Assessment of Water Quality and Its Relationship with Fish Diversity

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Abstract: *Freshwater fish are like the river's early warning system, they reveal more about water health than any single lab test. I selected three sites along the Ramganga River near Bareilly in Uttar Pradesh and sampled them monthly from June 2023 through November 2024, measuring dissolved oxygen, pH, BOD, Nitrates, Phosphates, Turbidity, and Coliforms. Fish assemblages were surveyed each season using electrofishing and gill nets. I found 22 fish species across 13 families. Urbanization left a clear mark. Site C, downstream of Bareilly, held only five species — all tough, pollution-tolerant survivors. Site A upstream had 14, including Catla catla and Tor tor, which only show up in clean, well-oxygenated water. The Shannon-Wiener index tracked this gap: 2.61 at Site A, 0.97 at Site C. Fish diversity correlated tightly with oxygen ($r = 0.91$, $p < 0.01$) and inversely with BOD ($r = -0.87$, $p < 0.01$).*

Keywords: *Ramganga River; dissolved oxygen; fish biodiversity; Shannon-Wiener index; Index of Biotic Integrity; Bareilly; water pollution indicators*

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1. Introduction

Rivers across the Indo-Gangetic Plain have been under sustained pressure for decades. Agricultural runoff, municipal sewage, and industrial effluents have collectively pushed many stretches to the point where fish can no longer survive. The Ramganga is a right-bank tributary of the Ganga running through Bareilly is a useful place to study this because it spans a gradient from relatively clean headwaters to a heavily urbanized stretch within a short distance. That compression makes patterns legible.

Fish make good bioindicators for a simple reason: they integrate chemical, physical, and biological stressors across time, and different species have very different tolerances. A community shift from oxygen-sensitive cyprinids to air-breathing species like *Clarias batrachus* is diagnostic — it tells you what the water has been doing over months, not just what it measures on a single sampling day.

Despite a decent volume of limnological data for the Ganga main-stem, the Ramganga receives comparatively little attention in peer-reviewed literature. The Bareilly stretch is particularly underrepresented, and local fisheries data are largely anecdotal. This study was designed to close that gap: document the current fish assemblage at three contrasting sites, measure the physico-chemical parameters most likely to shape community composition, and quantify the relationship between the two.

2. Study Area

Three sites were selected along an 18 km stretch of the Ramganga passing through the urban core of Bareilly.

Site A- at Badagaoun, roughly 6 km upstream of the city.

Site B -Chuwari

Site C -Bukhra

3. Materials and Methods

Water Quality Sampling

Samples were collected monthly from June 2023 through November 2024.Dissolved oxygen and water temperature were measured in situ with a DO meter calibrated daily. pH was measured on a benchtop Oakton PC 700 within two hours of collection. Turbidity was read on a Hach 2100Q portable turbidimeter.

BOD was determined by the standard 5-day method (APHA 5210-B). Nitrate was measured by cadmium reduction (APHA 4500-NO3), phosphate by ascorbic acid (APHA 4500-P), and total coliforms by membrane filtration (APHA 9222-B).

Fish Surveys

Fish assemblages were surveyed in March, July, and October 2024, covering dry pre-monsoon, wet monsoon, and dry post-monsoon seasons. Shallow margins (depth < 0.8 m) were sampled. Fish were identified to species using Jayaram (2010) and the Freshwater Fishes of India checklist, with length and weight recorded before release.

4. Results

Water Quality Parameters

Table 1 summarizes mean (± SD) values for all parameters across the three sites, pooled across seasons. The downstream gradient is hard to miss. Dissolved oxygen dropped from 8.6 mg/L at Site A to 3.8 mg/L at Site C — well below the 5.0 mg/L threshold for acceptable fish health. BOD climbed from 1.8 to 9.7 mg/L, more than three times the WHO guideline. Phosphate at Site C (0.42 mg/L) was over four times the permissible limit, driven largely by the domestic sewage discharge upstream. pH at Site C (mean 6.4) occasionally dipped below 6.0 during monsoon months, probably from organic acid inputs off flooded floodplain soils. Turbidity at Site C averaged 38.4 NTU and peaked above 90 NTU in August. Total coliform counts were the most striking figure: 1,240 CFU/100 mL at Site C is 12 times the WHO ceiling.

Table 1. Physico-chemical water quality parameters at three sampling sites on the Ramganga River.

Parameter	Site A (Upstream)	Site B (Mid-reach)	Site C (Downstream)	WHO Standard
Temperature (°C)	22.4 ± 0.8	25.1 ± 1.2	28.7 ± 1.5	< 30
pH	7.2 ± 0.3	6.9 ± 0.4	6.4 ± 0.5	6.5–8.5
DO (mg/L)	8.6 ± 0.5	6.3 ± 0.7	3.8 ± 0.9	> 5.0
BOD (mg/L)	1.8 ± 0.3	4.2 ± 0.6	9.7 ± 1.1	< 3.0
Nitrates (mg/L)	0.9 ± 0.2	3.1 ± 0.4	7.4 ± 0.8	< 10.0
Phosphates (mg/L)	0.04 ± 0.01	0.18 ± 0.03	0.42 ± 0.06	< 0.10
Turbidity (NTU)	4.1 ± 0.9	12.6 ± 2.1	38.4 ± 4.7	< 5.0
Total Coliform (CFU/100 mL)	24 ± 6	189 ± 31	1,240 ± 178	< 100

Mean ± SD; n = 18 sampling events per site. DO = dissolved oxygen; BOD = biological oxygen demand.

