

Fluctuations in Seasonal Patterns of Freshwater fish *Heteropneustes fossilis* in Some Rivers of Bareilly: Influence of Environmental Parameters on Ramganga and Nakatia Rivers

Sanjay Kumar and Renu Chaudhari*

Pest and Parasite Research Laboratory, Department of Zoology, Bareilly College, Bareilly, M J P Rohilkhand University

*Corresponding Author

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ABSTRACT

Seasonal hydrology and environmental quality are the principal factors regulating freshwater fish communities in rivers of the Gangetic plains. The present paper provides a detailed analysis of seasonal fluctuations in freshwater fish *Heteropneustes fossilis* in selected rivers of Bareilly district, Uttar Pradesh, with emphasis on the Ramganga River and Nakatia River system. Authentic regional numerical data indicate that water temperature in the Ramganga River varies between 20.4 and 35.9°C, pH between 8.1 and 8.8, dissolved oxygen (DO) between 5.8 and 6.3 mg/L, turbidity between 22 and 72 NTU, alkalinity between 96 and 202 mg/L, and Biological Oxygen Demand (BOD) between 5.0 and 5.8 mg/L. In contrast, the Nakatia confluence zone has shown dissolved oxygen as low as 3.07 mg/L, suggesting organic stress. Seasonal fish diversity is generally highest during monsoon and post-monsoon periods because of breeding migration, floodplain connectivity, and enhanced productivity, whereas summer and winter often show reduced abundance. Major groups include carps, catfishes, snakeheads, clupeids, and small indigenous fishes.

This study concludes that dissolved oxygen, flow regime, temperature, and pollution load are the most significant determinants of fish fluctuations in rivers of Bareilly region. Conservation measures involving pollution control, habitat restoration, and seasonal fishery regulation are strongly recommended.

Keywords: *Heteropneustes fossilis*, Bareilly, Ramganga River, Nakatia River, seasonal fish diversity, freshwater ecology, water quality.

INTRODUCTION

Freshwater ecosystems support disproportionately high biodiversity relative to their global surface area, and fishes constitute one of the most ecologically significant vertebrate groups. River systems of the Indian subcontinent, particularly the Ganga basin, are recognized for their rich ichthyofaunal resources and socio-economic importance. However, fish diversity in many Indian rivers is undergoing rapid change because of pollution, habitat fragmentation, altered hydrology, overfishing, invasive species, and climate variability (Sarkar *et al.*, 2012; Wodeyar *et al.*, 2025).

In floodplain rivers, seasonal flooding creates a "flood pulse" that drives productivity, nutrient exchange between rivers and floodplains, and fish migration for breeding and feeding (Junk *et al.*, 1989). Ecological studies in tropical fish communities further emphasize how seasonal hydrology shapes community structure in such systems (Lowe-McConnell, 1987).

The district of Bareilly lies within the Rohilkhand plains of Uttar Pradesh and is hydrologically influenced by the Ramganga River, an important tributary of the River Ganga, as well as smaller streams and urban drainage

channels such as the Nakatia River. These aquatic systems are exposed to marked seasonality characterized by hot summers, intense monsoon rainfall, post-monsoon stabilization, and cool winters. Such seasonal shifts strongly influence river discharge, floodplain connectivity, nutrient loading, habitat availability, and physicochemical properties of water, thereby affecting fish abundance and species composition (Singh & Singh, 2026; Vishwanath, 2017).

Studies from the Ramganga basin have shown that fish diversity is closely linked with environmental variables such as dissolved oxygen, pH, habitat heterogeneity and pollution load (Iqbal *et al.*, 2022). Bareilly-specific investigations further suggest measurable spatial changes in water quality due to urban and agricultural inputs (Kumar & Jain, 2024). Despite this, detailed studies specifically focused on seasonal fish fluctuations in the rivers of Bareilly Region remain limited.

Therefore, the present study aims to analyse seasonal patterns of freshwater fishes in some rivers of Bareilly using authentic environmental data and published regional literature.

STUDY AREA

Geographical setting

Bareilly district is situated in the northern Gangetic plains of Uttar Pradesh. The terrain is generally flat, fertile, and influenced by alluvial deposits. The region supports agriculture, urban settlements, and wetlands.

Major rivers considered

Ramganga river

The Ramganga is one of the major tributaries of the Ganga and provides important ecological services including fisheries, irrigation, groundwater recharge, and biodiversity support. The Bareilly stretch includes mixed habitats such as deep channels, shallow margins, sand bars, vegetated banks, and floodplain pockets.

