Analysis of the Statistical Relationship between Fish Diversity and Physicochemical Parameters of Water across Four Rivers (Hasdeo, Tan, Ahiran and Chornai) of Korba District, Chhattisgarh India

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ABSTRACT

Freshwater ecosystems are essential for biodiversity conservation and ecosystem functioning but are increasingly affected by anthropogenic disturbances. This study examined the relationship between fish diversity and water quality in the Hasdeo, Tan, Ahiran, and Chornai rivers of Korba district, Chhattisgarh, India. Seasonal sampling was conducted during pre-monsoon, monsoon, and post-monsoon periods (March 2025 to April 2026) across 12 sampling stations. A total of 62 fish species belonging to 36 genera, 23 families, and 12 orders were recorded. Fish diversity was evaluated using species richness, Shannon–Wiener diversity, Simpson's dominance, and Pielou's evenness indices, while physicochemical parameters including temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS) were analyzed.

The Hasdeo and Ahiran rivers exhibited higher species richness and diversity, associated with higher DO and lower BOD, COD, and TDS levels. In contrast, the Tan and Chornai rivers showed lower diversity, reflecting poorer water quality. Correlation analysis revealed a strong positive relationship between DO and fish diversity, whereas BOD, COD, and TDS were negatively correlated. Principal Component Analysis identified oxygen availability and pollution load as major factors influencing fish assemblages. The findings highlight the importance of water quality management for conserving freshwater fish diversity in Korba district.

Keywords: Fish diversity, freshwater ecosystems, water quality, physicochemical parameters, Korba rivers.

INTRODUCTION

Freshwater ecosystems are vital to ecological balance, human welfare, and regional livelihoods. Rivers, in particular, support a wide range of biological communities and provide essential services such as water supply, fisheries, irrigation, nutrient transport, and habitat connectivity. Despite this importance, freshwater ecosystems are under severe pressure worldwide due to pollution, habitat alteration, overexploitation, flow regulation, and climate-related disturbances. Recent studies have shown that freshwater biodiversity is declining rapidly, making riverine conservation an urgent scientific and policy priority (Tickner et al., 2020; Albert et al., 2021).

The composition and distribution of fish assemblages are strongly influenced by the physicochemical characteristics of water because environmental degradation, pollution, habitat alteration, and changes in river conditions are major drivers of freshwater biodiversity loss (Haase et al., 2023). Parameters such as temperature, pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand and total dissolved solids play an important role in determining habitat suitability for aquatic organisms. Temperature affects metabolism, oxygen demand, growth, and reproductive cycles, while pH influences physiological processes and chemical interactions in the aquatic environment (Poole and Berman, 2001).

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Dissolved oxygen is one of the most critical requirements for fish survival, whereas higher biochemical oxygen demand and chemical oxygen demand generally indicate organic pollution, reduced oxygen availability, and ecological stress. Similarly dissolved solids may reduce light penetration, disturb primary productivity, affect feeding and spawning habitats, and ultimately influence fish diversity, dominance, and evenness (Rees et al., 2021; Kemp et al., 2011; Haase et al., 2023).

The relationship between fish diversity and water quality becomes even more important in tropical river systems where seasonal variation is pronounced. In monsoon-dominated regions, pre-monsoon, monsoon, and post-monsoon periods create distinct environmental conditions in terms of discharge, sediment load, nutrient availability, temperature, and dilution effects. These seasonal shifts influence fish migration, breeding activity, recruitment success, and habitat connectivity. As a result, the ecological structure of fish assemblages may vary considerably not only among rivers but also across seasons within the same river system (Duncan et al., 2023; Su et al., 2021).

In biodiversity studies, fish assemblages are commonly evaluated using indices such as species richness, Shannon–Wiener diversity, Simpson's dominance, and Pielou's evenness, which together provide a more complete understanding of community structure by considering both the number of species present and the distribution of individuals among species (Shannon, 1948; Simpson, 1949; Pielou, 1966). However, these diversity measures become more meaningful when interpreted along with environmental variables through statistical approaches such as correlation, regression, and multivariate analysis, as these methods help explain the ecological processes and environmental gradients shaping fish communities (Karr, 1981; Braak and Verdonschot, 1995).

Korba district, Chhattisgarh, provides an ideal setting for evaluating the relationship between fish diversity and water quality. The Hasdeo, Tan, Ahiran, and Chornai rivers differ in their hydrological characteristics, habitat conditions, and levels of anthropogenic disturbance, making them suitable for comparative ecological assessment. Rivers with higher dissolved oxygen and lower pollution loads are generally expected to support greater species richness and diversity, whereas environmentally stressed systems often exhibit reduced diversity and increased dominance by tolerant species (Mishra et al., 2018; Patel, 2025).

Although freshwater biodiversity and water quality have been studied in various parts of India, integrated analyses linking fish diversity with physicochemical parameters remain limited for the river systems of Korba district. Therefore, the present study investigates the relationship between fish assemblages and water quality across the four rivers, by combining biodiversity indices with physicochemical assessments and statistical analysis . The findings provide important baseline information for freshwater ecosystem assessment, fisheries management, pollution monitoring, biodiversity conservation, and sustainable river management in the region. The objectives of the present study are:

I. To assess fish diversity and physicochemical parameters of water across four selected rivers of Korba District.

II. To examine the statistical relationship between environmental variables and patterns of fish diversity.

MATERIALS AND METHODS

Study Area

The present study was conducted in four major river systems of Korba district, Chhattisgarh, India, namely the Hasdeo, Tan, Ahiran, and Chornai rivers. Korba district lies approximately between 22°01′–23°01′ N latitude and 82°07′–83°07′ E longitude and is characterized by a tropical monsoonal climate with distinct pre-monsoon, monsoon, and post-monsoon seasons. These rivers support local fisheries, irrigation, domestic water use, and diverse freshwater habitats.

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Table 1. Sampling Sites Selected from Four Rivers of Korba District

S. No.	River	Site Code	Place Name	Stretch	Geographical Location
1	**Hasdeo River**	HS-1	Aitma Nagar (Bango)	Upstream	22.610318° N, 82.595326° E
		HS-2	Manjhidera (Darri Dam)	Midstream	22.438434° N, 82.686050° E
		HS-3	Thakur Ghat (Korba)	Downstream	22.340362° N, 82.694059° E
2	**Tan River**	TS-1	Gumani Dand (Jatga)	Upstream	22.708028° N, 82.400943° E
		TS-2	Gursia Pool	Midstream	22.643210° N, 82.523833° E
		TS-3	Podi Uproda Pool	Downstream	22.604102° N, 82.560125° E
3	**Ahiran River**	AS-1	Khodri (Tuman)	Upstream	22.586498° N, 82.411418° E
		AS-2	Sura Kachhar (Banki Mongra)	Midstream	22.378418° N, 82.632855° E
		AS-3	Dhanwar Para (Kusmunda)	Downstream	22.352203° N, 82.646825° E
4	**Chornai River**	CS-1	Keubahar (Mandir Ghat)	Upstream	22.621206° N, 82.855717° E
		CS-2	Lemru Pool (Bazar)	Midstream	22.650031° N, 82.835992° E
		CS-3	Deopahri Waterfall	Downstream	22.637436° N, 82.806604° E

Abbreviations**:** HS=Hasdeo Site**,** AS=Ahiran Site**,** TS=Tan Site**,** CS=Chornai Site;

For ecological comparison, three sampling stations were selected from each river, representing upstream, midstream, and downstream stretches. Thus, a total of 12 sampling sites were selected across the four rivers. Site selection was based on river accessibility, flow condition, habitat heterogeneity, riparian condition, fishing activity, and visible anthropogenic disturbance. Such spatial stratification helps in understanding river-wise and site-wise variation in fish assemblages and water quality conditions.

Sampling Design

The study followed a stratified seasonal sampling design. The four rivers were considered as primary strata, and within each river, three representative sampling stations were selected. Seasonal sampling was carried out during March 2025 to April 2026, covering pre-monsoon, monsoon, and post-monsoon periods.

Sampling was conducted at each of the 12 stations during all three seasons, resulting in 36 site-season observations. This design allowed comparison of fish diversity and physicochemical water quality across spatial and seasonal gradients. Seasonal sampling was conducted on weekends during two daily time intervals, i.e., morning hours from 07:00 AM to 10:00 AM and evening hours from 04:00 PM to 06:00 PM, to cover active fishing periods and minimize temporal sampling bias.

