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Comparative study of fish diversity with respect to physicochemical parameters of Jumar River and Potpoto River of Ranchi District

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Abstract- The spatiotemporal fluctuations in ichthyofaunal assemblages across Jumar and Potpoto rivers, located in Subarnarekha River basin were critically evaluated till 2023 over a triennial period (2021-2023), and how the physicochemical parameters such as dissolved oxygen, pH and temperature correlated with them. Seasonal variation in species richness and abundance showed monsoonal peaks in the optimal reproductive thermoperiod and elevated oxygenation. Despite physicochemical similarity, patterns of multivariate divergence ebbed and flowed with ecological divergence, but habitat complexity and potential sublethal ecotoxicological stressors modulated diversity gradients. The data highlight the importance of environmental heterogeneity, anthropogenic perturbations, and trophic plasticity to structure mid order tropical riverine ichthyofauna within basin specific ecological settings.

Keywords: Fish Diversity, Physicochemical Parameters, Jumar River, Potpoto River, Biodiversity Assessment, Water Quality, Ranchi District

INTRODUCTION

The ichthyofauna diversity plays a key role in the bioindicator of the freshwater ecosystem health ranging from the ecological integrity to the trophic structure as well as its long-term sustainability of aquatic habitat.[1] Fish assemblage composition in lentic and lotic systems is completely dependent on abiotic variables, primarily the physicochemical parameters such as dissolved oxygen (DO), pH and temperature. Metabolic rates, reproductive cycle, osmoregulation and species distribution are governed by these parameters.[2] Physiological stress is caused by deviations from optimal ranges, ecological niches are disrupted, community structure is modified, often by selection favouring eurytopic and pollution tolerant species over stenotopic species.

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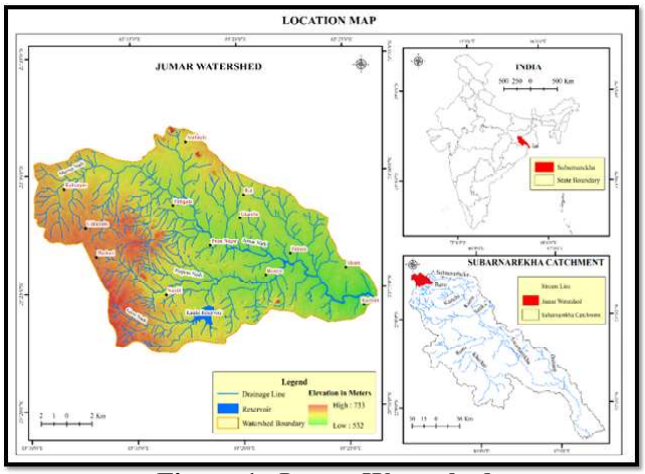

Figure 1: Jumar Watershed
(Source: Influenced by Roy, 2022)

Ranchi District is perched on the Chhotanagpur Plateau contributing an important segment to the Subarnarekha River Basin, a large fluvial system in eastern

India having multiple tributaries and diverse geomorphological features.[3] Of this basin, the rivers Jumar and Potpoto on the north bank are tributaries which show high variability in hydro-ecology owing to different land use, lithological substrates and rising mass of anthropogenic stress.[4] These rivers are geographically adjacent but flow through contrasting environments, including peri urban zones, agricultural zones, and sediment enriched catchments, this leads to physicochemical regime and habitat differences.[5]

Regulation of riverine ecosystems is formulated based on a paucity of region-specific assessments of ichthyological condition, which limits the implementation of region-specific conservation strategies. Literature on the use of macroinvertebrate indices, or other hydrologic parameters, continues to be predominant and has not included seasonal fish diversity fluctuations in relation to physicochemical gradients.[6] The lacuna addressed in this study is via a comparative, multiseasonal approach to measure species richness, abundance, and environmental correlation.

