreated domestic sewage discharge, agricultural runoff laden with chemical fertilizers, and unmanaged anthropogenic disturbances have led to severe degradation of these fragile water bodies. Small lentic systems are particularly vulnerable to chemical alterations due to their limited volume and static nature (Mukherjee *et al.,* 2022). Similar spatial and environmental degradation patterns driven by urban runoff and domestic waste discharge have been observed in surrounding regional aquatic networks across Bihar (Kumar & Prasad Singh, 2023; Priyadarshee *et al.,* 2024).

The physico-chemical parameters of water serve as key indicators for evaluating the trophic status, health, biological productivity, and overall pollution

levels of an aquatic ecosystem. Critical factors such as water temperature, pH, dissolved oxygen (DO), total alkalinity, hardness, light penetration (transparency), and nutrient dynamics directly dictate the survival, distribution, and physiology of aquatic flora and fauna.

This study presents a two-year systematic investigation (July 2021 - June 2023) assessing the seasonal fluctuations of water quality parameters across two distinct freshwater ponds in Samastipur district, Bihar. By comparing a moderately managed aquatic ecosystem with a stress-loaded urban-adjacent pond subjected to domestic sewage, this research underscores the impact of human activity on local aquatic ecosystems and highlights the necessity for scientific conservation practices.

MATERIALS & METHODS

Study Area

The study was conducted in Samastipur district, situated in the fertile alluvial plains of North Bihar, India. Two perennial freshwater ponds representing different environmental conditions were selected for sampling:

Pusa Pond: Pusa Pond is situated within the campus of Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, in Samastipur district, Bihar, India. Geographically, the pond is located at 25.9780° N latitude and 85.6488° E longitude, with an average elevation of approximately 58 m above mean sea level (MSL). It is one of the important perennial freshwater ponds of the university campus and serves as a valuable resource for fisheries, research, and academic activities.

The pond is moderately large and shallow, with its water level being maintained throughout the year by the Department of Fisheries through a pumping system, supplemented by seasonal rainfall. During the monsoon season, the maximum water depth reaches approximately 3.0 m, whereas the water level declines slightly during the summer months due to evaporation. This artificial regulation of water level ensures the perennial nature of the pond and supports a stable aquatic environment suitable for fish culture and limnological investigations.

The pond has a predominantly sandy bottom with patches of submerged and emergent aquatic vegetation distributed along its margins. These macrophytes provide habitat and breeding grounds for a variety of aquatic organisms, thereby contributing to the ecological productivity of the ecosystem. The surrounding area is characterized by agricultural fields, university buildings, and green vegetation, with minimal industrial or urban influence.

Compared with other freshwater bodies in the region, Pusa Pond experiences relatively low anthropogenic pressure. The water remains largely free from significant pollution, although occasional activities such as bathing and washing by local residents are observed. A small drain located on the south-western side of the pond discharges a limited quantity of domestic wastewater, causing slight localized pollution near the inlet. However, owing to the relatively small volume of wastewater and the pond's natural assimilative capacity, the overall water quality remains comparatively good. Consequently, Pusa Pond represents a moderately managed freshwater ecosystem with relatively stable physicochemical characteristics, making it an ideal reference site for comparative limnological and water quality studies.

Khairi Pond: Khairi Pond geographically lies at 25°0.76667' N latitude and 85°7.9222' E longitude, with an elevation of approximately 58 m above mean sea level (MSL). The pond is situated in the Khairi locality, an area characterized by inadequate sanitation and poor waste management practices. As a result, the water body is subjected to continuous inputs of both liquid and solid domestic wastes, making it vulnerable to anthropogenic pollution.

The pond is a large, shallow, perennial freshwater ecosystem with a surface area of approximately 2.4 acres and an average depth of 2.5 m. The pond bed consists predominantly of sandy-clay sediments, which influence nutrient retention and sediment-water interactions. Groundwater serves as the principal source of water, ensuring the perennial nature of the pond despite seasonal fluctuations in rainfall.

Khairi Pond experiences considerable environmental stress due to the year-round discharge of untreated domestic wastewater, household refuse, and human excreta from the surrounding residential areas. These continuous pollutant inputs have significantly affected the physicochemical characteristics of the water and increased the organic and nutrient load, thereby accelerating the process of eutrophication. Such conditions adversely influence water quality, dissolved oxygen dynamics, and the overall ecological health of the pond ecosystem.

In addition to receiving domestic waste, the pond is extensively utilized for various human and livestock activities. Local residents use the pond for bathing and washing clothes, while cattle frequently enter the water for wallowing. These activities contribute additional organic matter, suspended solids, and microbial contaminants, further degrading water quality. The combined effects of domestic sewage, livestock activities, and intensive human use make Khairi Pond an ideal site for assessing the impacts of anthropogenic disturbances on freshwater ecosystems.

