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Seasonal Dynamics of Physicochemical Parameters in Puraini Pokhar, Bihar: Implications for Freshwater Quality and Ecosystem Health

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ABSTRACT

Puraini Pokhar, a perennial freshwater pond in Madhepura, Bihar, India, holds ecological, economic, and cultural significance for the surrounding communities. This study was conducted to assess the physicochemical properties of the pond water across three seasons-pre-monsoon, monsoon, and post-monsoon-to evaluate its ecological status and suitability for human and aquatic life. Parameters analyzed included temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, total dissolved solids (TDS), electrical conductivity (EC), nitrate, and phosphate concentrations. Results revealed seasonal fluctuations, with some parameters exceeding BIS permissible limits, particularly during the pre-monsoon period. These variations are attributed to anthropogenic activities such as agricultural runoff, domestic discharge, and solid waste dumping. The findings underscore the urgent need for regular monitoring and implementation of sustainable pond management practices.

Key Words - Physicochemical parameters, Puraini Pokhar, Anthropogenic impact, Environmental monitoring, Sustainable pond management, Agricultural runoff, Ecological degradation

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INTRODUCTION

Freshwater ecosystems such as ponds are essential to sustaining both the hydrological cycle and ecological balance. Despite their relatively small size, these water bodies function as vital reservoirs that nurture diverse aquatic life, offering critical habitats for breeding and feeding. Their role in enhancing regional biodiversity is well recognized. In addition to their ecological significance, ponds contribute to crucial hydrological processes-including groundwater replenishment, flood mitigation, and the stabilization of local climate conditions. Especially in rural and semi-urban landscapes, they serve as indispensable resources, supplying water for household activities, crop irrigation, livestock, and small-scale fish farming, thereby directly supporting the livelihoods of nearby communities.

Puraini Pokhar, situated in Madhepura, Bihar, is a perennial pond that exemplifies this multifunctional utility. It has traditionally fulfilled the water needs of surrounding villages while supporting agriculture and aquaculture throughout the year. However, increasing human activities have begun to upset this fragile ecosystem. The combined impacts of urban sprawl and intensified agricultural practices have significantly compromised the pond's water quality. Nutrient-rich runoff from adjacent agricultural lands, often laden with chemical

fertilizers and pesticides, along with untreated domestic sewage and indiscriminate waste dumping, has introduced excessive pollutants into the pond. These contaminants pose a serious threat to aquatic ecosystems and simultaneously diminish the water's usability for essential purposes like bathing, irrigation, and drinking.

In light of these emerging threats, it is imperative to conduct a detailed evaluation of the pond's seasonal physicochemical variations. Key parameters—such as pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, total dissolved solids (TDS), and nutrient concentrations like nitrates and phosphates—serve as indicators of water quality and ecological status. Monitoring these variables seasonally is particularly crucial in regions like Bihar, where monsoonal fluctuations in rainfall, runoff, and water retention can drastically influence water chemistry.

The present study focuses on a thorough assessment of Puraini Pokhar's water quality across three distinct seasons: pre-monsoon, monsoon, and post-monsoon. By comparing the observed values with the Bureau of Indian Standards (BIS) water quality guidelines, the study aims to determine the pond's current condition and its suitability for various uses. The outcomes of this research are intended to inform sustainable management practices, guide pollution control measures, and support the long-term preservation of this ecologically important and socially beneficial freshwater resource.

MATERIALS & METHODS

Location:

Puraini Pokhar is situated at 28.0607° N latitude and 81.6538° E longitude in the state of Bihar, India. It is a perennial freshwater pond of ecological and socio-economic significance to the surrounding communities. The pond lies within a subtropical climatic zone characterized by hot summers, a pronounced monsoon season, and mild winters.

Geographical Features:

The pond covers an approximate surface area of 1.25 hectares, though this varies seasonally depending on rainfall and evaporation rates. The catchment area consists primarily of agricultural fields, interspersed with semi-urban settlements and fallow lands.

Hydrological Characteristics:

Puraini Pokhar receives inflow primarily from seasonal rainwater runoff during the monsoon season, along with minor contributions from adjacent irrigation channels and household wastewater. There is no formal outlet system; water exits the pond mainly through percolation and evaporation. Its perennial nature ensures year-round availability of water, making it a reliable source for local water-dependent activities.

Surrounding Land Use:

The land use pattern in the surrounding area is dominated by intensive agriculture, including the cultivation of paddy, wheat, maize, and vegetables. Chemical fertilizers and pesticides are commonly used, increasing the risk of non-point source pollution entering the pond through runoff. Additionally, human settlements along the pond's periphery contribute to domestic wastewater discharge and occasional solid waste dumping, further impacting water quality. Small-scale fishing, livestock watering, and irrigation withdrawals are common practices observed around the pond.

Ecological Significance:

Despite the anthropogenic pressures, Puraini Pokhar still harbors various aquatic macrophytes, phytoplankton, and fish species, playing an essential role in supporting local biodiversity. Its ecological productivity also supports migratory birds during certain seasons, underlining its role as a minor wetland ecosystem in the regional context.

