The Biobrio ISSN : 2393-9508 e-ISSN: 2582-4902
An International Quarterly Journal of Life Sciences
Website: www.thebiobrio.in SJIF:8.259
12(3&4): 1558-1564, 2025

Ichthyofaunal Diversity and Seasonal Dynamics of the Kosi River near Supaul, Bihar, India: Implications for Conservation

Neha Shikha[1]* & B. P. Singh[2]
[1]University Department of Zoology, B.N. Mandal University, Madhepura, Bihar, India
[2]Department of Zoology, SNSRKS College, Saharsa, Bihar, India

Received : 14th October, 2025 ; Accepted : 15th November, 2025
DOI:- https://doi.org/10.5281/zenodo.19247455

ABSTRACT

The present investigation provides a detailed assessment of ichthyofaunal diversity and seasonal dynamics of the Kosi River near Supaul, Bihar, India. The study was conducted from January to December 2024 across three representative sampling stations, namely Bhimnagar, Nirmali, and Triveniganj, covering upper, middle, and Lower River stretches. Fish samples were collected fortnightly using a combination of traditional and standard fishing gears. Specimens were preserved in 8% formalin and identified using standard taxonomic keys. A total of 24-32 species were recorded across the study sites, with maximum species richness observed at Nirmali (32 species), followed by Bhimnagar (28 species) and Triveniganj (24 species). Diversity analysis using Shannon-Wiener and Simpson's indices revealed peak diversity during the monsoon season (H' = 3.21; D = 0.91), indicating favorable ecological conditions. Seasonal fluctuations in diversity were strongly linked with hydrological changes, including increased discharge, habitat connectivity, and nutrient influx during monsoon. The study highlights the ecological significance of the Kosi River as a productive yet vulnerable freshwater system. Increasing anthropogenic pressures, including habitat alteration and overfishing, may threaten its biodiversity. The findings provide a baseline for future monitoring and emphasize the need for sustainable conservation strategies.

Key Words - Ichthyofauna, Kosi River, biodiversity indices, seasonal variation, freshwater ecology

***Corresponding author :** miss.nehashikha@gmail.com

INTRODUCTION

Freshwater ecosystems are globally recognized for their exceptional biodiversity and ecological importance, supporting a disproportionately high number of species relative to their limited spatial extent. Although they occupy less than one percent of the Earth's surface, these ecosystems harbor nearly ten percent of all known species, highlighting their critical ecological value (Dudgeon *et al.*, 2006; Reid *et al.*, 2019). Among freshwater biota, fish communities constitute a fundamental component, playing key roles in maintaining ecological stability, nutrient cycling, and providing an essential source of protein and livelihood for millions of people worldwide (Lynch *et al.*, 2016; FAO, 2022).

India is one of the richest countries in terms of freshwater fish diversity, with over 850 species reported from its inland water systems (Jayaram, 2010; Lakra *et al.*, 2010). However, this diversity is increasingly threatened by rapid anthropogenic changes, including water pollution, river regulation

through dams and embankments, overexploitation of fishery resources, and large-scale habitat degradation. These pressures have resulted in significant declines in native fish populations and alterations in community structure across major river systems (Sarkar *et al.*, 2012; Reid *et al.*, 2019).

The Kosi River, a major tributary of the Ganga, is one of the most dynamic and geomorphologically unstable rivers in South Asia. It is characterized by a high sediment load, braided channel morphology, and frequent flooding events, which collectively shape a highly fluctuating aquatic environment (Sinha, 2009; Gole & Chitale, 2016). The river's tendency to shift its course and its flood-driven hydrological regime create both opportunities, such as habitat expansion and nutrient enrichment, and challenges, including habitat instability and species displacement for fish communities.

Despite its considerable ecological and socio-economic importance, particularly in supporting fisheries and local livelihoods, the Kosi River near Supaul remains relatively understudied with respect to ichthyofaunal diversity and ecological dynamics. In this context, the present study was undertaken to document the ichthyofaunal diversity of the Kosi River, analyze spatial and seasonal variations in fish assemblages, and evaluate the ecological conditions influencing fish distribution patterns.

MATERIALS & METHODS

Study Area

The present study was carried out along a selected stretch of the Kosi River flowing through the Supaul district of Bihar, India. This stretch extends from Bhimnagar in the upstream region to Triveniganj in the downstream section. The Kosi River in this region exhibits a highly dynamic fluvial character, marked by a braided channel system, heavy sediment deposition, and pronounced seasonal flooding. These geomorphological features significantly influence habitat heterogeneity and, consequently, the distribution and diversity of fish communities.