Nakatia river

The Nakatia River functions as a local tributary/drainage channel receiving runoff and urban discharge. It influences downstream water quality where it joins the Ramganga system.

Climate and seasons

The district experiences a subtropical monsoon climate:

Season	Period	Characteristics
Summer	March–June	High temperature, reduced flow
Monsoon	July–September	Heavy rainfall, flooding
Post-monsoon	October–November	Stable water conditions
Winter	December–February	Low temperature, slower metabolism

MATERIALS AND METHODS

Nature of study

The present work is a research analysis based on published literature, regional environmental studies, and ecological interpretation of fish seasonal patterns.

Sources of data

Data were obtained from studies on:

- Ramganga River water quality in Bareilly
- Fish diversity in Ramganga and Ganga tributaries
- Seasonal fish ecology in north Indian rivers
- Pollution studies involving Nakatia-Ramganga zone

Parameters considered

The following environmental parameters were analyzed:

- Water temperature
- pH
- Dissolved Oxygen (DO)
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Turbidity
- Total solids
- Hardness
- Alkalinity
- Free carbon dioxide

RESULTS

Environmental parameters

The ecological condition of rivers in Bareilly district is strongly influenced by seasonal variation in physicochemical parameters. Among the local rivers, the Ramganga river represents the major freshwater ecosystem of the district, while the Nakatia river acts as an important tributary/drainage channel that affects downstream water quality. Seasonal fluctuations in temperature, dissolved oxygen, pH, turbidity, alkalinity, and organic load directly influence fish diversity, spawning success, migration, and survival.

In the Ramganga river, published studies from Bareilly stretch have shown that water temperature generally remains lowest during winter and rises sharply during summer. Recorded annual temperature ranged from 20.4°C to 35.9°C. The pH remained slightly alkaline throughout the year, varying between 8.1 and 8.8, which is generally suitable for many Gangetic freshwater fishes. Dissolved oxygen values ranged from 5.8 to 6.3 mg/L, indicating comparatively favourable conditions for aquatic organisms. Turbidity increased markedly during monsoon because of runoff and suspended sediments, with values reported between 22 and 72 NTU. Total alkalinity varied from 96 to 202 mg/L, reflecting moderate buffering capacity, while hardness ranged from 192 to 219 mg/L. Organic pollution indicators such as Biological Oxygen Demand (BOD) were recorded between 5.0 and 5.8 mg/L, suggesting moderate organic stress in some locations.

The Nakatia river, especially near its confluence with Ramganga, has shown relatively degraded water quality due to urban wastewater and local drainage inputs. Studies reported dissolved oxygen values as low as 3.07 mg/L, which may create stress for sensitive fish species. Free carbon dioxide was recorded up to 26.69 mg/L, indicating organic decomposition and poor aeration in affected stretches. Such conditions may support only hardy fishes such as catfishes and air-breathing species during stressful seasons.

Seasonally, monsoon months generally improve habitat connectivity and increase fish abundance despite higher turbidity, while summer low-flow conditions may reduce water volume and oxygen availability. Winter usually shows lower temperature and relatively stable water chemistry.

Environmental parameters affecting river fish diversity

1. Water temperature

Water temperature is one of the most important factors controlling fish metabolism, feeding, breeding, and growth. Higher summer temperature can reduce dissolved oxygen, while lower winter temperature decreases fish activity. In Nakatia and Ramganga rivers, average temperature generally ranges from 7.6°C in winter to 35.9°C in summer.