Table2. Sampling design adopted for seasonal fish and water quality samplingAcross four rivers of the Korba District, Chhattisgarh duringMarch 2025 - April 2026

	HasdeoRiver			**AhiranRiver**			**TanRiver**			**ChornaiRiver**			**Total**
Season/Month/ Site Code	HS1	HS2	HS3	AS1	AS2	AS3	TS1	TS2	TS3	CS1	CS2	CS3	
Pre Monsoon (Mar.-Jun.)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
Monsoon (Jul.-Sep.)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12

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Post Monsoon (Oct.-Apr.)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
Total	3	3	3	3	3	3	3	3	3	3	3	3	36

Abbreviations: **HS**=Hasdeo Site, **AS**=Ahiran Site, **TS**=Tan Site, **CS**=Chornai Site;

S1-S3 = Sampling sites; ✓ = Sampling conducted

Fish Sampling Methodology

Fish sampling was conducted with the help of local fishers using different fishing gears according to river depth, flow condition, habitat structure, and fish size. Cast nets of 10–15 mm mesh size, drag/seine nets of 10–20 mm mesh size, gill nets of 20–35 mm mesh size, and hand nets were used for fish collection. Similar fishing gears and comparable sampling effort were maintained across sites and seasons as far as possible.

At each sampling site, collected fishes were sorted, counted, photographed, and identified up to species level. Local fisher information and landing observations were also used to supplement field records, especially for species that were uncommon or seasonally available. Doubtful specimens were preserved and later confirmed using standard taxonomic literature and expert consultation. Fish identification was carried out following standard taxonomic keys and ichthyological references such as Talwar and Jhingran (1991), Jayaram (2010), and Nelson et al. (2016).

Fish diversity was assessed using species richness, Shannon–Wiener diversity index, Simpson's dominance index, and Pielou's evenness index. Species richness was considered as the total number of fish species recorded from each site or river. Shannon–Wiener diversity index was used to measure overall diversity by considering both abundance and evenness, Simpson's index was used to assess dominance, and Pielou's evenness index was used to evaluate the uniformity of individuals among species (Shannon, 1948; Simpson, 1949; Pielou, 1966).

Water Quality Analysis

Water samples were collected from the same locations where fish sampling was carried out, so that fish diversity could be directly compared with physicochemical water conditions. Water quality parameters included temperature, pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand and total dissolved solids.

Temperature and pH were measured in the field immediately after sample collection using calibrated instruments. Dissolved oxygen, BOD, COD and TDS were analyzed following standard procedures recommended by APHA. Dissolved oxygen was fixed in the field where required and analyzed using standard Winkler or laboratory-based methods. BOD was estimated after incubation, while COD was determined using standard chemical oxidation procedures. All water quality analyses were performed according to Standard Methods for the Examination of Water and Wastewater (Baird et al., 2017).

Quality Assurance and Quality Control

Quality assurance and quality control measures were followed during field sampling, sample handling, laboratory analysis, species identification, and data entry. Water samples were collected in clean, properly labeled, and pre-rinsed sampling bottles. Instruments used for field measurement were calibrated before use to ensure reliability of recorded values.

Water samples were transported carefully to the laboratory to minimize changes in physicochemical properties. Standard APHA protocols were followed for analysis of DO, BOD, COD and TDS. Wherever required, repeated measurements and cross-checking were performed to reduce analytical error. Fish sampling was carried out using comparable gear types and sampling effort across rivers and seasons.

For taxonomic quality control, fish specimens were identified using standard taxonomic keys, photographic records, and expert verification. Doubtful or uncommon species were rechecked before final inclusion in the checklist. Data were entered into spreadsheets and verified before statistical analysis to minimize transcription and calculation errors.

Data Analysis and Statistical Assumptions

Fish diversity and water quality data were analyzed using descriptive statistics, Pearson correlation, multiple linear regression, and Principal Component Analysis. Descriptive statistics were used to summarize river-wise and seasonal variation in fish diversity and physicochemical parameters. Pearson correlation analysis was used to examine the direction and strength of association between fish diversity indices and water quality parameters.

Multiple linear regression analysis was performed to identify important predictors of fish diversity. In the final regression model, dissolved oxygen, chemical oxygen demand, and total dissolved solids were included as predictor variables. Dissolved oxygen was selected because it is directly related to fish survival and respiration. COD was selected as a major pollution indicator because it showed a strong negative relationship with fish diversity. TDS was included because it represents dissolved mineral load and possible anthropogenic input. BOD and COD were carefully interpreted because both may show high inter-correlation; therefore, multicollinearity was checked before final model interpretation.

Before applying parametric statistical tests, major statistical assumptions were examined. Normality of variables and regression residuals was assessed using the Shapiro–Wilk test, Kolmogorov–Smirnov test, and normal probability plots. Homoscedasticity was evaluated using residual scatter plots and the Breusch–Pagan test, while independence of residuals was examined using the Durbin–Watson statistic. Multicollinearity among predictor variables was assessed using tolerance values and variance inflation factor (VIF) values. A VIF value below the accepted threshold was considered suitable for regression interpretation.

Principal Component Analysis was applied to identify major ecological gradients among fish diversity indices and physicochemical variables. Since the variables were measured in different units, data were standardized using Z-score transformation before PCA. The suitability of data for PCA was tested using the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity. PCA interpretation was based on eigenvalues, percentage of variance explained, component loadings, and river-wise PCA scores. Components with eigenvalues greater than 1 were considered important for ecological interpretation. All statistical analyses were carried out using SPSS version 26, and statistical significance was considered at $p < 0.05$.

RESULTS

Physicochemical Parameters of Water

Physicochemical parameters varied considerably among the four rivers. The Hasdeo River recorded comparatively higher dissolved oxygen levels (DO), and its BOD and COD values were modest, which led to the conclusion that the water quality was superior. The Tan and Chornai rivers, on the other hand, revealed considerably higher levels of BOD, COD, and TDS. The temperature of the rivers varied from 19.5 degrees Celsius to 32.2 degrees Celsius, depending on the season and location, whereas the pH of all rivers stayed within a slightly alkaline range (6.50–8.02).

Table 3: Systematic checklist of fish species recorded from Hasdeo, Tan, Ahiran, and Chornai rivers of the Korba District, Chhattisgarh, India, during March 2025-April 2026

Systematic position:

Phylum : Chordata

Subphylum : Vertebrata

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Infraphylum : Gnathostomata

Superclass : Pisces

Class : Teleostomi

Subclass : Actinopterygii

S. No.	**Order**	**Family**	**Species Name**	**Hasdeo**	**Tan**	**Ahiran**	**Chornai**	**IUCNStatus**
1	*Anabantiformes*	*Channidae*	*Channa gachua*	+	+	+	+	LC
2			*Channa punctatus*	+	+	+	+	LC
3			*Channa morulius*	+	+	+	+	LC
4			*Channa striatus*	+	+	+	+	LC
5		*Anabantidae*	*Anabas testudineus*	+	+	+	+	LC
6		*Nandidae*	*Nandus nandus*	+	+	+	+	LC
7		*Osphronemidae*	*Trichogaster fasciatus*	+	-	-	-	LC
8	*Beloniformes*	*Belonidae*	*Xenentodon cancilla*	+	+	+	+	LC
9	*Cichliformes*	*Cichlidae*	*Oreochromis mossambicus*	+	-	-	-	VU
10			*Oreochromis niloticus*	+	+	+	+	LC
11	*Clupeiformes*	*Clupidae*	*Gudusia chapra*	+	+	+	-	LC
12	*Cypriniformes*	*Cyprinidae*	*Catla catla*	+	+	+	+	LC
13			*Cirrhinus mrigala*	+	+	+	+	LC
14			*Labeo rohita*	+	+	+	+	LC
15			*Labeo calbasu*	+	+	+	+	LC
16			*Labeo gonius*	+	+	+	+	LC
17			*Labeo bata*	+	+	+	+	LC
18			*Cirrhinus reba*	+	-	+	-	LC
19			*Labeo angra*	+	-	+	-	LC
20			*Labeo boga*	+	-	-	-	LC
21			*Osteobrama cotio*	+	-	+	-	LC
22			*Puntius chola*	+	+	+	+	LC
23			*Puntius conchonicus*	+	+	+	+	LC
24			*Puntius sarana*	+	+	+	+	LC
25			*Puntius dorsalis*	+	+	+	+	LC
26			*Puntius ticto*	+	+	+	+	LC