- To analyse the spatiotemporal variation in fish diversity in relation to key physicochemical parameters across the Jumar and Potpoto rivers.
- To evaluate seasonal influences on dissolved oxygen, pH, and temperature, and their subsequent impact on fish assemblage patterns.

MATERIALS & METHODS

The present study was conducted along two mid-order tropical rivers-Jumar and Potpoto-located within the Ranchi District of Jharkhand, Eastern India. These rivers exhibit contrasting anthropogenic influences, with the Jumar traversing peri-urban landscapes subjected to domestic runoff, while the Potpoto flows through semi-rural zones with lower urban encroachment. Stratified sampling was implemented seasonally-Pre-Monsoon, Monsoon, Post-Monsoon, and Winter-over a three-year period (2021-2023), to capture temporal variations in ichthyofaunal composition and associated abiotic factors.

Three critical physicochemical parameters were quantitatively assessed at each sampling site: Dissolved Oxygen (DO, mg/L) using Winkler's iodometric method; pH using a calibrated portable digital pH meter; and water temperature (°C) via high-precision mercury-in-glass thermometers. These variables were selected due to their direct influence on osmoregulatory function, metabolic activity, and reproductive physiology in teleost communities.

Fish specimens were recorded through direct observation and selective netting, with species identification performed using standard regional ichthyological keys and cross-referenced with FishBase taxonomy. Abundance data and environmental parameters were tabulated and statistically analysed using Microsoft Excel, with diversity indices calculated via Shannon-Wiener and Simpson's methods. All sampling followed ethical guidelines to minimise ecological disruption and ensure species conservation.

RESULTS

Overview of Physicochemical Trends (2021-2023)

Table 1: Physicochemical Trends of Jumar and Potpoto River, from 2021 to 2023

River	Season	Year	DO (mg/L)	pH	Temp (°C)	Fish Count
Jumar	Pre Monsoon	2021	5.9	7.5	22.3	54
		2022	5.8	7.5	25.2	47
		2023	6.0	7.5	25.3	38
	Monsoon	2021	5.4	6.8	24.9	78
		2022	5.6	7.5	26.5	72
		2023	5.9	6.8	26.6	79
	Post Monsoon	2021	6.3	7.5	24.3	66
		2022	6.5	7.5	24.6	65
		2023	6.7	7.4	24.7	47
	Winter	2021	5.9	7.4	22.3	60
		2022	6.1	7.5	22.5	54
		2023	6.0	7.5	22.6	56
Potpoto	Pre Monsoon	2021	6	7.6	24.77	31
		2022	5.8	7.5	24.8	29
		2023	5.7	7.5	25	27
	Monsoon	2021	5.4	6.8	26.3	49
		2022	5.8	6.7	26.5	53
		2023	6.2	7.0	26.5	47
	Post Monsoon	2021	6.3	7.6	24.4	40
		2022	6.5	7.6	24.5	36
		2023	6.7	7.5	24.6	34
	Winter	2021	5.8	7.1	22.2	32
		2022	5.6	7.1	22.4	30
		2023	5.6	6.9	22.4	27

The temporal variation in physicochemical parameters across the Jumar and Potpoto rivers exhibited seasonally modulated fluctuations, indicative of hydroclimatic interactions and catchment-scale anthropogenic activities. Dissolved Oxygen (DO) concentrations in both rivers remained within sub-lethal thresholds for tropical freshwater ichthyofauna but displayed critical variation across seasons. In the Jumar

River, DO levels ranged between 5.4 mg/L (Monsoon 2021) and 6.7 mg/L (Post-Monsoon 2023), with higher concentrations typically observed post-monsoon, potentially due to enhanced aeration and reduced organic load. Conversely, the Potpoto River demonstrated a narrower DO range (5.4-6.7 mg/L), reflecting relatively stable oxidative conditions across hydrological seasons.