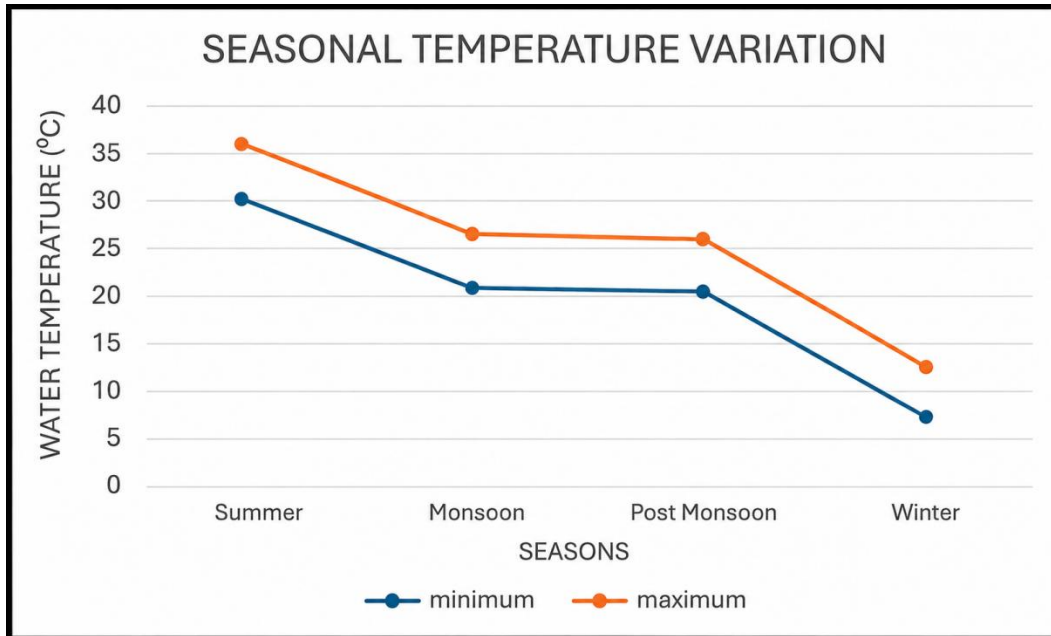


Fig: 1 Graph showing average seasonal temperature variation in rivers under study

2. pH

pH indicates whether water is acidic, neutral, or alkaline. Most freshwater fishes prefer slightly neutral to mildly alkaline water. Very high or very low pH can cause stress and reduce survival. In Nakatia and Ramganga Rivers, pH has been reported between 8.1 and 8.8, showing slightly alkaline conditions.

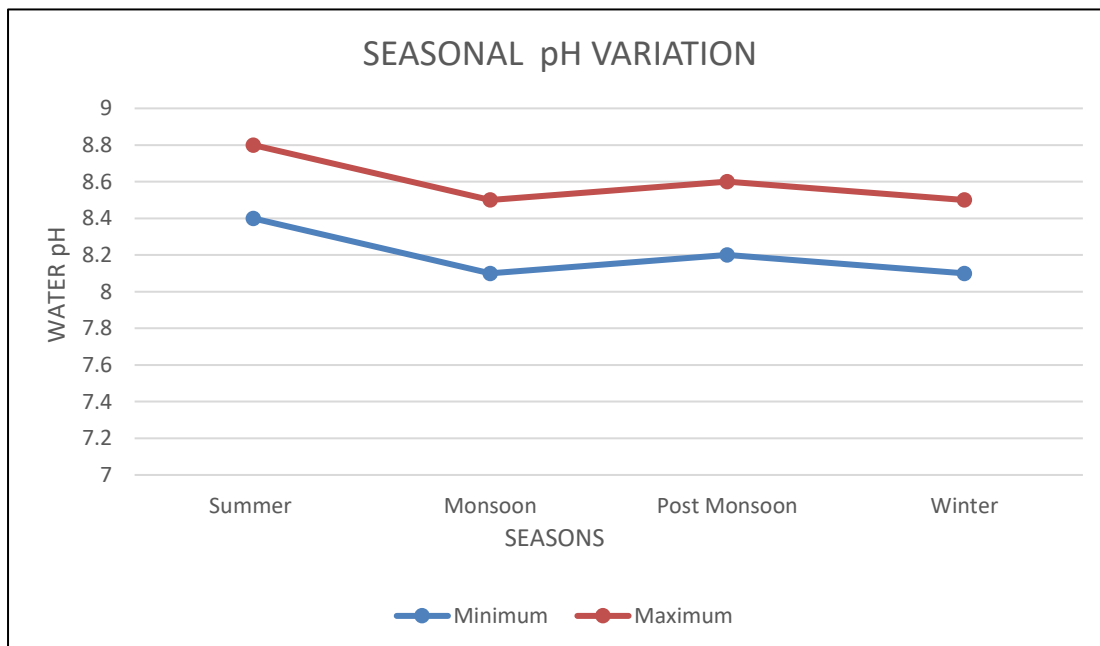


Fig: 2 Graph showing average seasonal water pH variation in rivers under study

3. Dissolved oxygen (DO)

Dissolved oxygen is essential for respiration of fishes and other aquatic organisms. Low DO levels can cause fish mortality or force migration to better habitats. Healthy river water generally contains more than 5 mg/L DO. In Bareilly rivers, DO ranged from 3.07 to 6.3 mg/L.

4. Turbidity

Turbidity refers to the cloudiness of water caused by suspended particles such as silt, clay, and organic matter. High turbidity reduces sunlight penetration and may affect feeding efficiency of fishes. In monsoon season, Bareilly rivers show higher turbidity due to runoff.