27			*Puntius terio*	+	+	+	-	LC
28			*Puntius punctatus*	+	+	+	+	LC
29			*Ctenopharyngodon idella*	+	-	-	-	LC
30			*Cyprinus carpio*	+	-	-	-	LC
31		*Cobitidae*	*Lepidocephalichthys thermalis*	+	+	+	+	LC
32			*Lepidocephalichthys guntea*	+	+	+	+	LC
33		*Danionidae*	*Danio devario*	+	+	+	+	LC
34			*Chela cachius*	+	-	-	-	LC
35			*Esomus danricus*	+	+	+	+	LC
36			*Rasbora daniconius*	+	+	+	+	LC
37			*Amblypharyngodon mola*	+	+	+	+	LC
38			*Salmostoma bacaila*	+	+	+	+	LC
39			*Salmostoma phulo*	+	-	-	-	LC
40	*Gobiiformes*	*Gobiidae*	*Glossogobius giuris*	+	+	+	+	LC
41	*Mugiliformes*	*Ambassidae*	*Pseudambassis lala*	+	-	-	-	LC
42	*Osteoglossiformes*	*Notopteridae*	*Notopterus notopterus*	+	+	+	+	LC
43	*Perciformes*	*Ambassidae*	*Chanda nama*	+	+	+	+	LC
44			*Chanda ranga*	+	+	+	+	LC
45	*Siluriformes*	*Bagridae*	*Mystus bleekeri*	+	+	+	+	LC
46			*Mystus cavasius*	+	+	+	+	LC
47			*Mystus seenghala*	+	+	-	-	LC
48			*Mystus tengara*	+	+	+	+	LC
49			*Mystus vittatus*	+	+	+	+	LC
50			*Mystus aor*	+	-	-	-	LC
51		*Clariidae*	*Clarias batrachus*	+	-	-	-	LC
52		*Heteropneustidae*	*Heteropneustes fossilis*	+	+	+	+	LC
53		*Pangasiidae*	*Pangasius pangasius*	+	-	-	-	LC
54		*Ritidae*	*Rita rita*	+	+	+	-	LC
55		*Siluridae*	*Ompok bimaculatus*	+	+	+	+	NT
56			*Ompok pabda*	+	-	+	-	NT
57			*Wallago attu*	+	-	-	-	VU

58	*Synbranchiformes*	*Mastacembelidae*	*Macrognathus aculeatus*	+	+	+	+	LC
59			*Macrognathus armatus*	+	+	+	+	LC
60			*Mastacembelus pancalus*	+	+	+	+	LC
61		*Synbranchidae*	*Ophichthys cuchia*	+	-	-	-	LC
62	*Tetraodontiformes*	*Tetraodontidae*	*Leiodon cutcutia*	+	-	-	-	LC
Total	*12*	*23*	*62*	62	44	47	40	

Symbol : (+) Present , (-)Absent, (LC) Least concern, (VU) Vulnerable, (NT) Near threatened

Table 4 .River wise Species distribution

Category	**Hasdeo**	**Tan**	**Ahiran**	**Chornai**
Order	12	09	09	08
Family	23	16	16	14
Species	62	44	47	40

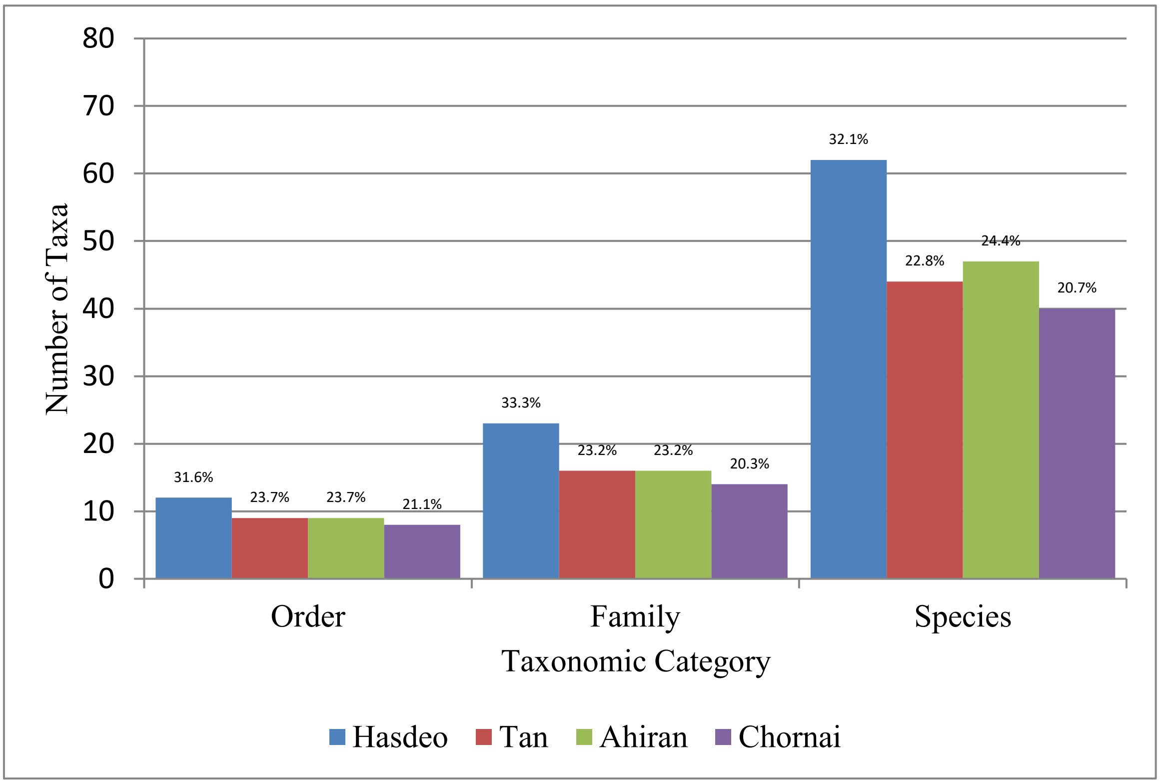

Figure 1. River-wise taxonomic composition of fish diversity.

Table 5. River-wise Seasonal Fish Abundance and Total Species Abundance

River	**Pre-monsoon Total Abundance**	**Monsoon Total Abundance**	**Post-monsoon Total Abundance**	**Total Species Abundance**
Hasdeo	1335	1485	1595	4415

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Tan	785	860	950	2595
Ahiran	935	1045	1150	3130
Chornai	655	730	835	2220
Grand Total	**3710**	**4120**	**4530**	**12360**

Hasdeo recorded the highest fish abundance. Ahiran and Tan showed intermediate abundance, whereas Chornai exhibited the lowest abundance, reflecting comparatively higher ecological stress. Seasonally, fish abundance peaked during winter/post-monsoon and declined during summer/pre-monsoon due to reduced water availability and habitat constraints.

Table 6. Combined Site-wise and Season-wise Dataset of Four Rivers(Fish Diversity Indices and Physicochemical Parameters, n = 36)

S. No.	River	Site Code	Season	Species Richness	Shannon H'	Simpson D	Pielou Evenness J'	Temp °C	pH	DO mg/L	BOD mg/L	COD mg/L	TDS mg/L
1	Hasdeo	HS-1	Pre-monsoon	38	3.42	0.10	0.86	29.8	7.1	6.5	4.0	17	95.4
2	Hasdeo	HS-1	Monsoon	41	3.50	0.09	0.88	25.2	6.58	8.2	3.6	16	150
3	Hasdeo	HS-1	Post-monsoon	43	3.56	0.08	0.90	20.0	6.74	8.1	2.8	12	75
4	Hasdeo	HS-2	Pre-monsoon	42	3.54	0.08	0.90	30.2	7.0	6.2	4.2	18	92.6
5	Hasdeo	HS-2	Monsoon	46	3.66	0.07	0.92	25.4	6.57	8.0	3.8	17	190
6	Hasdeo	HS-2	Post-monsoon	48	3.72	0.06	0.93	22.0	6.7	7.5	3.0	13	72
7	Hasdeo	HS-3	Pre-monsoon	40	3.48	0.09	0.88	30.5	7.2	6.0	4.4	19	97.3
8	Hasdeo	HS-3	Monsoon	44	3.58	0.08	0.90	25.6	6.55	7.7	4.0	18	130
9	Hasdeo	HS-3	Post-monsoon	46	3.64	0.07	0.92	24.0	6.81	7.0	3.2	14	87
10	Tan	TS-1	Pre-monsoon	28	2.98	0.14	0.78	31.2	7.88	5.8	6.1	29	450
11	Tan	TS-1	Monsoon	30	3.08	0.13	0.80	26.5	6.52	6.2	5.9	29	260
12	Tan	TS-1	Post-monsoon	32	3.16	0.12	0.82	20.8	7.69	7.8	5.0	23	380
13	Tan	TS-2	Pre-monsoon	30	3.05	0.13	0.80	32.1	8.02	5.6	6.4	31	470
14	Tan	TS-2	Monsoon	32	3.12	0.12	0.82	26.4	6.57	6.8	6.2	31	240
15	Tan	TS-2	Post-monsoon	34	3.20	0.11	0.84	21.4	7.84	7.5	5.3	25	430
16	Tan	TS-3	Pre-monsoon	27	2.94	0.15	0.77	31.6	7.95	5.7	6.7	33	465
17	Tan	TS-3	Monsoon	29	3.02	0.14	0.79	26.3	6.64	7.0	6.5	33	160
18	Tan	TS-3	Post-monsoon	31	3.12	0.13	0.81	20.8	7.66	7.6	5.6	27	425
19	Ahiran	AS-1	Pre-monsoon	32	3.12	0.12	0.83	30.8	7.6	6.0	4.6	22	210
20	Ahiran	AS-1	Monsoon	35	3.22	0.11	0.85	25.3	6.5	7.4	4.3	21	165