The riverine landscape is further shaped by frequent channel shifting, formation of sandbars, and variable flow regimes, particularly during the monsoon season. Such conditions create a mosaic of microhabitats, including shallow pools, fast-flowing channels, and floodplain wetlands, all of which support diverse ichthyofaunal assemblages.

To capture spatial variation in ecological conditions, three representative sampling stations were selected along the river stretch. These stations differ in terms of hydrological characteristics, habitat structure, and anthropogenic pressure, including fishing intensity and proximity to human settlements.

Table 1- Sampling Stations and Their Geographic Coordinates

Station	Location	Latitude	Longitude	Altitude
I	Bhimnagar	26.5162°N	86.7693°E	71 m
II	Nirmali	26.3149°N	86.5895°E	61 m
III	Triveniganj	26.1235°N	86.7691°E	56 m

Station I (Bhimnagar) represents the upper stretch with relatively higher flow velocity and less anthropogenic disturbance. Station II (Nirmali), located in the middle stretch, is characterized by moderate flow conditions and increased habitat complexity, while Station III (Triveniganj) represents the lower stretch, where sediment deposition, slower currents, and human activities are more prominent. Together, these stations provide a comprehensive representation of the ecological variability within the study area.

Sampling Design

Fish sampling was conducted on a fortnightly basis from January to December 2024 to ensure adequate representation of seasonal variation in species composition and abundance. Sampling was carried out during daylight hours, typically between 08:00 and 18:00 hrs, to maximize catch efficiency and ensure consistency in sampling effort.

A combination of traditional and standardized fishing gears was employed to ensure comprehensive sampling across different habitats and fish size groups. The use of multiple gear types was particularly important given the heterogeneous nature of the river system, where different species occupy distinct ecological niches.

The gears used included:

- Cast nets with mesh sizes ranging from 16 to 22 mm
- Gill nets with mesh sizes of 32, 64, and 110 mm
- Drag nets and scoop nets for shallow and marginal habitats
- Hooks and lines for selective capture of larger species
- Indigenous bamboo traps, locally known and widely used by fishermen

This multi-gear approach allowed for the effective capture of both small-sized and large-sized fishes, as well as surface-dwelling and bottom-dwelling species. It also helped reduce sampling bias and ensured a more representative assessment of the ichthyofaunal diversity across different microhabitats.

Preservation and Identification

Immediately after collection, fish specimens were carefully washed with river water to remove mud, debris, and mucus that could obscure morphological features. The cleaned specimens were then preserved in 8% formalin solution, which is widely used for long-term preservation in ichthyological studies.

Each specimen was labeled with relevant information, including date, location, and sampling station, to maintain proper documentation. The preserved samples were subsequently transported to the laboratory for detailed taxonomic analysis.

Identification of fish species was carried out using standard taxonomic keys and reference literature. The identification process primarily relied on observable morphological and morphometric characteristics such as body shape, fin structure and formula, scale arrangement, barbel presence, and coloration patterns. Special attention was given to diagnostic features to ensure accurate species-level identification.

In cases where identification was challenging due to juvenile stages or morphological similarities, specimens were further examined with the help of photographic records and expert consultation. Additionally, indigenous knowledge provided by local fishermen was utilized to verify species identity, particularly in relating scientific names to vernacular nomenclature and ecological behavior (Ahmed & Paul, 2020). This integration of scientific and traditional knowledge enhanced the reliability of species identification.

Physico-Chemical Parameters

To understand the environmental conditions influencing fish diversity, water samples were collected monthly from all sampling stations and analyzed for key physico-chemical parameters. These parameters play a crucial role in determining the suitability of aquatic habitats for fish survival, growth, and reproduction.

The parameters analyzed included temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (CO,), and total dissolved solids (TDS). Standard analytical methods were employed for each parameter to ensure accuracy and consistency.

Table 2- Physico-Chemical Parameters of Water

Parameter	Observed Value	Suitable Range
Temperature	25.4°C	20–30°C
pH	7.3	6.5–8.5
DO	5.8 mg/L	>5 mg/L
BOD	3.1 mg/L	<5 mg/L
CO_2	7 mg/L	<10 mg/L
TDS	370 mg/L	<500 mg/L

The observed values of these parameters were found to be within the acceptable limits for freshwater fish survival. Temperature and pH conditions were conducive to normal metabolic activity, while dissolved oxygen levels were sufficient to support aerobic aquatic life. Although slight variations were observed across stations and seasons, the overall water quality indicated moderately favorable conditions for sustaining fish diversity in the study area.

Diversity Analysis

To quantitatively assess fish diversity, standard ecological indices were calculated for different sampling stations and seasons. These indices

provide insights into species richness, evenness, and dominance patterns within the fish community.