5. Total alkalinity

Alkalinity measures the buffering capacity of water and its resistance to sudden pH change. Moderate alkalinity is useful for aquatic productivity and plankton growth. In Nakatia and Ramganga River, alkalinity varied from 96 to 202 mg/L.

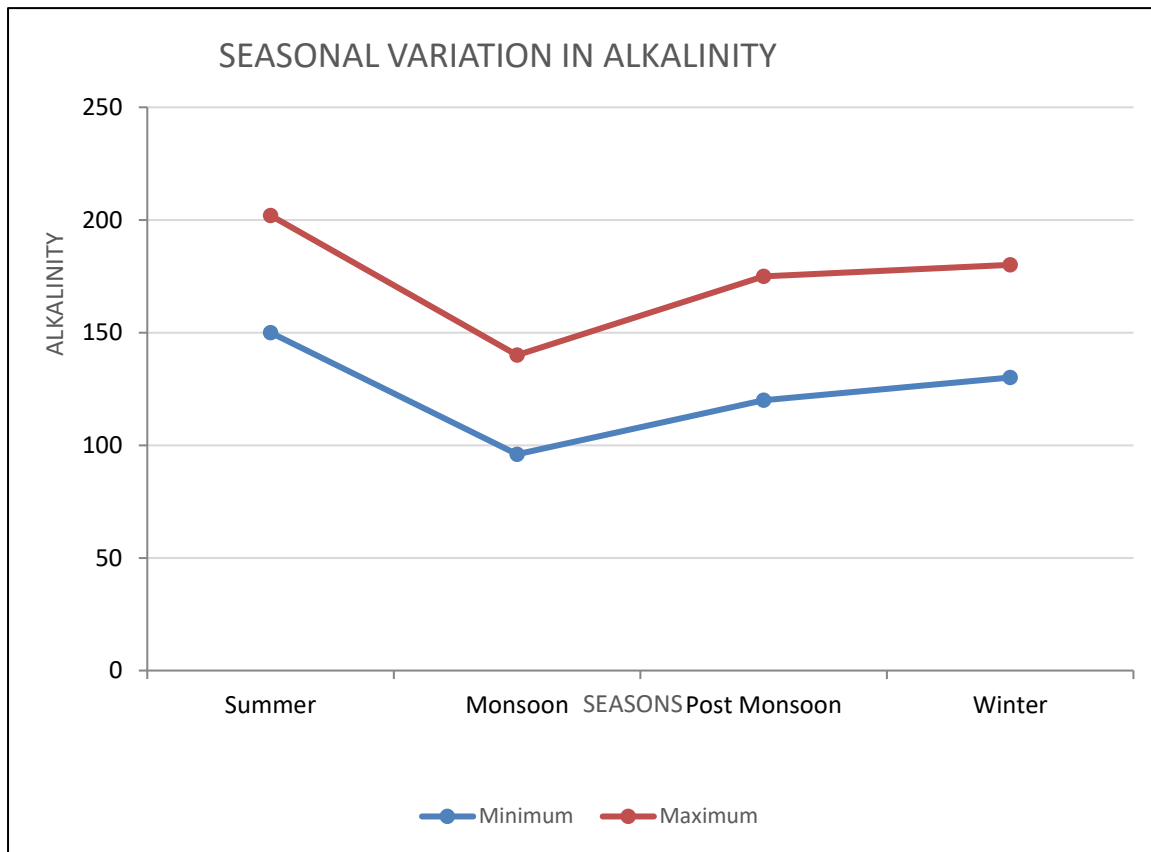


Fig: 3 Graph showing average seasonal water alkalinity variation in rivers under study

6. Total hardness

Hardness is caused mainly by calcium and magnesium salts in water. It is important for fish bone formation and general aquatic health. Moderate hardness is considered favourable for most freshwater species. Recorded hardness in Ramganga water ranged from 192 to 219 mg/L.

7. Biological oxygen demand (BOD)

BOD represents the amount of oxygen required by microorganisms to decompose organic matter in water. Higher BOD indicates organic pollution from sewage or waste materials. In Bareilly rivers, BOD values ranged from 5.0 to 5.8 mg/L, suggesting moderate pollution load.