21	Ahiran	AS-1	Post-monsoon	37	3.30	0.10	0.87	19.5	7.83	8.1	3.5	17	85
22	Ahiran	AS-2	Pre-monsoon	34	3.18	0.11	0.85	31.5	7.7	5.8	4.8	23	230
23	Ahiran	AS-2	Monsoon	37	3.28	0.10	0.87	25.5	6.50	7.1	4.5	22	185
24	Ahiran	AS-2	Post-monsoon	39	3.36	0.09	0.89	20.1	6.89	8.3	3.7	18	89
25	Ahiran	AS-3	Pre-monsoon	30	3.06	0.13	0.81	32.2	7.5	5.6	5.0	24	260
26	Ahiran	AS-3	Monsoon	33	3.16	0.12	0.83	26.1	6.55	7.0	4.7	23	275
27	Ahiran	AS-3	Post-monsoon	35	3.24	0.11	0.85	20.6	6.57	8.0	3.9	19	82
28	Chornai	CS-1	Pre-monsoon	24	2.72	0.17	0.76	30.5	6.9	5.5	6.8	31	110
29	Chornai	CS-1	Monsoon	26	2.82	0.16	0.78	26.2	6.51	6.2	6.6	31	62
30	Chornai	CS-1	Post-monsoon	28	2.92	0.15	0.80	24.5	6.58	8.0	5.7	25	80
31	Chornai	CS-2	Pre-monsoon	26	2.78	0.16	0.78	31.2	7.1	5.2	7.1	33	120
32	Chornai	CS-2	Monsoon	28	2.86	0.15	0.80	27.0	6.53	6.5	6.9	33	65
33	Chornai	CS-2	Post-monsoon	30	2.96	0.14	0.82	23.8	6.83	8.4	6.0	27	58
34	Chornai	CS-3	Pre-monsoon	25	2.76	0.16	0.77	32.0	7.0	4.8	7.4	35	150
35	Chornai	CS-3	Monsoon	27	2.84	0.15	0.79	25.3	6.58	5.8	7.2	35	140
36	Chornai	CS-3	Post-monsoon	31	3.02	0.13	0.83	22.9	6.73	8.8	6.3	29	55

Fish Species Richness and Diversity

A total of 62 fish species belonging to 12 orders, 23 families, and 36 genera were recorded from the four rivers. Hasdeo River recorded the highest species richness (62 species) and the highest site- and season-wise mean Shannon–Wiener diversity value (H′ = 3.57), indicating comparatively better ecological conditions. In contrast, Chornai River recorded the lowest species richness (40 species) and comparatively lower site- and season-wise mean Shannon–Wiener diversity value (H′ = 2.85), suggesting greater ecological stress than the other rivers.Fish diversity was evaluated using standard ecological indices as:

Species Richness

Species richness was calculated as the total number of fish species recorded at each site or river during a particular season.

Shannon-Wiener Diversity Index (H′)

The Shannon-Wiener index was used to assess species diversity by considering both abundance and evenness.

$H' = -\sum(p_i \ln p_i)$

Where:

H′ = Shannon–Wiener diversity index

p_i = proportion of individuals in the *i*th species

ln = natural logarithm

S = total number of species

Simpson's Index

Simpson's index was used to estimate dominance or diversity concentration within fish assemblages.

$D = \sum_{i=1}^{s} p_i^2$

Where:

D = Simpson's dominance index

p_i = proportion of individuals in the i-th species

S = total number of species

Lower dominance generally indicates healthier and more evenly distributed fish communities.

Pielou's Evenness Index (J′)

Evenness was computed to understand the uniformity of species distribution.

$J' = H' / \ln(S)$

Where:

J′ = Pielou's evenness index

H′ = Shannon–Wiener diversity index

S = total number of species

ln = natural logarithm.

Higher evenness values indicate a more equitable distribution of individuals among species.

Relationship Between Water Quality and Fish Diversity

The present section evaluates the relationship between fish diversity indices and physicochemical characteristics of river water using Pearson correlation, multiple linear regression and principal component analysis (PCA).

Statistical Approach

Pearson correlation analysis was used to assess the strength and direction of association between selected water quality variables and fish diversity indices. The fish diversity variables included species richness, Shannon-Wiener diversity index, Simpson's dominance index and Pielou's evenness index. The physicochemical variables included temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS).

Pearson Correlation Coefficient

$r = \Sigma[(X_i - \bar{X})(Y_i - \bar{Y})] / \sqrt{\Sigma(X_i - \bar{X})^2 \times \Sigma(Y_i - \bar{Y})^2}$

Where

r = Pearson correlation coefficient;

X_i = observed value of the first variable, such as DO, BOD, COD, TDS, temperature and pH;

Y_i = observed value of the second variable, such as species richness, Shannon-Wiener index, Simpson's dominance or Pielou's evenness;

$\bar{X}$ and $\bar{Y}$ = mean values of X and Y variables, respectively; and Σ = summation of all observations.

Table 7. Correlation Matrix Between Fish Diversity Indices And Physicochemical Parameters

Parameter	**Species Richness**	**Shannon-Wiener (H')**	**Simpson's Dominance (D)**	**Pielou's Evenness (J')**
Temperature	-0.38*	-0.35*	0.38*	-0.42**
pH	-0.20	-0.13	0.12	-0.22
DO	0.49**	0.47**	-0.48**	0.54**
BOD	-0.90**	-0.91**	0.92**	-0.91**
COD	-0.91**	-0.91**	0.91**	-0.92**
TDS	-0.28	-0.19	0.19	-0.35*

* Significant at $p < 0.05$; ** Significant at $p < 0.01$.