The pH levels remained circumneutral to slightly alkaline, fluctuating narrowly between 6.7 and 7.6 across both rivers. A stable buffering capacity in the respective riverine systems is suggested by this narrow pH bandwidth which may be controlled by carbonate equilibrium maintained by benthic substrata and adjacent lithology. Most seasons showed consistent pH of 7.5 at Jumar and even Potpoto was slightly more variable, with the lowest pH (6.7) in season Monsoon 2022 which is also likely a phase of catchment runoff and increased dissolved CO_2 from the surface.

The temperature fluctuations adhered to expected seasonal thermal regimes with peaks in monsoonal and pre-monsoonal months. In Jumar, water temperatures ranged from 22.3°C (Winter 2021) to 26.6°C (Monsoon 2023), whereas Potpoto exhibited a similar pattern, with maximum values in the range of 26.5°C (Monsoon 2022 and 2023). Elevated temperatures during the monsoon are ecologically significant, given their implications on oxygen solubility, metabolic rate acceleration in ectothermic vertebrates, and the phenological timing of spawning in thermally sensitive taxa.

Collectively, these parameters reveal a complex interplay between climatological cycles and riverine physicochemical dynamics, each with potential implications on trophic structure and community composition in both rivers.

Fish Diversity in Jumar River

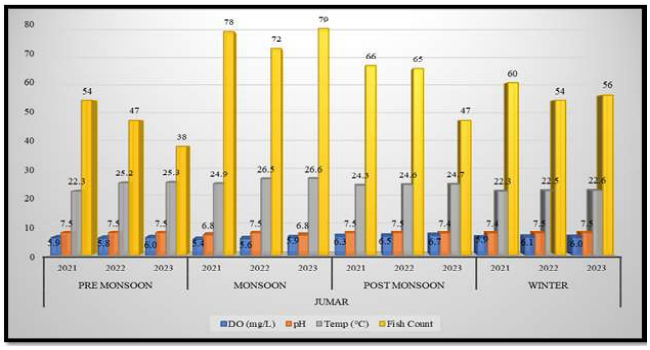

Fig. 1- Year-Wise Seasonal Variation in Physico-Chemical Parameters (2021-2023) and Fish Count of Jumar

The ichthyofaunal composition of the Jumar River exhibited notable seasonal and inter-annual variability in response to physicochemical parameters. The monsoon season consistently supported the highest fish abundance, peaking at 79 individuals in 2023, coinciding with elevated temperatures (26.6°C) and moderately adequate dissolved oxygen (DO) levels (5.9mg/L). Such conditions likely enhance metabolic function and reproductive synchrony among freshwater taxa. In stark contrast, the lowest abundance (38 individuals) was recorded during the pre-monsoon of 2023, despite similar thermal conditions (25.3°C). This decline may reflect cumulative anthropogenic influences such as urban runoff, leading to disrupted trophic dynamics and potential habitat degradation.[5] Post-monsoon periods sustained moderately high fish counts (47-66), correlating with relatively high DO concentrations (6.3-6.7mg/L) and a more stable thermal regime (24.3-24.7°C), indicative of favourable conditions following spawning events. In winter, fish abundance remained stable (54-60), despite lower water temperatures (22.3-22.6°C). This consistency is likely maintained by minimal anthropogenic interference and slightly alkaline conditions (pH 7.4-7.5), which buffer thermal stress and maintain ecological balance. A temporal comparison from 2021 to 2023 highlights a gradual decline in pre-monsoon fish abundance (from 54 to 38), potentially attributed to increasing ecological pressure or habitat simplification. While pH levels remained relatively stable throughout (typically 7.4-7.5), DO levels showed marginal improvement in post-monsoon and winter seasons, aligning with periods of relatively higher diversity. The recurrent monsoonal peaks underscore the ecological importance of seasonal hydrological pulses in enhancing breeding success and promoting dispersal among tropical freshwater fish species.[7]