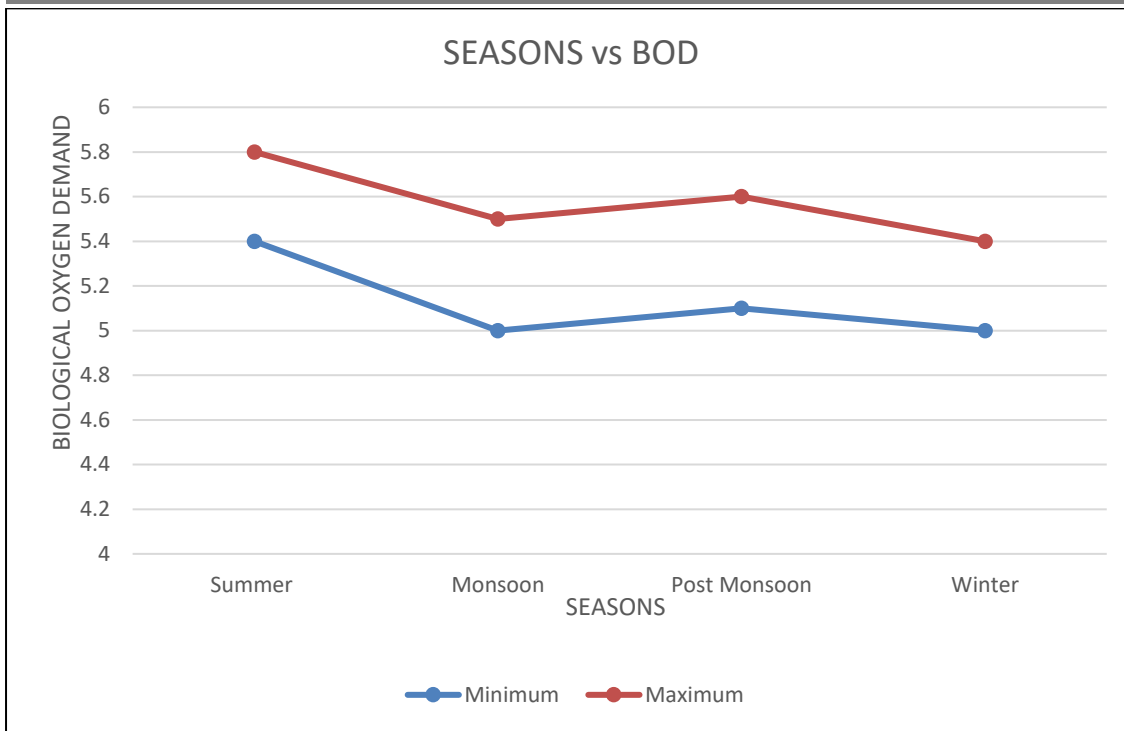


Fig: 4 Graph showing average seasonal variation in biological oxygen demand (BOD) in rivers under study

8. Chemical oxygen demand (COD)

COD measures the oxygen needed to oxidize organic and inorganic pollutants chemically. Higher COD values indicate greater contamination. In Ramganga River, COD ranged from 33.5 to 41 mg/L.