The Shannon-Wiener diversity index (H2) was used to evaluate species diversity by considering both species richness and relative abundance. Simpson's diversity index (D), on the other hand, was used to measure dominance and the probability that two individuals randomly selected from a sample belong to different species.

These indices were calculated seasonally—winter, pre-monsoon, monsoon, and post-monsoon—to examine temporal variations in diversity patterns. The combined use of these indices enabled a comprehensive understanding of the ecological structure of fish communities and helped in identifying periods of maximum and minimum biodiversity within the river system.

RESULTS

Species Composition

The ichthyofaunal survey conducted across the three sampling stations of the Kosi River revealed considerable spatial variation in species composition and richness. A total of 24 to 32 fish species were recorded during the study period, indicating moderate to high biodiversity within the selected river stretch.

Among the sampling stations, Nirmali (Station II) exhibited the highest species richness with a total of 32 species, suggesting the presence of favorable ecological conditions such as moderate flow velocity, habitat heterogeneity, and adequate food availability. Bhimnagar (Station I) recorded 28 species, reflecting relatively stable upstream conditions with comparatively lower anthropogenic disturbances. In contrast, Triveniganj (Station III) showed the lowest species richness, with 24 species, possibly due to increased sedimentation, reduced flow velocity, and higher human interference in the downstream region.

The observed variation in species composition across stations highlights the influence of spatial heterogeneity in habitat structure, hydrological conditions, and ecological factors on fish distribution within the river system.

Diversity Indices

To further understand the structure and distribution of fish communities, diversity indices were calculated for each sampling station. The calculated values represent pooled observations across the entire study period (January–December 2024). The results are presentedin table 3.

Table 3 - Diversity indices of fish communities at different sampling stations of the Kosi River near Supaul

Station	Species (S)	Shannon (H')	Simpson (D)
Bhimnagar	28	2.94	0.87
Nirmali	32	3.21	0.91
Triveniganj	24	2.65	0.84

Values represent pooled observations across the study period (January–December 2024)

The values of the Shannon-Wiener index (H') ranged from 2.65 to 3.21, indicating a moderate to high level of species diversity with relatively good species evenness across the study area. Similarly, Simpson's index (D), which reflects species dominance and evenness, varied between 0.84 and 0.91, suggesting a balanced distribution of species without excessive dominance by any single species.

Among the stations, Nirmali recorded the highest diversity index values (H' = 3.21; D = 0.91), indicating a well-structured and ecologically stable fish community. The comparatively lower values observed at Triveniganj suggest reduced diversity and possible ecological stress. Overall, the diversity indices demonstrate that midstream regions of the river provide more favorable conditions for sustaining diverse fish assemblages.

Seasonal Variation

A clear pattern of seasonal variation in fish diversity was observed throughout the study period. The composition and abundance of fish species fluctuated significantly in response to seasonal changes in hydrological and environmental conditions.

During the monsoon season, fish diversity reached its peak. This increase can be attributed to the

expansion of aquatic habitats due to increased water volume, enhanced connectivity between river channels and floodplain areas, and improved availability of nutrients. These conditions facilitate migration, breeding, and dispersal of fish species, thereby increasing overall diversity.

In the pre-monsoon season, diversity levels were moderate, reflecting relatively stable environmental conditions with sufficient water availability and limited disturbance. The winter season exhibited a noticeable decline in fish diversity, which may be associated with lower water temperatures, reduced metabolic activity, and decreased water flow, leading to habitat contraction.

Following the monsoon, the post-monsoon season showed a gradual recovery in diversity. As water levels stabilized and habitats re-established, fish communities began to reorganize, leading to an increase in species presence and abundance.

These seasonal trends clearly indicate that hydrological dynamics play a crucial role in regulating fish diversity in the Kosi River.

Environmental Influence

The analysis of physico-chemical parameters revealed that the overall water quality of the Kosi River remained within tolerable limits for freshwater fish survival throughout the study period. However, certain localized and seasonal variations were observed, which influenced fish distribution patterns.

A slight increase in biological oxygen demand (BOD) was recorded in areas closer to human settlements, indicating the presence of organic pollution, possibly from domestic waste discharge and agricultural runoff. Despite this, dissolved oxygen (DO) levels remained above the critical threshold, ensuring suitable conditions for most fish species (Rao & Mishra, 2022).

During the monsoon season, increased runoff and sediment load led to higher turbidity levels in the river. This seasonal turbidity influenced species distribution, particularly affecting visual feeders and species sensitive to suspended particles. However, the same conditions also contributed to nutrient enrichment, indirectly supporting higher productivity and fish diversity.