Sampling frequency:

The sampling for this study was carried out on a monthly basis, with particular attention given to the seasonal variations observed throughout the year—pre-monsoon, monsoon, and post-monsoon periods. The purpose of this approach was to capture the temporal changes in water quality that may arise due to varying climatic conditions,

anthropogenic activities, and seasonal water input. Monthly sampling enables a thorough understanding of the fluctuations in key physicochemical parameters, while seasonal sampling ensures that specific changes associated with the monsoon—such as nutrient influx from agricultural runoff—are adequately captured.

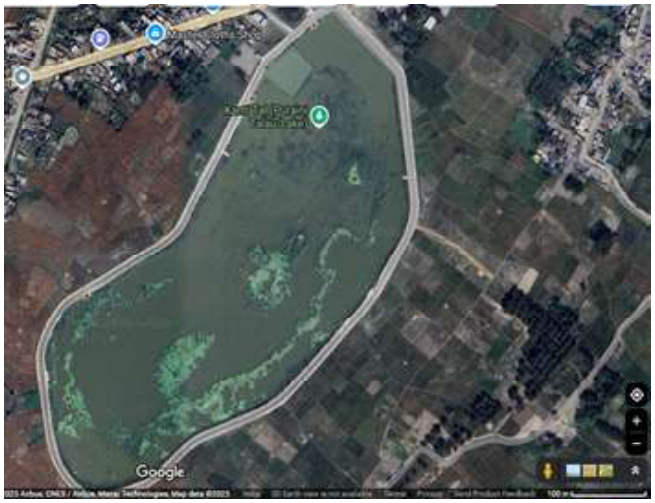

Fig. 1- Map of Puraini Pokhar, Madhepura, Bihar (source- googlemap)

Sampling Methods:

For consistency and to minimize contamination, standard grab sampling methods were employed throughout the study. Water samples were collected using sterilized glass or plastic bottles that were thoroughly cleaned and sterilized prior to use. This ensured that the samples remained free of any external contaminants that could interfere with the analysis of physicochemical properties.

Sample Collection Process:

- Water samples were drawn at a depth of approximately 0.5 to 1 meter from the surface to ensure the inclusion of the most representative water column, as the upper layers of the pond are typically more influenced by atmospheric and biological activity.
- Samples were collected early in the day to minimize the potential effects of diurnal fluctuations in temperature and oxygen levels.
- Each sampling site was visited in a systematic rotation to ensure that both spatial and temporal variability was captured effectively.

Handling and Transport:

- After collection, the samples were stored in coolers with ice packs to maintain their integrity during transport to the laboratory.
- Depending on the parameter being tested, certain samples were analyzed immediately upon arrival, while others were preserved as needed, following standard preservation protocols.

Parameters Analyzed

RESULTS & DISCUSSION

Seasonal Variation in Water Quality

Sl.N.	Parameter	Method Used	Instrument
1	Temperature	Direct reading	Mercury Thermometer
2	pH	Potentiometric	Digital pH meter
3	DO	Winkler's method	-
4	BOD	5-day incubation	BOD Incubator
5	COD	Closed reflux	COD Digester
6	Turbidity	Nephelometric	Nephelometer
7	TDS	Gravimetric	TDS meter
8	EC	Conductivity	Conductivity meter
9	Nitrate	Spectrophotometer	UV-Vis Spectophotometer
10	Phosphate	Spectrophotometer	UV-Vis Spectophotometer

The physicochemical analysis of Puraini Pokhar revealed marked seasonal variations across pre-monsoon, monsoon, and post-monsoon periods, reflecting the influence of climatic conditions and anthropogenic pressures. The results are compared with the Bureau of Indian Standards (BIS) permissible limits to evaluate water quality and ecological implications.

Temperature

Water temperature exhibited typical seasonal trends, peaking during the pre-monsoon season (31.2°C) and gradually declining through monsoon (28.5°C) to post-monsoon (25.6°C). Elevated temperatures in the pre-monsoon period can be

Table 1. Showing collected data of Puraini Pokhar, Madhepura, Bihar

Sl.N.	Parameter	Unit	Pre-monsoon	Monsoon	Post-monsoon	BIS Standard Limit
1	Temperature	°C	31.2	28.5	25.6	-
2	pH	-	7.8	7.3	7.6	6.5 – 8.5
3	Dissolved Oxygen (DO)	mg/L	4.2	5.1	6	≥ 5.0
4	Biochemical Oxygen Demand (BOD)	mg/L	6.5	4.8	3.2	≤ 3.0
5	Chemical Oxygen Demand (COD)	mg/L	20.2	16.7	12.5	≤ 10
6	Turbidity	NTU	11.5	23.2	8.6	≤ 5
7	Total Dissolved Solids (TDS)	mg/L	560	490	510	≤ 500
8	Electrical Conductivity (EC)	-	890	770	820	-
9	Nitrate (NO_3^-)	µS/cm	9.2	12.3	7.8	≤ 10
10	Phosphate (PO_4^{3-})	mg/L	0.94	1.28	0.72	≤ 0.1

attributed to intense solar radiation and lower water levels, which enhance heat retention. Temperature influences biological activity, especially the solubility of gases like oxygen and the metabolic rates of aquatic organisms.

pH

The pH values ranged from 7.3 (monsoon) to 7.8 (pre-monsoon), remaining within the BIS permissible range of 6.5 – 8.5. Slight alkalinity during the pre-monsoon may be linked to reduced dilution effects and higher photosynthetic activity, which consumes carbon dioxide and increases pH. The dip during monsoon indicates the influence of acidic runoff and increased organic input from catchment areas.