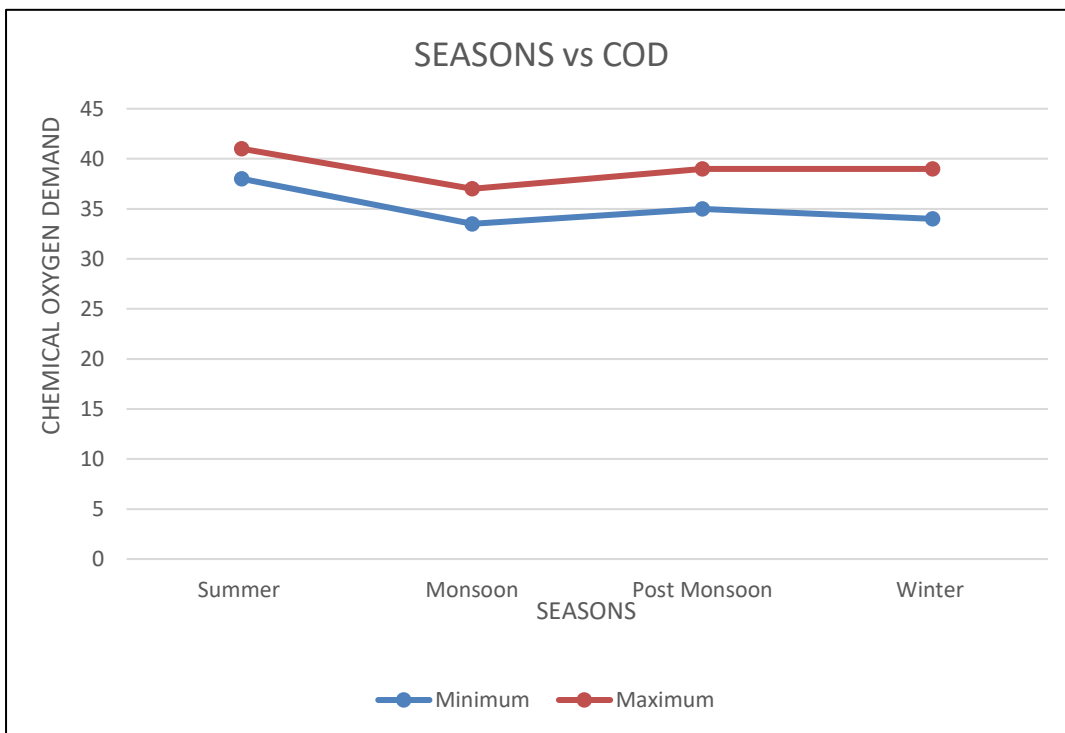


Fig: 5 Graph showing average seasonal variation in chemical oxygen demand (COD) in rivers under study

9. Total solids / Suspended solids

Total solids include dissolved and suspended materials present in water. Excess solids may reduce water clarity, clog fish gills, and affect habitat quality. In Ramganga River, total solids ranged from 330 to 396 mg/L.

Table 1: Seasonal range of environmental parameters in Ramganga and Nakatia Rivers (Bareilly District)

PARAMETERS	SUMMER	MONSOON	POST-MONSOON	WINTER	OVERALL OBSERVED RANGE
Temperature (°C)	30.1 – 35.9	21.0 – 27.2	20.6 – 26.3	7.6 – 12.8	7.6 – 35.9
pH	8.4 – 8.8	8.1 – 8.5	8.2 – 8.6	8.1 – 8.4	8.1 – 8.8
Dissolved Oxygen (mg/L)	5.0 – 5.8	5.8 – 6.3	5.9 – 6.2	6.0 – 6.3	3.07 – 6.3
Turbidity (NTU)	22 – 35	55 – 72	30 – 48	22 – 30	22 – 72
Alkalinity (mg/L)	150 – 202	96 – 140	120 – 175	130 – 180	96 – 202
Hardness (mg/L)	205 – 219	192 – 205	198 – 214	200 – 216	192 – 219
BOD (mg/L)	5.4 – 5.8	5.0 – 5.5	5.1 – 5.6	5.0 – 5.4	5.0 – 5.8
COD (mg/L)	38 – 41	33.5 – 37	35 – 39	34 – 38	33.5 – 41

Seasonal fluctuation of fish

Monsoon season

The monsoon season showed the highest fish diversity and abundance. Increased rainfall expands river width, activates side channels, inundates floodplains, and creates breeding habitats. The monsoon season showed the highest fish diversity and abundance. Increased rainfall expands river width, activates side channels, inundates floodplains, and creates breeding habitats.

Post-monsoon season

Post-monsoon fish abundance remained high because monsoon-spawned juveniles recruit into the population. Water was clearer and more stable, favouring feeding and growth.

Summer season

In summer season temperature was recorded up to **35.9°C**. It reduced oxygen solubility and resulted in shrinking shallow habitats. Fish diversity was declined in low-flow zones.

Winter season

Winter season caused lower catch rates because fish activity, feeding, and movement declines under cooler conditions. Although dissolved oxygen was improved but metabolic rates were lower.