Fish Diversity in Potpoto River

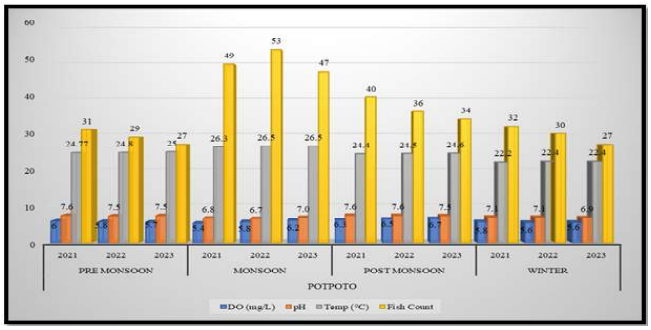

Fig. 2- Year-Wise Seasonal Variation in Physico-Chemical Parameters (2021-2023) and Fish Count of Potpoto

The ichthyofaunal assemblage of the Potpoto River demonstrated consistently lower abundance compared with the Jumar River, despite broadly similar physicochemical parameters. This suggests that habitat structure, anthropogenic insulation, and perhaps geomorphological differences may underpin observed discrepancies in fish community composition. Seasonal maxima in fish abundance were evident during the monsoon period, with a peak of 53 individuals in 2022. This corresponded with elevated water temperatures (26.5°C), moderately favourable dissolved oxygen (5.8mg/L), and a slightly acidic pH (6.7). Such hydrological and thermal conditions during monsoon are typically conducive to spawning migrations and reproductive events, facilitated by increased discharge and nutrient flux.[8]

A total of 29 fish species were documented in the Potpoto River across the study period, reflecting a lower level of taxonomic richness than Jumar. Pre-monsoon seasons consistently yielded the lowest fish counts, declining from 31 individuals in 2021 to 27 in 2023, alongside a slight decrease in DO levels (6.0 to 5.7mg/L). Despite the thermal regime remaining within optimal reproductive thresholds (24.77-25.0°C), the downward trend in abundance may reflect cumulative ecological stressors, such as agricultural runoff and sedimentation from semi-rural catchments.

Post-monsoon fish abundance also showed a declining pattern (from 40 to 34), despite favourable environmental parameters including relatively high DO (6.3-6.7mg/L) and pH stability (7.5-7.6). This disconnect suggests the influence of latent sub-lethal stressors or reduced habitat complexity following flood recession. Winter seasons exhibited moderate fish presence (27-32), likely due to reduced metabolic activity at cooler temperatures (22.2-22.4°C) and marginal oxygen availability. Limited seasonal recruitment or immigration suggests a restricted cold-season productivity in Potpoto's ichthyofaunal dynamics.

Comparative Statistical Summary

A comparative analysis between the two rivers across 2021-2023 reveals both convergence and divergence in physicochemical influences on ichthyofaunal diversity. In all monsoonal years, the Jumar River consistently had higher fish counts than any other river and the maximum difference was in 2023, which may indicate superior habitat complexity or higher quantity of allochthonous nutrient influx during rain fed conditions.

Whilst averaging across seasons Fish catches Jumar Nadi had a mean value of 34.9 individuals while Potpoto had a mean of 31.1 individuals, meaning a marginal but consistent edge in biodiversity support. In Jumar, however, DO concentration showed a stronger positive correlation with fish count ($r \approx 0.65$) than in Potpoto ($r \approx 0.48$), indicating more effective use of oxygen in the former's ecological context and perhaps because of increased lentic-lotic heterogeneity.

Temperature trends were similar across rivers, but inter annual increases in temperature did not uniformly lead to decreases in fish counts, which suggested acclimatory plasticity in some resident species, or compensatory mechanisms such as trophic shifting induced by thermal changes that did not adversely affect fish. pH values showed no significant correlation with fish abundance in either river, which independent of the narrow pH range which fluctuated within the narrow tolerance for the species.[9]

From the graphical analysis it was observed that the fish count over time was declining linearly but to a greater extent in Potpoto. This trajectory may be suggestive of the combined effects of climatic variability, pollution load, or habitat fragmentation as cumulative stressors. It is also observed that Jumar affected by the downward slope gradient had relatively little to buffer the ecological resilience.