While the river system currently maintains conditions suitable for sustaining fish life, the observed environmental variations suggest the need for continuous monitoring to prevent potential ecological degradation.

DISCUSSION

The findings of the present study indicate that the Kosi River near Supaul sustains a moderate to high level of ichthyofaunal diversity, with distinct spatial and seasonal variations. Such variability in fish diversity is a common feature of large river systems and is primarily influenced by hydrological dynamics, habitat heterogeneity, and ecological gradients (Reid *et al.,* 2019; Lynch *et al.,* 2016). The recorded diversity range (H' = 2.65–3.21) suggests that the river stretch under investigation maintains a relatively balanced and productive aquatic ecosystem.

The highest species diversity observed at Nirmali (midstream region) highlights the ecological significance of intermediate river stretches in supporting fish communities. Midstream zones typically exhibit a combination of moderate flow velocity, diverse substrate composition, and increased habitat complexity, which collectively enhance resource availability and niche diversity (Vannote *et al.,* 1980). These conditions promote species coexistence by reducing competition and supporting both pelagic and benthic fish species. Similar patterns of higher diversity in midstream sections have been reported from other river systems in the Ganga basin (Sarkar *et al.,* 2012).

Seasonal variation emerged as a critical factor influencing fish diversity in the Kosi River. The monsoon season recorded the highest diversity, which can be attributed to increased river discharge, expansion of aquatic habitats, and improved connectivity between the main channel and adjacent floodplains (Kumar & Sharma, 2021). This phenomenon aligns with the flood-pulse concept, which emphasizes the ecological importance of seasonal flooding in enhancing

productivity, nutrient exchange, and biological diversity in river-floodplain systems (Junk *et al.,* 1989). During this period, many fish species undertake breeding migrations, and the availability of inundated areas provides suitable spawning and nursery grounds (Nayak & Reddy, 2020; Welcomme, 2001).

In contrast, the reduced diversity observed during the winter season may be linked to lower water levels, reduced habitat availability, and decreased metabolic activity of aquatic organisms. Such seasonal fluctuations are characteristic of tropical river ecosystems and reflect the strong dependence of fish communities on hydrological cycles (Lynch *et al.,* 2016).

The comparatively lower diversity recorded at Triveniganj (downstream region) may be attributed to multiple interacting factors. Increased sedimentation in this region can lead to the smothering of benthic habitats and spawning grounds, thereby negatively affecting fish populations. Additionally, habitat instability, resulting from channel shifting and irregular flow patterns, may limit the establishment of stable fish communities. Furthermore, anthropogenic disturbances, including overfishing, sand mining, and domestic waste discharge, contribute to habitat degradation and reduced species richness (Chaudhary & Sinha, 2021; Dudgeon *et al.,* 2006; Sarkar *et al.,* 2012).

Despite these localized pressures, the overall diversity indices suggest that the river ecosystem is still in a moderately healthy condition, capable of supporting a diverse assemblage of fish species. However, the presence of emerging threats, particularly increasing human interference and environmental stressors, may disrupt this balance in the future. Continuous monitoring and the implementation of sustainable management practices are therefore essential to preserve the ecological integrity of the Kosi River.

CONCLUSION

The present study clearly demonstrates that the Kosi River near Supaul supports a moderately rich and structurally stable ichthyofaunal community, as evidenced by the recorded species richness (24–32 species) and diversity indices (H' = 2.65–3.21; D= 0.84–0.91). The variation in species composition across the three sampling stations highlights the influence of spatial heterogeneity, with the midstream region at Nirmali exhibiting the highest diversity due to favorable ecological conditions such as balanced flow, habitat complexity, and resource availability.

Seasonal dynamics emerged as a key factor regulating fish diversity, with the monsoon season contributing significantly to increased species richness and abundance. Enhanced water discharge, habitat expansion, and improved connectivity during this period create optimal conditions for fish migration, breeding, and dispersal. In contrast, reduced diversity during winter reflects the impact of lower water levels and limited habitat availability.

Although the overall water quality parameters remained within permissible limits, localized increases in organic load and sedimentation, particularly in downstream regions, indicate emerging environmental pressures. Anthropogenic activities such as overfishing, habitat alteration, and unregulated resource use may pose long-term threats to the sustainability of fish diversity in the river.

The study underscores the importance of maintaining natural hydrological regimes, conserving critical habitats, and adopting sustainable fishery practices to protect the ecological integrity of the Kosi River. The baseline data generated through this investigation provide a valuable foundation for future ecological monitoring, biodiversity assessment, and the formulation of effective conservation and management strategies for this dynamic river system.

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