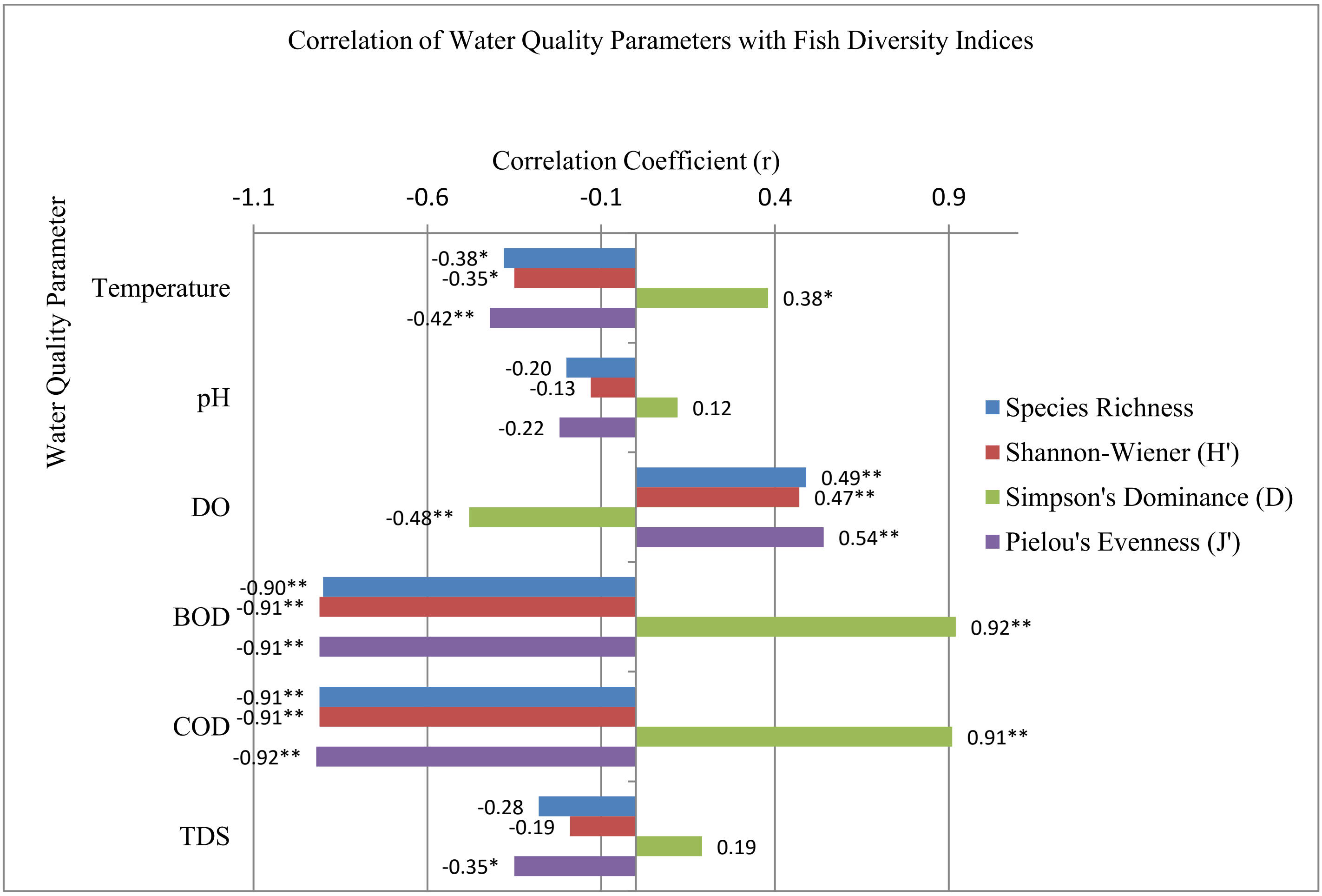

Figure 2. Correlation graph showing positive and negative correlations separately. Significance marks are included on the bars (* $p < 0.05$, ** $p < 0.01$).

The correlation analysis indicated that dissolved oxygen (DO) had a significant positive relationship with species richness ($r = 0.49$, $p < 0.01$), Shannon–Wiener diversity ($r = 0.47$, $p < 0.01$), and Pielou's evenness ($r = 0.54$, $p < 0.01$), while showing a negative relationship with Simpson's dominance ($r = -0.48$, $p < 0.01$). In contrast, BOD and COD exhibited the strongest negative effects on fish diversity. BOD was negatively correlated with species richness ($r = -0.90$), Shannon diversity ($r = -0.91$), and evenness ($r = -0.91$), and positively correlated with dominance ($r = 0.92$). Similarly, COD showed strong negative correlations with species richness ($r = -0.91$), Shannon diversity ($r = -0.91$), and evenness ($r = -0.92$), while its correlation with dominance was positive ($r = 0.91$), all significant at $p < 0.01$. Temperature showed weak negative relationships with diversity indices, whereas pH had no significant influence. Overall, the results indicate that higher dissolved oxygen promotes richer and more balanced fish communities, while increasing BOD and COD reduce diversity and favor pollution-tolerant species.

Multiple Linear Regression Analysis

DO, COD, and TDS were selected for the final regression model because they represent three important ecological dimensions of river water quality: oxygen availability, chemical pollution load, and dissolved mineral/anthropogenic input. DO was included as a key requirement for fish survival and habitat suitability, while COD was retained as the major pollution indicator due to its strong negative relationship with fish diversity. TDS was included as a supporting indicator of dissolved solids and water quality variation. BOD was excluded from the final COD-based model to avoid possible multicollinearity with COD, as both parameters reflect organic and pollution load. Therefore, the selected predictors were considered suitable for evaluating the combined influence of water quality on fish diversity. Multiple linear regression analysis was applied to estimate the predictive influence of selected water quality parameters on fish diversity. In the revised COD-based model, species richness was treated as the dependent variable, while DO, COD and TDS were entered as predictor variables.

General Multiple Linear Regression Formula

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n + e$$

Where

Y = dependent variable, i.e., fish diversity measure;

a = intercept or constant value;

$b_1, b_2, b_3 \ldots b_n$ = regression coefficients;

$X_1, X_2, X_3 \ldots X_n$ = independent variables, i.e., physicochemical parameters; and e = error term.

Regression Model Used in the Present Study

$$Fish\ Diversity = a + b_1(DO) + b_2(COD) + b_3(TDS) + e$$

Table 8. Diagnostic Tests for Multiple Linear Regression Assumptions

Assumption	Test/Criteria	Result	Decision
Normality of residuals	Shapiro–Wilk test	W = 0.982, p = 0.819	Normality satisfied
Normality of residuals	Kolmogorov–Smirnov test	D = 0.098, p = 0.848	Normality satisfied
Multicollinearity	VIF and Tolerance	VIF = 1.123–1.455; Tolerance = 0.687–0.891	No serious multicollinearity

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Homoscedasticity	Breusch–Pagan test	LM = 3.081, p = 0.379; F = 0.998, p = 0.406	Homoscedasticity satisfied
Residual independence	Durbin–Watson statistic	DW = 0.997	Possible positive autocorrelation; interpret cautiously

VIF = variance inflation factor; DO = dissolved oxygen; COD = chemical oxygen demand; TDS = total dissolved solids. A p-value greater than 0.05 for normality and Breusch–Pagan tests indicates that the assumptions are not violated.

Interpretation: The diagnostic tests indicate that the regression residuals were normally distributed and the Breusch–Pagan test was non-significant, suggesting homoscedasticity. VIF values ranged from 1.123 to 1.455, indicating absence of serious multicollinearity among DO, COD and TDS. The Durbin–Watson value was 0.997, suggesting possible positive autocorrelation; therefore, regression findings should be interpreted cautiously with respect to the site-season sampling structure.

Table 9. Multiple regression analysis of species richness on selected water quality factors

Predictor	Standardized Coefficient (β)	t-value	Significance (p)
DO	0.008	0.09	0.927
COD	-0.903	-10.10	< 0.001**
TDS	-0.002	-0.02	0.984

* Significant at p < 0.05; ** Significant at p < 0.01.

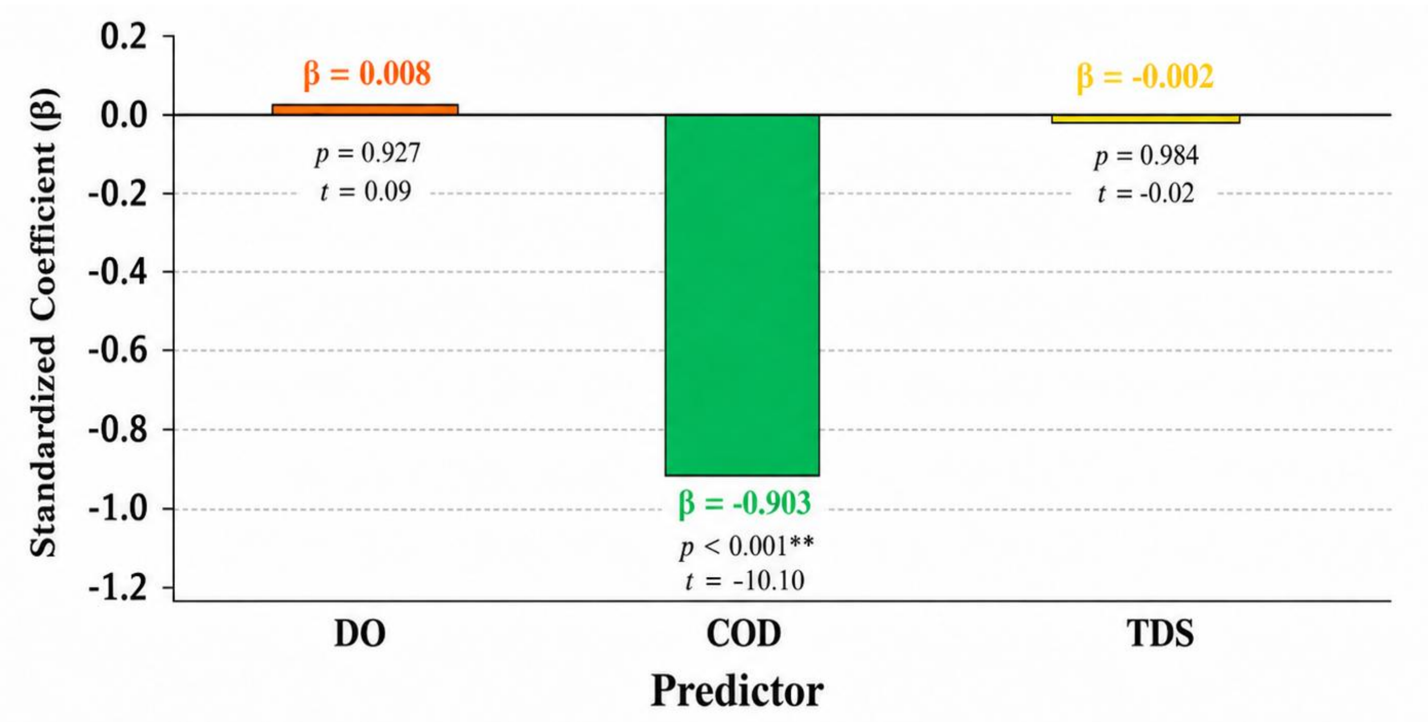

Figure3. Standardized regression coefficient (β) plot showing the relative effect of water quality predictors on fish diversity