Fish Species Composition

Twenty-two fish species from 13 families were recorded across all sites and seasons. Site A held 14 species, Site B held 9, and Site C held only 5. No species found exclusively at Site C was absent from both upstream sites. The upstream assemblage was dominated by economically valuable cyprinids — *Labeo rohita*, *Catla catla*, *Tor tor* — along with a reasonable spread of small-bodied species. Downstream, the assemblage narrowed to air-breathing catfishes: Clarias batrachus and Heteropneustes fossilis, both capable of surviving dissolved oxygen below 1 mg/L. *Catla catla* and *Tor tor* were absent from both Site B and Site C. Both are large-bodied rheophiles with very low pollution tolerance. Their absence from the lower reach is exactly what the DO and BOD data would predict.

Table 2. Selected fish species recorded during the study, with family, site occurrence, and pollution tolerance.

Species	Family	Site Occurrence	Pollution Tolerance	IBI Score
Labeo rohita	Cyprinidae	A, B	Low	5
Catla catla	Cyprinidae	A only	Very Low	5
Tor tor	Cyprinidae	A only	Very Low	5
Channa marulius	Channidae	A, B	Moderate	3
Mystus vittatus	Bagridae	A, B, C	High	1
Clarias batrachus	Clariidae	B, C	Very High	1
Heteropneustes fossilis	Heteropneustidae	C only	Very High	1

Pollution tolerance classifications after Singh et al. (2014). IBI score: 5 = sensitive, 3 = intermediate, 1 = tolerant.

Fish Diversity Indices and IBI Scores

The Shannon-Wiener index dropped from 2.61 at Site A to 0.97 at Site C — a 63% reduction. Simpson's diversity fell from 0.84 to 0.43. Evenness collapsed too: at Site C, just two species (*Clarias batrachus* and *Mystus vittatus*) made up over 70% of total catch. IBI placed Site A as "Good," Site B as "Fair," and Site C as "Poor."

Water Quality–Diversity Correlations

Dissolved oxygen was the strongest positive predictor of fish diversity across all three sites combined ($r = 0.91$, $p < 0.01$). BOD was the most strongly negative ($r = -0.87$, $p < 0.01$). Temperature correlated moderately negatively ($r = -0.69$, $p < 0.05$), as did turbidity ($r = -0.72$, $p < 0.01$). Nitrate and phosphate both correlated negatively with diversity, with somewhat weaker coefficients ($r = -0.61$ and -0.58, both $p < 0.05$). pH showed a moderate positive correlation ($r = 0.66$, $p < 0.05$).The PCA separated Site A samples clearly from Site C along the first two principal components, which together explained 74% of variance. PC1 was driven by DO, BOD, and coliform counts; PC2 by turbidity and phosphate. Site B samples scattered broadly, which fits its transitional character.

5. Discussion

The pattern here is not surprising in direction — water degrades downstream, fish diversity tracks it down — but the degree of degradation at Site C is worth sitting with. A dissolved oxygen reading of 3.8 mg/L is not a borderline case. For many fish, that represents functional hypoxia during activity and feeding. The near-absence of large cyprinids from Site B onward, and their complete disappearance at Site C, is consistent with what the literature would predict: *Labeo rohita* begins to show behavioral stress below 4 mg/L DO and cannot sustain feeding below 3 mg/L (Mukherjee et al., 2019).What stands out more is what persists at Site C. *Clarias batrachus* and *Heteropneustes fossilis* are not just tolerant of these conditions — they are thriving in them, because they carry accessory air-breathing organs that most fish lack. Their dominance downstream is not a sign of a moderately stressed system. It is a sign that only the most specialized survivors remain. An IBI score of 21 captures this numerically, but the species list says it more directly.

The correlation between DO and fish diversity (r = 0.91) is strong and consistent with comparable riverine studies in the Gangetic Plain (Pinder et al., 2015; Ahmad et al., 2021). But treating DO as the only variable that matters would be a mistake. The PCA makes clear that BOD, turbidity, and coliform loads move together in this system. The downstream deterioration is not a single-variable problem, and fixing only the oxygen deficit without addressing organic loading would likely produce limited gains.

One finding worth flagging is the seasonal variability at Site B. During monsoon months, higher river discharge actually improves some parameters at that site — dilution reduces BOD and coliform concentrations, and small cyprinid juveniles were briefly recorded in July surveys. Site B is not permanently degraded; it responds to hydrological forcing. That creates a real recovery window if the two nearby urban drains could be better managed.

The tannery effluents in the Site C reach deserve specific attention. Chromium concentrations were not part of this study's analytical suite, but the sediment color, odor, and near-complete absence of benthic invertebrates — noted incidentally during electrofishing — all point toward heavy metal contamination. A follow-up study on sediment chemistry and its relationship to the absence of benthic-feeding fish species would be a logical next step.

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