Despite these environmental challenges, the pond supports aquaculture and is managed by private fish farmers who obtain lease rights from the Department of Fisheries, Government of Bihar. Fish culture constitutes an important economic activity for the local community; however, the long-term sustainability of aquaculture depends on effective water quality management and the implementation of appropriate conservation measures. Continuous monitoring of limnological parameters and the adoption of scientific management practices are therefore essential to restore and maintain the ecological integrity and productivity of this freshwater pond.

Sampling Procedure

Monthly water sampling was systematically conducted over a 24-month period spanning from July 2021 to June 2023. To analyze seasonal patterns, the data were categorized into three distinct seasons (Mukherjee *et al.,* 2022):

- Pre-Monsoon / Summer (March to June)
- Monsoon (July to October)
- Post-Monsoon / Winter (November to February)

Water samples were collected early in the morning (between 07:00 AM and 09:00 AM) using clean, pre-sterilized 2-liter polyethylene bottles. Parameters sensitive to immediate atmospheric exposure (such as temperature, pH, and dissolved oxygen) were recorded in situ at the time of collection.

Analytical Methods

Water quality parameters were analyzed in accordance with standardized protocols established by APHA (1985) and Golterman *et al.* (1978):

- Temperature: Measured on-site using a standard mercury-in-glass thermometer (0°C to 100°C).
- Transparency: Evaluated using a standard 20 cm diameter Secchi disc.
- pH: Determined on-site using a calibrated digital pH meter.
- Dissolved Oxygen (DO): Estimated via Winkler's iodometric method with azide modification.
- Free Carbon Dioxide & Alkalinity: Measured by titration against standard sodium hydroxide (NaOH) and hydrochloric acid (HCl) solutions, respectively.
- Total Hardness: Analyzed using the EDTA complexometric titration method.
- Chloride (Cl^-): Estimated by Argentometric titration against standard silver nitrate ($AgNO_3$) solution.
- Sulphate (SO_4^{2-}), Nitrate (NO^-_3), and Phosphate (PO_4^{3-}): Quantified using spectrophotometric methods.
- Biochemical Oxygen Demand (BOD): Measured after 5 days of incubation at 20°C.
- Chemical Oxygen Demand (COD): Evaluated via the closed dichromate reflux digestion method.

Statistical Analysis

Seasonal mean values and standard deviations were computed for both ponds across the two-year study period. Comparative evaluation was performed to identify seasonal trends and statistically significant differences between the two aquatic environments.

RESULTS & DISCUSSION

The physico-chemical profile showed clear seasonal variation across both study sites, as summarized in Table 1.

Table 1: Comparative Physico-Chemical Characteristics (Seasonal Trends)

Parameter	Pusa Pond (Managed)	Khairi Pond (Polluted)	Primary Drivers / Cause
Water Temp. (^oC)	Peak in Summer, Lowest in Winter	Peak in Summer, Lowest in Winter	Solar radiation, atmospheric changes
Transparency (cm)	High (Monsoon dilution/Low solids)	Low (High suspended solids & algae)	Organic load, domestic sewage, turbidity
pH	Slightly Alkaline (7.2-8.1)	Strongly Alkaline (7.8-8.8)	Microbial decomposition, carbonate equilibrium
Dissolved Oxygen (mg/L)	High (6.2-8.5mg/L)	Depleted (2.1-4.8mg/L)	Organic decomposition, thermal variation
Free CO_2 (mg/L)	Low to Moderate	High	Active bacterial respiration, degradation
Nutrients (NO_3^-, PO_4^{3-})	Controlled	Very High	Agricultural runoff, domestic detergents
BOD & COD (mg/L)	Within Permissible Limits	Severely Elevated	Organic pollution, untreated sewage

Water Temperature and Transparency

Water temperature closely paralleled ambient air temperatures, showing maximum values during the summer months (31.5°C-4.2°C) and minimum values in winter (14.1°C-16.8°C). Similar thermal patterns are widely reported in lentic systems across North Bihar (Kumar & Prasad Singh, 2023). High summer temperatures accelerate biological activity, increase metabolic oxygen demand, and speed up the breakdown of organic matter.

Transparency was consistently higher at Pusa Pond throughout the investigation, supported by lower suspended particulate matter and reduced anthropogenic interference. Conversely, Khairi Pond exhibited low transparency, particularly in summer, driven by continuous sewage discharge, suspended organic particles, cattle activity, and dense algal blooms (Patra *et al.,* 1970).

pH, Dissolved Oxygen (DO), and Carbon Dioxide Dynamics

Both aquatic bodies displayed alkaline conditions (pH>7.0) across all seasons. However, Khairi Pond consistently recorded higher pH levels (up to 8.8), driven by excessive organic decomposition, carbonate-bicarbonate equilibrium shifts, and alkaline detergent inputs from household washing activities.

Dissolved Oxygen (DO) levels showed significant differences between the two ponds:

- Pusa Pond maintained healthy DO levels (6.2-8.5 mg/L), favoring aquatic organism survival.
- Khairi Pond experienced notable oxygen depletion, dropping to 2.1mg/L during summer.