The regression results demonstrate that COD was the only statistically significant predictor in the model (β = -0.903, t = -10.10, p < 0.001). The negative coefficient indicates that increasing COD substantially reduces fish diversity, reflecting the adverse influence of chemical pollution and organic load on aquatic community structure. In contrast, DO (β = 0.008, t = 0.09, p = 0.927) and TDS (β = -0.002, t = -0.02, p = 0.984) were statistically non-significant predictors in the COD-based model. COD emerged as the dominant explanatory factor in this regression model.

Principal Component Analysis of Environmental Variables

Principal component analysis was performed after Z-score normalization because the selected variables were measured in different units. Standardization converted each variable into a unit-free scale, thereby allowing direct comparison of component loadings and ordination scores.

Z-score Standardization Formula

$Z_{ij} = (X_{ij} - \bar{X}_j) / SD_j$

Where

Z_{ij} = standardized value of the variable;

X_{ij} = observed value;

$\bar{X}_j$ = mean value of the variable; and SD_j = standard deviation of the variable.

Eigenvalue Equation

$|R - \lambda I| = 0$

Where

R = correlation matrix, λ = eigenvalue and I = identity matrix.

General Form of Principal Components

$PC_1 = a_{11}Z_1 + a_{12}Z_2 + a_{13}Z_3 + ... + a_{1n}Z_n$

$PC_2 = a_{21}Z_1 + a_{22}Z_2 + a_{23}Z_3 + ... + a_{2n}Z_n$

PCA Model for the Present Study

$PC = a_1(DO) + a_2(BOD) + a_3(COD) + a_4(TDS) + a_5(Temperature) + a_6(pH) + diversity\ variables$

Percentage of Variance Explained

$Variance\ explained\ (\%) = (\lambda_i / \Sigma\lambda) \times 100$

Table 10. KMO and Bartlett’s Test of Sphericity

Test	**Value**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.690
Bartlett’s Test of Sphericity: Approx. Chi-square	711.899
df	45
Significance	$p < 0.001$

Interpretation: The KMO value of 0.690 indicates acceptable sampling adequacy for PCA. Bartlett’s test of sphericity was significant ($\chi^2 = 711.899$, df = 45, $p < 0.001$), confirming that the correlation matrix is suitable for Principal Component Analysis.

Table 11. PCA eigenvalues and variance explained for the first six principal components

Principal Component	Eigenvalue	Variance Explained (%)	Cumulative Variance (%)
PC1	6.443	64.43	64.43
PC2	1.716	17.16	81.59
PC3	1.157	11.57	93.16
PC4	0.362	3.62	96.77
PC5	0.156	1.56	98.33
PC6	0.131	1.31	99.63

Interpretation; Although PC3 had an eigenvalue greater than 1, PC1 and PC2 together explained 81.59% of the total variance and provided the clearest ecological separation among rivers; therefore, interpretation was focused mainly on the first two components.

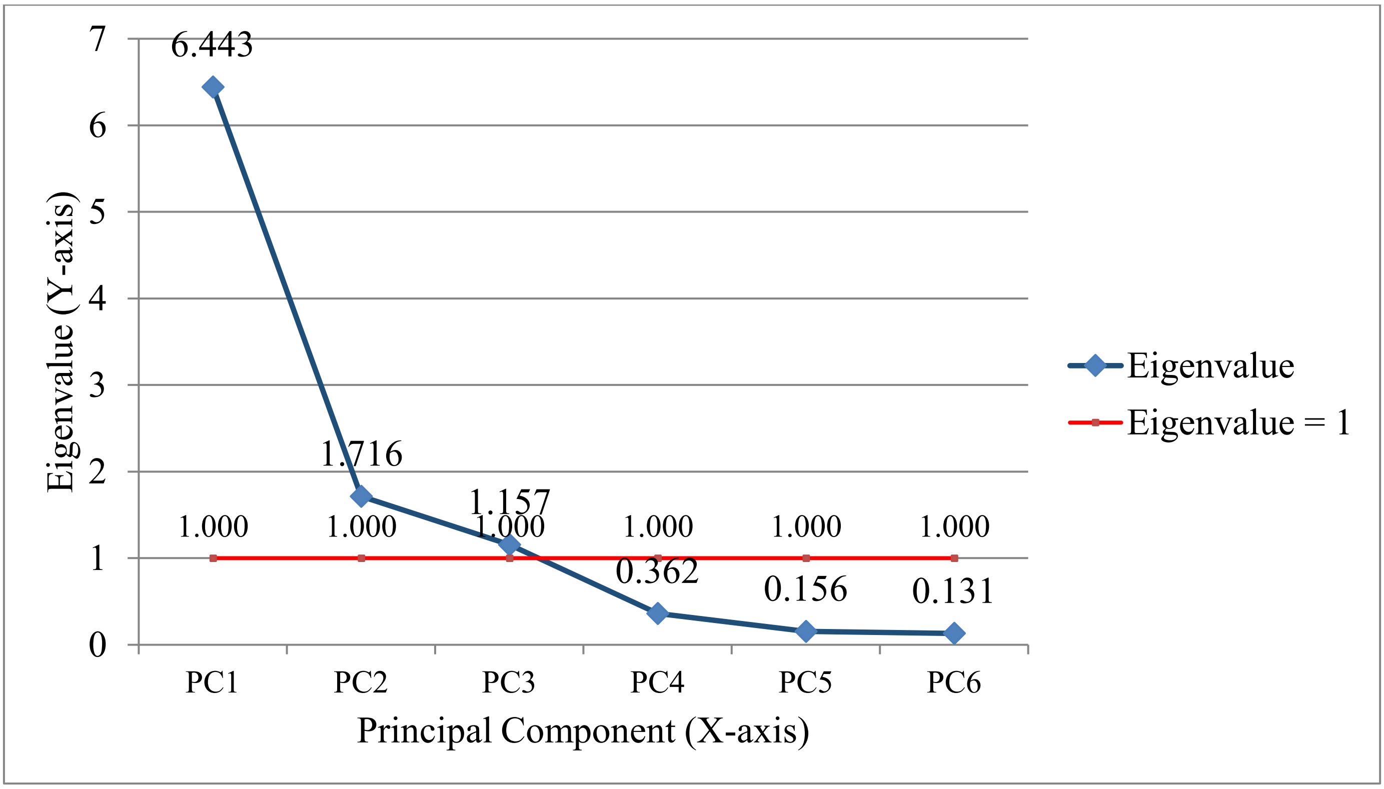

Figure 4. Scree plot showing eigenvalues of principal components derived from standardized fish diversity and physicochemical variables. Components with eigenvalues greater than 1 were considered important for ecological interpretation

Table 12. PCA Component Loadings After Z-Score Normalization

Variable	PC1	PC2	PC3	PC4
Species Richness	0.965	0.154	0.137	0.106
Shannon H'	0.952	0.237	0.099	0.129
Simpson D	-0.957	-0.233	-0.080	-0.107
Pielou J'	0.976	0.088	0.123	0.026

Temp °C	-0.553	0.445	0.660	0.023
pH	-0.263	0.810	-0.349	-0.365
DO	0.656	-0.416	-0.570	-0.004
BOD	-0.949	-0.172	-0.007	0.134
COD	-0.949	-0.152	-0.049	0.181
TDS	-0.365	0.704	-0.470	0.370

Table 13. River-Wise Mean PCA Scores

River	PC1 Score	PC2 Score	Interpretation
Hasdeo	3.161	0.324	Highest diversity and better water quality
Ahiran	0.786	0.185	Moderate to good ecological condition
Tan	-1.581	0.890	Pollution stress and lower diversity; PC2 influenced by pH, TDS and temperature
Chornai	-2.365	-1.399	Highest ecological stress and lowest diversity