Dissolved Oxygen (DO)

DO levels showed an increasing trend from pre-monsoon (4.2 mg/L) to post-monsoon (6.0 mg/L). The pre-monsoon values were below the BIS threshold (≥5.0 mg/L), indicating potential stress for aquatic life. Lower DO during this period could be due to elevated temperatures and heightened decomposition of organic matter. Post-monsoon improvement is attributed to reduced biological oxygen demand and enhanced aeration due to rainfall and surface agitation.

Biochemical Oxygen Demand (BOD)

BOD values were highest during the pre-monsoon (6.5 mg/L) and declined significantly post-monsoon (3.2 mg/L). All seasonal values, however, exceeded the BIS limit (≤3.0 mg/L), especially in the pre-monsoon season, signaling substantial organic pollution. This is likely due to accumulation of untreated domestic sewage and organic debris under reduced water volumes.

Chemical Oxygen Demand (COD)

Similar to BOD, COD levels exceeded the BIS standard (≤10 mg/L) across all seasons, with the highest value in pre-monsoon (20.2 mg/L). COD indicates the presence of chemically oxidizable organic and inorganic matter, reflecting a consistent pollutant load possibly due to detergent residues, agricultural runoff, and solid waste leachate.

Turbidity

Turbidity spiked during the monsoon season (23.2 NTU), significantly exceeding the BIS permissible limit (≤5 NTU). This can be attributed to the inflow of silt, suspended solids, and decomposing plant material. In contrast, lower turbidity in the post-monsoon (8.6 NTU) and pre-monsoon (11.5 NTU) reflects clearer conditions, though still above permissible levels.

Total Dissolved Solids (TDS)

TDS levels were highest in the pre-monsoon (560 mg/L), slightly decreasing during monsoon (490 mg/L) and post-monsoon (510 mg/L). While monsoon rains dilute the solute concentration, pre-monsoon values exceeded the BIS limit (≤500 mg/L), pointing toward increased evaporation, reduced dilution, and solute concentration due to anthropogenic inputs.

Electrical Conductivity (EC)

Electrical conductivity followed a pattern consistent with TDS, indicating a strong correlation. The highest EC was observed in the pre-monsoon (890 µS/cm), suggestive of a higher ionic load due to reduced water volume and increased solute concentration. Although there are no BIS guidelines for EC, elevated values are indicative of salinity stress and ionic pollution.

Nitrate (NO_3^-)

Nitrate concentrations varied from 7.8 µS/cm (post-monsoon) to 12.3 µS/cm (monsoon). The monsoon value exceeded the BIS permissible limit (≤10 µS/cm), reflecting substantial nitrate loading from fertilizer runoff and decomposed organic material. High nitrate levels pose risks of eutrophication and health hazards such as methemoglobinemia in infants.

Phosphate (PO_4^{3-})

Phosphate levels were consistently above the BIS standard (≤0.1 mg/L), with the highest concentration during the monsoon (1.28 mg/L). These elevated levels signify heavy nutrient enrichment from agricultural runoff and detergents, leading to eutrophication and algal bloom risks. The post-monsoon decline (0.72 mg/L) suggests temporary flushing of nutrients but remains ecologically concerning.

CONCLUSION

The present study on the seasonal variation of physicochemical parameters in Puraini Pokhar highlights significant fluctuations in water quality influenced by both natural and anthropogenic factors. The findings demonstrate that several key indicators—such as BOD, COD, turbidity, TDS, nitrate, and phosphate—consistently exceeded the Bureau of Indian Standards (BIS) permissible limits, particularly during the pre-monsoon and monsoon seasons. Elevated nutrient loads, high organic content, and increased suspended solids during these periods reflect the impacts of agricultural runoff, domestic wastewater discharge, and unregulated solid waste dumping around the pond. Seasonal patterns suggest that while monsoonal rains temporarily improve certain parameters through dilution and aeration, they also intensify the influx of pollutants, especially nutrients like nitrates and phosphates. The consistently low dissolved oxygen levels during the pre-monsoon and elevated BOD and COD values across all seasons point toward persistent organic pollution and ecological stress on aquatic biota.

Overall, Puraini Pokhar is undergoing gradual ecological degradation that could threaten its role as a vital water source and biodiversity hotspot if left unaddressed. These results underscore the urgent need for regular monitoring, stricter regulation of pollutant inputs, community awareness programs, and the implementation of integrated pond management strategies. Adoption of sustainable agricultural practices, proper sewage treatment, and the establishment of buffer zones around the pond can contribute significantly to restoring and preserving the water quality and ecological integrity of this important freshwater ecosystem.

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