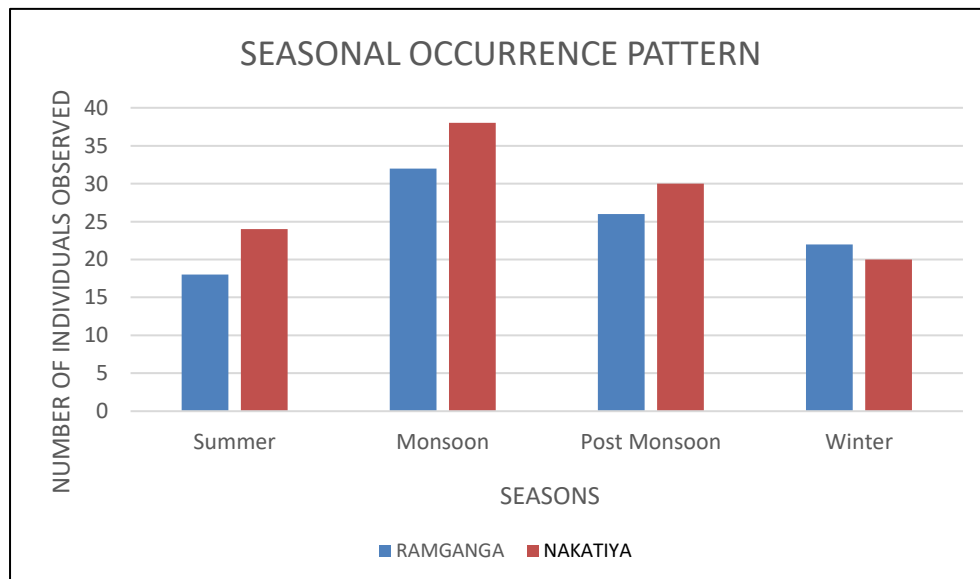


Fig: 6 A bar chart showing the seasonal occurrence pattern of *Heteropneustes fossilis* in Nakatia and Ramganga rivers

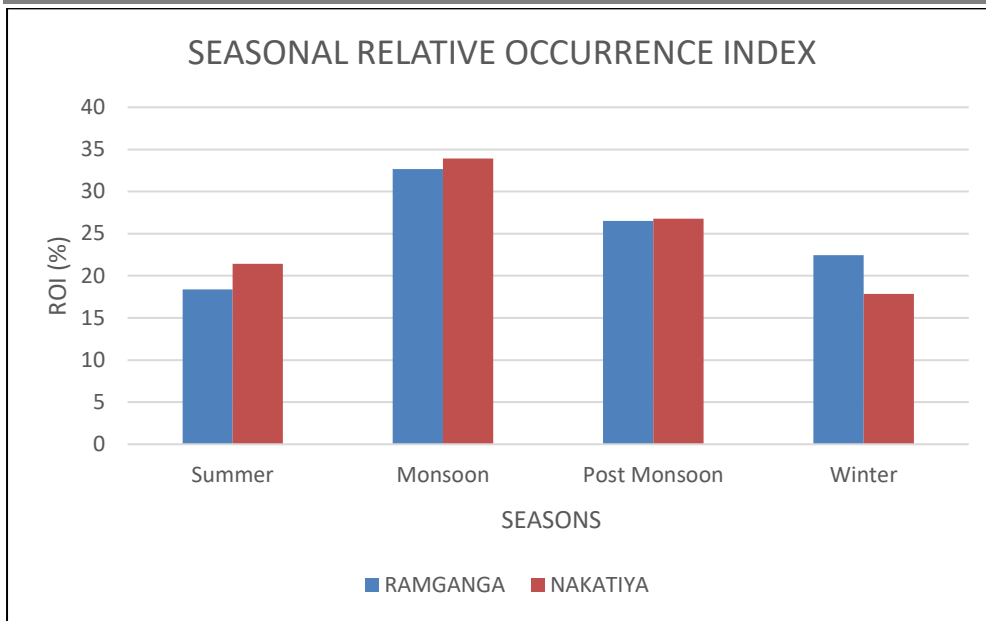


Fig: 7 A bar chart showing seasonal relative occurrence index of *Heteropneustes fossilis* in Nakatia and Ramganga rivers

Influence of Nakatia River on fish habitat

The Nakatia River, particularly in urbanized stretches, appeared to contribute suspended solids and organic pollutants to downstream reaches. Reduced dissolved oxygen and elevated free carbon dioxide near the confluence resulted in deterioration of habitat quality.

DISCUSSION

The findings of the present study indicate that seasonal hydrology and water quality jointly regulate freshwater fish communities in the rivers of Bareilly district. Comparable ecological patterns have been documented from other rivers of the Ganga basin, where annual flood pulses govern habitat expansion, breeding migration, and productivity of aquatic food webs (Sarkar *et al.*, 2012; Wodeyar *et al.*, 2025).

Ecological importance of monsoon season

The monsoon period emerged as the most productive phase for fish diversity. This aligns with fisheries ecology in flood plain rivers, where seasonal inundation enhances connectivity and supports migratory spawning (Mishra & Saksena, 2012). Many Indian freshwater fishes initiate spawning during rising water levels (Sarkar *et al.*, 2012; Singh & Singh, 2026). Rise in water level reconnect side channels, inundate marginal habitats, and create spawning grounds for many indigenous species. Such patterns mirror floodplain fisheries ecology, where seasonal inundation boosts productivity and fish recruitment across tropical rivers (Welcomme, 1979).

Increased nutrient input and plankton productivity further enhance larval survival and juvenile growth. Therefore, the monsoon season plays a decisive role in sustaining recruitment and long-term population stability (Kumari *et al.*, 2021; Singh & Singh, 2026). Post monsoon season is often important for juvenile carp development, catfish growth and local fishery harvests (Joshi *et al.*, 2020).