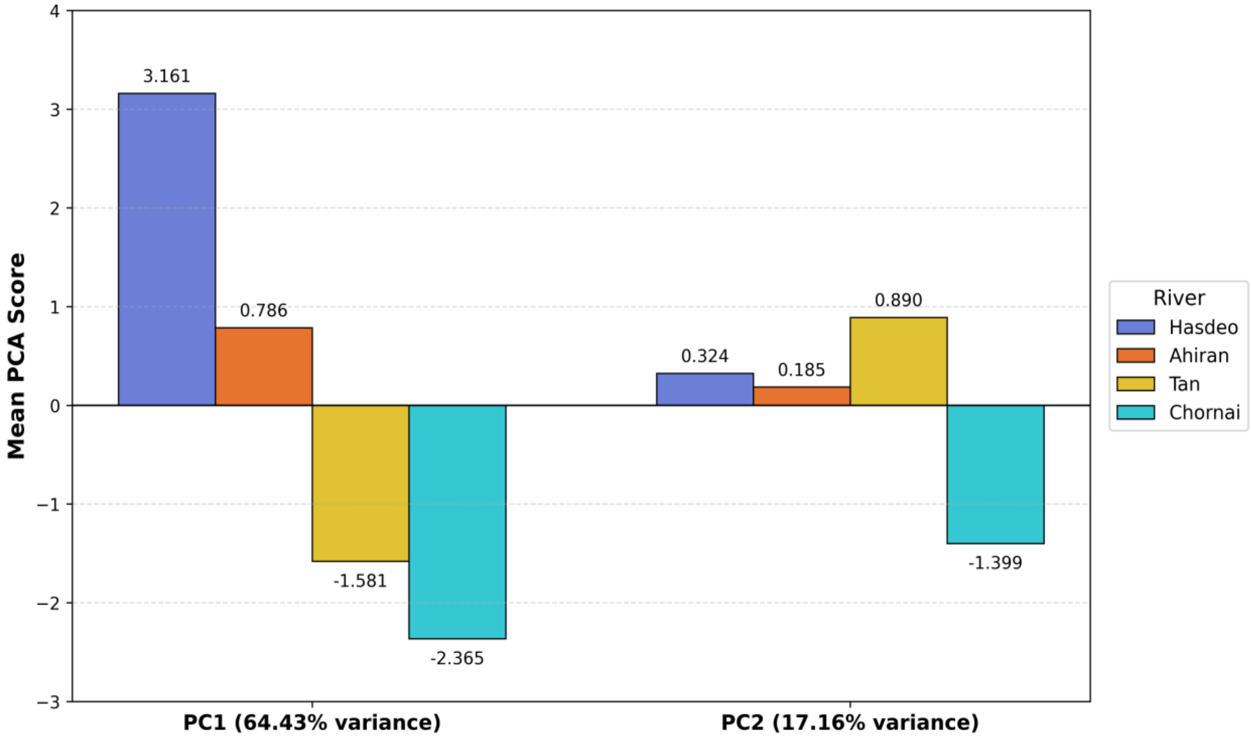

Figure 5. River-wise mean PCA scores showing ecological separation among the four rivers based on PC1 and PC2.

Interpretation

PCA showed that PC1 explained 64.43% of the total variance and represented the main fish diversity–water quality gradient. It had strong positive loadings for species richness (0.965), Shannon–Wiener diversity (0.952), Pielou's evenness (0.976), and DO (0.656), while Simpson's dominance (−0.957), BOD (−0.949), COD (−0.949), and TDS (−0.365) loaded negatively. Thus, positive PC1 scores indicate higher fish diversity and better oxygenated conditions, whereas negative scores reflect pollution stress and reduced diversity.

PC2 explained 17.16% of the variance and was mainly related to pH (0.810), TDS (0.704), temperature (0.445), and negatively with DO (−0.416), indicating a seasonal temperature–pH–mineralization gradient.

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Together, PC1 and PC2 explained 81.59% of total variation, showing that PCA effectively summarized the major ecological patterns.

River-wise scores confirmed ecological differences: Hasdeo had the highest positive PC1 score (3.161), showing the best ecological condition, followed by Ahiran (0.786). Tan (−1.581) and Chornai (−2.365) showed negative PC1 scores, denoting pollution stress and lower fish diversity, with Chornai being the most stressed river.

DISCUSSION

Influence of Water Quality on Fish Diversity

The present study indicates that fish diversity patterns in the selected rivers of Korba district were closely associated with physicochemical water quality conditions. Comparative analysis showed clear ecological variation among the Hasdeo, Tan, Ahiran, and Chornai rivers in terms of species richness, Shannon–Wiener diversity, Simpson's dominance, and Pielou's evenness. The Hasdeo River recorded the highest species richness and diversity values, suggesting relatively favourable habitat and water quality conditions. In contrast, the Tan and Chornai rivers showed comparatively lower diversity and higher dominance values, which may reflect greater ecological stress and a higher representation of tolerant species.

These findings are consistent with earlier studies reporting close relationships between water quality, habitat condition, and fish assemblage structure in riverine ecosystems. Similar patterns have been reported from the Mahanadi River Basin (Mishra et al., 2018), the Ganga tributaries of northern India (Singh et al., 2025), the Yangtze River Basin, China (Fu et al., 2003), and Neotropical rivers of Brazil (Agostinho et al., 2008), where habitat degradation, pollution pressure, and anthropogenic disturbances were associated with changes in fish community composition. At the global scale, freshwater biodiversity decline has also been linked with increasing pressures from industrialization, pollution, habitat modification, and flow alteration (Reid et al., 2019; Albert et al., 2021).

Role of Dissolved Oxygen in Regulating Fish Diversity

Dissolved oxygen appeared to be an important environmental variable associated with fish diversity in the studied rivers. Significant positive correlations were observed between DO and species richness ($r = 0.49$), Shannon–Wiener diversity ($r = 0.47$), and Pielou's evenness ($r = 0.54$), whereas Simpson's dominance showed a negative correlation with DO ($r = -0.48$). These relationships suggest that oxygen-rich conditions were generally associated with richer and more evenly distributed fish assemblages.

Ecologically, higher dissolved oxygen may indicate better aeration, lower organic load, and improved habitat suitability for a wider range of fish species. However, DO should not be interpreted as acting alone, because fish assemblages are also shaped by habitat structure, flow condition, food availability, seasonal migration, substrate type, and anthropogenic disturbance. Similar observations have been reported in tropical and temperate freshwater ecosystems, where dissolved oxygen is considered an important indicator of habitat quality and fish assemblage condition (Karr, 1981; Arthington et al., 2016; Su et al., 2021). Comparable positive associations between dissolved oxygen and fish diversity have also been documented in the Yangtze River Basin (Fu et al., 2003) and Mekong River Basin (Ziv et al., 2012), indicating the broader ecological relevance of oxygen availability in maintaining riverine fish communities.

Impact of Organic and Chemical Pollution

BOD and COD showed the strongest negative associations with fish diversity indices in the present study. Higher BOD and COD values were associated with lower species richness, Shannon diversity, and evenness, while Simpson's dominance increased under such conditions. This pattern suggests that sites with higher organic and chemical pollution loads may support fewer sensitive species and may favour a limited number of tolerant taxa.

From an ecological perspective, elevated BOD and COD indicate greater organic and chemical oxygen demand in the aquatic system. Such conditions can contribute to reduced oxygen availability and may create stressful habitats for many freshwater fishes, particularly species that require well-oxygenated water. However, the present results should be interpreted as statistical associations rather than direct proof of causation, because fish diversity may also be influenced by habitat complexity, fishing pressure, seasonal flow variation, and local disturbance.

Similar associations between pollution indicators and reduced fish diversity have been reported from freshwater ecosystems in India (Patel, 2025), Brazil (Agostinho et al., 2008), and global freshwater assessments (Reid et al., 2019; Su et al., 2021). The present findings therefore support the broader understanding that anthropogenic pollution pressure is an important ecological factor associated with freshwater biodiversity decline (Tickner et al., 2020; Albert et al., 2021).

Influence of Temperature, pH and TDS

Temperature showed weak to moderate negative relationships with fish diversity indices. This may indicate that higher water temperature, particularly during the pre-monsoon season, was associated with relatively lower diversity and evenness. Ecologically, increased temperature may affect fish assemblages indirectly by influencing oxygen solubility, metabolic activity, breeding behaviour, and habitat suitability. Similar temperature-related patterns have been reported in subtropical and tropical river systems of Asia and South America (Fu et al., 2003; Su et al., 2021).