This severe oxygen depletion during peak thermal periods aligns with observations from other eutrophicated ponds in North India (Kumar & Prasad Singh, 2023; Mukherjee *et al.,* 2022). Reduced DO in Khairi Pond is linked to high organic loading, which drives intense microbial respiration and decomposition. Free carbon dioxide levels correlated inversely with DO; Khairi Pond recorded elevated CO_2 concentrations due to rapid organic degradation.

Hydro-Chemical Profile: Alkalinity, Hardness, Chlorides, and Sulphates

Total alkalinity and hardness levels peaked during the summer months due to water evaporation and the resulting concentration of dissolved ions. Monsoon rains introduced a clear dilution effect,

temporarily lowering ion concentrations (Mukherjee *et al.,* 2022).

Chlorides and sulphates were noticeably higher in Khairi Pond compared to Pusa Pond. Elevated chloride levels in Khairi Pond highlight the impact of domestic sewage, animal waste, and organic runoff.

Nutrient Dynamics and Organic Load (BOD & COD)

Nutrient levels (nitrates and phosphates) were considerably higher in Khairi Pond. The influx of domestic wastewater containing detergents, alongside agricultural runoff, contributed to high phosphate (PO_4^{3-}) and nitrate (NO_3^-) concentrations, creating conditions favorable for rapid eutrophication (Patra *et al.,* 1970).

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) serve as key indicators of organic pollution:

- **Pusa Pond:** Displayed lower BOD (1.8-3.4 mg/L) and COD (12.0-24.5mg/L) levels, reflecting a stable and functional aquatic ecosystem.
- **Khairi Pond:** Exhibited elevated BOD (8.5-18.2mg/L) and COD (45.0-92.0mg/L) levels. These high values demonstrate heavy organic pollution caused by ongoing discharge of untreated domestic waste.

CONCLUSION

The present two-year investigation demonstrated distinct seasonal variations in the physico-chemical characteristics of Pusa Pond and Khairi Pond in Samastipur, Bihar. Comparative analysis revealed that Pusa Pond maintained relatively stable water quality, characterized by higher transparency and dissolved oxygen along with lower nutrient concentrations and organic load. In contrast, Khairi Pond exhibited elevated levels of nutrients, BOD, and COD, reduced dissolved oxygen, and greater seasonal fluctuations, reflecting the influence of untreated domestic wastewater, agricultural runoff, and other anthropogenic activities.

The observed seasonal patterns showed that summer conditions intensified the concentration of dissolved ions and organic pollutants, whereas monsoon rainfall produced a dilution effect on several water quality parameters. These findings highlight the close relationship between seasonal hydrological changes and human-induced disturbances in determining the ecological status of freshwater pond ecosystems. The study demonstrates that anthropogenic pressures significantly influence the limnological characteristics and ecological health of freshwater ponds. The comparative assessment provides valuable baseline information on seasonal water quality dynamics in the freshwater ecosystems of Samastipur and contributes to a better understanding of the factors affecting pond health, which may support future ecological assessments and sustainable freshwater resource management.

REFERENCES

APHA. 1985. *Standard Methods for the Examination of Water and Wastewater.* 16th ed. American Public Health Association, Washington, DC.

Golterman, H. L., Clymo, R. S., & Ohnstad, M. A. M. 1978. *Methods for Physical and Chemical Analysis of Freshwater.* IBP Handbook No. 8. Blackwell Scientific Publications, Oxford.

Kumar, D., & Prasad Singh, B. B. 2023. Water Quality Parameters and Ecological Status of Eutrophicated Taj Baj Pond, Hajipur (Vaishali). *Research Journal of Science and Technology,* 15(2): 88–94. https://doi.org/10.52711/2349-2988.2023.00015

Mukherjee, P., Kumar, P., Gupta, S. K., & Kumar, R. 2022. Seasonal variation in physicochemical parameters and suitability for various uses of Bouli Pond water, Jharkhand. *Water Science,* 36(1): 125–135. https://doi.org/10.1080/23570008.2022.2127552

Patra, A., Santra, K. B., & Manna, C. K. 2010. Limnological studies related to physico-chemical characteristics of water of Santragachi and Joypur Jheel, West Bengal, India. *Our Nature,* 8(1): 185–203. https://doi.org/10.3126/on.v8i1.4328

Priyadarshee, A., Rahul, A. K., Kumar, V., Kumar, A., & Kumar, N. 2024. Spatial variation in water quality of the Burhi Gandak River: A multi-location assessment. *Frontiers in Environmental Science,* 12: Article 1487469. https://doi.org/10.3389/fenvs.2024. 1487469

Saha, L. C., & Pandit, A. K. 1986. Ecological studies on freshwater ecosystems of Eastern India. *Environmental Ecology,* 4(1): 112–118.

Sharma, R., Trivedi, R. K., & Goel, P. K. 2000. Studies on limnological characteristics and water quality of freshwater ponds. *Journal of Environmental Biology,* 21(3): 221–227.

Wetzel, R. G. 2001. *Limnology: Lake and River Ecosystems.* 3rd ed. Academic Press, San Diego.

***