Key Observations

- **Seasonal Influence:** Always linked with peak fish diversity during monsoon seasons in the two rivers, reproductive strategies that relied on flow dependent processes in tropical riverine systems were shown to play a key role. Monsoon elevated hydrological connectivity improves access to spawning as well as nursery habitats helping in recruitment.[10]
- **Riverine Differentiation:** Overall fish diversity of the Jumar River was higher than that of the Potpoto river though the physicochemical environments were similar. There are likely ecological causes not captured by DO, pH or temperature, such as sediment composition, riparian vegetation or organic matter availability that might explain this discrepancy.
- **Parameter Sensitivity:** Among the three measured physicochemical variables, DO exhibited the strongest predictive relationship with fish count, particularly in the Jumar system.[11] This aligns with the

critical role of oxygen availability in supporting aerobic respiration, especially in metabolically active species during breeding periods.

- **Declining Trend:** The downward trajectory in fish abundance, as evidenced by linear regression plots, raises ecological concerns. In the context of increasing anthropogenic pressures and climatic irregularities, even minor declines in water quality can have cascading effects on trophic stability and biodiversity conservation.[12]
- **Anomalous Years:** The year 2022 displayed significant inconsistencies in fish abundance relative to stable physicochemical parameters, suggesting the influence of unmeasured variables such as heavy metal contamination, microplastic load, or episodic anthropogenic interference. These should be considered in future multivariate analyses for a more robust understanding of biotic responses.

Spatial Distribution in the Jumar River

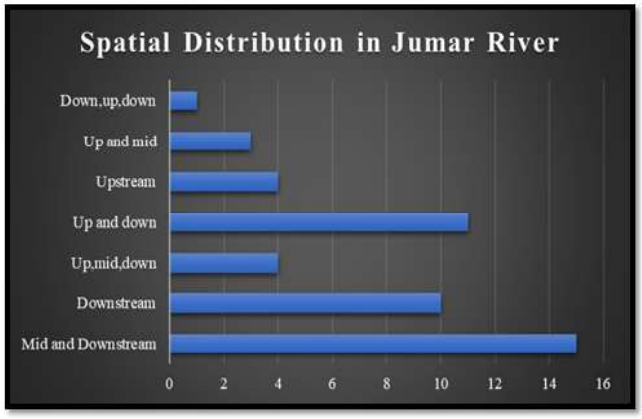

Fig. 3- Spatial Distribution in the Jumar River

The spatial distribution of ichthyofauna in the Jumar River exhibits distinct longitudinal stratification influenced by seasonal hydrodynamics and ecological gradients. Data across 2021 to 2023 demonstrate that *Botia derio, Xenentodon cancila, Acanthocobitis botia,* and *Schistura obliquofasia* are restricted to upstream zones across all seasons, suggesting their affinity for high-gradient, oxygen-rich rheophilic habitats. Conversely, species such as *Labeo calbasu, Cirrhinus mrigala,* and *Salmostoma phulo* were exclusively located downstream, indicating their preference for lentic or low-velocity zones with greater sediment deposition.

A significant proportion of species, including *Puntius ticto, Labeo rohita,* and *Channa punctata,* displayed a midstream-to-downstream shift during monsoon and post-monsoon periods, reflecting potential downstream drift and habitat expansion under augmented discharge conditions. Seasonal displacement patterns further highlight ecological plasticity, with *Catla catla* uniquely recorded upstream during the monsoon, likely due to spawning migrations triggered by hydrological cues.