In contrast, pH showed weak and statistically non-significant relationships with fish diversity. This suggests that pH values in the studied rivers remained within a range that was generally tolerable for most recorded freshwater fish species during the study period. Therefore, pH may not have acted as a major limiting factor in the present dataset.

TDS showed comparatively weaker relationships with fish diversity than BOD and COD. However, its association with evenness suggests that dissolved solids and mineral load may contribute to changes in community structure at some sites. Higher TDS values may reflect natural geological inputs as well as anthropogenic influences such as runoff, domestic discharge, or other land-use-related inputs. Thus, TDS should be interpreted as a supporting indicator of water quality variation rather than a single determining factor.

Statistical Validation through Multiple Regression Analysis

Multiple regression analysis provided further insight into the relationship between selected water quality variables and fish diversity. In the final model, COD emerged as the only statistically significant predictor ($\beta = -0.903$, $p < 0.001$). This result suggests that COD had the strongest independent statistical association with fish diversity among the selected predictor variables. However, this should be interpreted cautiously, as regression analysis identifies predictive relationships but does not by itself establish direct causation.

The negative coefficient of COD indicates that higher COD values were associated with lower fish diversity in the studied rivers. This pattern is ecologically meaningful because COD represents chemical oxygen demand and may reflect organic and chemical pollution pressure. Similar regression-based studies from freshwater ecosystems have also identified organic and chemical pollution indicators as important variables associated with fish community structure (Karr, 1981; Su et al., 2021).

Although dissolved oxygen was not statistically significant in the regression model, its positive correlation with diversity indices indicates that it remains ecologically relevant. The non-significant regression result may be due to shared variation among water quality variables, particularly the possible interrelationship between DO, BOD, and COD. Therefore, COD should be interpreted as the strongest statistical predictor in the present model, while DO remains an important ecological indicator of habitat condition.

Insights from Principal Component Analysis

Principal Component Analysis helped summarize the major ecological gradients present in the dataset. PC1 explained 64.43% of the total variance and represented a broad water quality–fish diversity gradient. Positive loadings of species richness, Shannon diversity, Pielou's evenness, and dissolved oxygen indicated relatively favourable ecological conditions, whereas negative loadings of Simpson's dominance, BOD, COD, and TDS indicated comparatively stressed conditions.

This pattern suggests that sites with higher DO and higher diversity indices were positioned toward the positive side of PC1, while sites with higher BOD, COD, TDS, and dominance values were positioned toward the negative side. Similar PCA-based environmental gradients have been reported from freshwater ecosystems in China (Fu et al., 2003), Europe (Su et al., 2021), and Indian river systems (Mishra et al., 2018), where pollution-related variables and oxygen conditions explained important variation in fish assemblage structure.

PC2 explained 17.16% of the variance and appeared to represent a seasonal physicochemical gradient associated with pH, temperature, and mineralization. This indicates that fish assemblages in the studied rivers were not only associated with pollution-related parameters but also with seasonal changes in water chemistry. Therefore, PCA supports the interpretation that fish diversity patterns across the Korba river systems reflect combined effects of water quality, seasonal variation, and site-specific ecological conditions.

Ecological Implications and Conservation Significance

The present study suggests that fish diversity in the rivers of Korba district is closely linked with water quality and habitat condition. Higher dissolved oxygen and lower pollution indicators were associated with greater species richness, higher Shannon diversity, and better evenness, whereas higher BOD and COD were associated with reduced diversity and increased dominance. These patterns are consistent with global freshwater conservation studies emphasizing water quality degradation as one of the major pressures on freshwater biodiversity (Albert et al., 2021; Tickner et al., 2020; Reid et al., 2019).

Among the investigated rivers, the Hasdeo River showed comparatively better ecological condition, while the Tan and Chornai rivers showed stronger indications of ecological stress. However, these differences should be viewed as ecological patterns observed during the study period rather than permanent river conditions, because river ecosystems are dynamic and may change with season, flow, land use, and management interventions.

From a conservation perspective, the findings highlight the need for regular water quality monitoring, identification of pollution sources, improved wastewater management, riparian habitat protection, and long-term fish diversity assessment in the Korba river systems. Maintenance of environmental flows and protection of breeding and nursery habitats may also help support native fish assemblages. Similar integrated river-basin management approaches have been recommended for major freshwater ecosystems worldwide, including the Mekong, Yangtze, and Neotropical river systems (Ziv et al., 2012; Fu et al., 2003; Agostinho et al., 2008).

MANAGEMENT RECOMMENDATIONS

The present findings suggest that river management in Korba district should focus on improving water quality, reducing pollution load, and protecting fish habitats. Since COD and BOD showed strong negative associations with fish diversity, untreated sewage, industrial discharge, agricultural runoff, and other organic or chemical inputs should be regularly monitored and controlled.

The Tan and Chornai rivers require priority attention because they showed comparatively lower fish diversity and stronger indicators of ecological stress. Regular monitoring of DO, BOD, COD, TDS, pH and temperature should be conducted across upstream, midstream, and downstream sites, particularly during pre-monsoon and post-monsoon seasons.

The Hasdeo River, which showed comparatively higher fish richness and diversity, should be protected as an important reference river system. Preventive measures such as control of waste disposal, sand mining, overfishing, and riverbank disturbance are necessary to maintain its ecological condition.

Riparian vegetation should be restored along degraded riverbanks to reduce sediment input, improve habitat stability, regulate water temperature, and support breeding and nursery habitats of fishes. Protection of shallow pools, side channels, and natural flow conditions should be included in local river conservation planning.

Sustainable fishing practices should be promoted through community awareness. Destructive fishing methods, poisoning, overfishing, and use of very small mesh-size nets should be discouraged, especially during breeding seasons.

A long-term river health monitoring programme should be developed for the Korba river systems by integrating fish diversity assessment, water quality analysis, habitat evaluation, and pollution-source mapping. Such integrated management will help conserve native fish diversity and improve freshwater ecosystem health (Albert et al., 2021; Arthington et al., 2016; Reid et al., 2019; Tickner et al., 2020).

Study Limitations And Future Research

The present study provides baseline information on the relationship between fish diversity and physicochemical water quality in the Hasdeo, Tan, Ahiran, and Chornai rivers of Korba district. However, the study was limited to 12 sampling sites and three seasonal observations; therefore, short-term monthly variation, extreme flow conditions, and long-term ecological changes could not be fully assessed. Fish sampling may also have been affected by gear selectivity, site accessibility, river depth, flow condition, and local fishing activity, due to which rare, cryptic, nocturnal, or migratory species may have been under-recorded.

The study focused mainly on selected physicochemical parameters such as temperature, pH, DO, BOD, COD and TDS. Other important factors, including river flow, habitat structure, substrate type, riparian vegetation, sediment quality, nutrients, heavy metals, plankton, macroinvertebrates, and land-use patterns, were not examined in detail. Therefore, the statistical relationships observed in correlation, regression, and PCA should be interpreted as ecological associations rather than direct causal effects.

Future research should include long-term and monthly monitoring of fish diversity and water quality across additional river stretches. Further studies should integrate habitat assessment, flow measurement, sediment and heavy metal analysis, nutrient load, plankton and macroinvertebrate diversity, and pollution-source mapping. Molecular approaches such as DNA barcoding and eDNA analysis may also be used for accurate species confirmation and detection of rare species. Such integrated research will support better conservation planning, sustainable fisheries management, and river ecosystem restoration in Korba district.

CONCLUSION

The study documented 62fish species belonging to 36 genera, 23 families, and 12 orders from the Hasdeo, Tan, Ahiran, and Chornai rivers. The Hasdeo River exhibited the highest species richness (62 species), followed by Ahiran (47), Tan (44), and Chornai (40), with peak diversity during the post-monsoon season. Correlation analysis showed that dissolved oxygenwas positively associated with species richness ($r = 0.49$), Shannon diversity ($r = 0.47$), and evenness ($r = 0.54$), whereas BOD and COD were strongly negatively correlated with all diversity indices ($r = −0.90$ to $−0.92$; $p < 0.01$). Multiple regression identified COD as the strongest predictor of fish diversity ($\beta = −0.903$; $p < 0.001$), while PCA explained 81.59% of the total variance, clearly depicting the fish diversity–water quality gradient. These findings emphasize that maintaining good water quality through pollution control and habitat conservation is essential for sustaining freshwater fish diversity in the Korba river systems.

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