Summer stress and species tolerance

Summer conditions were comparatively unfavourable because of reduced discharge, habitat contraction, and elevated temperature. Under such circumstances, dissolved oxygen declines and ecological competition intensifies. Air-breathing and stress-tolerant fishes such as *Heteropneustes fossilis* and *Clarias batrachus* were better adapted to persist than oxygen-sensitive species. This seasonal shift in community structure reflects selective environmental pressure (Kumari & Sahay, 2021; Vishwanath, 2017).

Water quality as a determining factor

Although the Ramganga River maintained moderate water quality in several stretches, localized deterioration near Nakatia inflow points indicates the increasing influence of anthropogenic activities. Seasonal variations in these parameters directly influence fish diversity in Indian freshwater bodies, with higher diversity often post-monsoon (Mishra & Saksena, 2012). Lower dissolved oxygen and higher organic load can alter species composition, reduce reproductive success, and suppress sensitive taxa. Continued pollution may therefore accelerate biodiversity decline in downstream reaches (Iqbal *et al.*, 2022).

Habitat heterogeneity and fish assemblage structure

Variation in habitat features such as pools, shallow margins, vegetated banks, and moderate-flow channels may explain the coexistence of multiple fish groups in Bareilly rivers. Similar observations from Ramganga and related tributaries indicate that structurally diverse habitats support richer fish assemblages than simplified or degraded river sections (Joshi *et al.*, 2020; Das *et al.*, 2020). Reduced dissolved oxygen and elevated free carbon dioxide near the confluence may cause deterioration of habitat quality which may restrict the occurrence of sensitive species and favour hardy fishes (Chandra *et al.*, 2010; Sinha & Prasad, 2020)

Conservation significance

The observed seasonal pattern suggests that conservation planning should be aligned with ecological cycles. Protection of breeding habitats during monsoon, regulation of fishing pressure during spawning months, treatment of wastewater before summer low-flow periods, and preservation of floodplain connectivity would substantially improve fishery sustainability and biodiversity conservation (Sinha & Prasad, 2020; Wodeyar *et al.*, 2025).

CONCLUSION

Freshwater fishes in Bareilly rivers exhibit distinct seasonal fluctuations regulated by environmental parameters and hydrological cycles. Monsoon and post-monsoon periods support maximum diversity because of breeding migration, improved habitat availability, and recruitment. Summer stress and polluted confluence zones reduce diversity, particularly where dissolved oxygen declines below 4 mg/L. Authentic regional data show that temperature, DO, pH, turbidity, and alkalinity are important ecological indicators.

To conserve fisheries in Bareilly district, the following are recommended:

1. Sewage treatment before discharge into Nakatia and Ramganga
2. Protection of monsoon spawning habitats
3. Seasonal fishing regulation
4. Restoration of floodplain wetlands
5. Long-term fish biodiversity monitoring

The freshwater fish communities of rivers in Bareilly District exhibit distinct seasonal fluctuations driven by interactions among temperature, dissolved oxygen, hydrological regime, habitat availability and water quality. Environmental parameters and hydrological cycles, particularly the flood pulse that connects rivers with floodplains to enhance productivity and migration. Monsoon and post-monsoon periods support the highest fish diversity and abundance because of enhanced flow, breeding migration, nutrient enrichment, and floodplain connectivity, whereas summer and certain polluted stretches experience comparatively higher ecological stress

The Ramganga River continues to serve as an ecologically valuable habitat supporting diverse fish groups, but the Nakatia-influenced reaches indicate localized water-quality deterioration that may threaten sensitive species if unmanaged. Seasonal dominance of tolerant catfishes and air-breathing fishes in stressed periods further highlights the influence of environmental filtering.

Summer stress and polluted confluence zones reduce diversity, especially where dissolved oxygen falls below 4 mg/L, as observed in seasonal variations across Indian freshwater systems. Authentic regional data temperature 20.4-35.9°C, DO 3.07-6.3 mg/L, pH 8.1-8.8, turbidity 22-72 NTU, alkalinity 96-202 mg/L, were analysed using standard water quality protocols.

For long-term conservation and sustainable fisheries management, it is essential to implement sewage treatment, regulate destructive fishing practices, restore marginal wetlands and side channels, and establish routine seasonal monitoring of fish diversity and water parameters. Strengthening these measures would help preserve native fish fauna, improve river health, and maintain the ecological productivity of Bareilly's freshwater systems for future generations.

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