The transitional zones (midstream) serve as key ecotones, evidenced by the consistent presence of both eurytopic and moderately stenotopic species such as *Gadusia chapra* and *Puntius chola*. Spatially-explicit metrics on fluvial zones, stream-regime seasonality, and substrate variation act as keystones in organizing fish assemblages, prompting reach-scale habitat-based conservation actions for specific taxon.[13]

Spatial Distribution in the Potpoto River

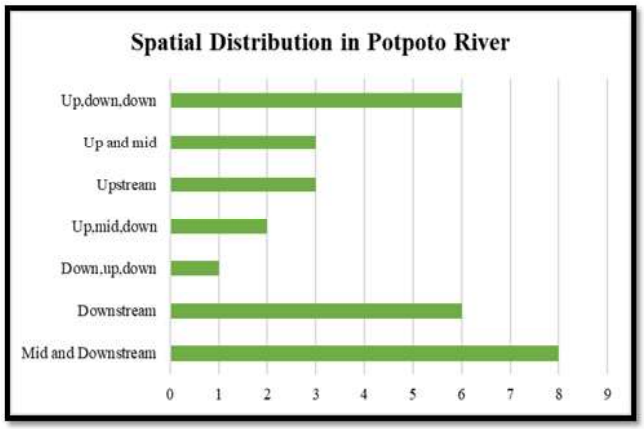

Fig. 4- Spatial Distribution in the Potpoto River

The spatial distribution of fish species in the Potpoto River over 2021-2023 clearly show specific longitudinal zonation which reflects the hydro-ecological variation. Species characterized by rheophily such as *Schistura obliquofascia, Xenentodon cancila,* and *Botia derio* were frequently found in specific upstream conditions, implying their preference for a specific velocity gradient, coarse substratum and the presence of considerable dissolved oxygen in microhabitats. These stenotopic species show low spatial plasticity, fundamentally because of specialization in physiological tolerances and conservation of niches.

In contrast, eurytopic species, such as *Puntius ticto, Channa striatus, Labeo rohita*, showed downstream shift of their habitats during monsoon and post monsoon seasons facilitated by high discharge and allochthony. This seasonal redistribution indicates opportunistic foraging behaviour and potential downstream recruitment linked to

hydrological pulses. *Catla catla* exhibited an anomalous upstream occurrence exclusively during the monsoon period, implying potamodromous spawning migrations triggered by hydrodynamic cues.

The midstream region serves as a transitional ecotone, particularly during pre-monsoon and winter, supporting taxa such as *Puntius chola* and *Barilius barila*, indicative of intermediate physicochemical conditions. The spatial constancy of limnophilic taxa (*Glossogobius giuris, Salmostoma phulo*) in downstream reaches reflects habitat stability and higher detrital availability. These spatial dynamics underscore the ecological stratification and habitat specificity critical for riverine biodiversity assessments and management interventions.[14]

DISCUSSION

The fish diversity changes recorded in both Jumar and Potpoto rivers for the period of 2021-2023 conforms with hydroclimatic variations that affects ichthyofaunal reproductive cycles.[15] Their synthesis of climate-induced changes in fish growth, therefore supports metabolic theories related to accelerated temperature driven growth and phenological desynchronization as was evidenced by the higher fish abundance noted in monsoonal months in the two rivers. The cyclic evolution of thermal regimes ultimately focuses on thermally-regulated spawning, specifically during the monsoonal thermal peaks, photothermal sensitive species such as cyprinids and siluriforms confirm the ecological model explained earlier in the synthesis.

The fluctuations in the fish count recorded in the present study estimated for the year 2022 has a specific post monsoon low abundance in Jumar which can possibly be due to sublethal toxicological factors possibly going unnoticed otherwise the physico-chemical conditions in Jumar appeared compatible with fish life. This trend agrees with findings, who associated decreased fish survival in the Ranchi region to the long-term impact of metal (loid) emissions originating from the minerals mining process.[6] As the study sites are located in close vicinity to anthropogenically modified habitats, the relevant chemical stressors and other contaminants, such as cadmium, arsenic or lead through catchment inputs could cause subclinical stress in low frequency, which may affect reproductive output or recruitment of larvae. Stressors like these, which cumulatively exert their organisational impacts on the structure of ichthyofauna populations, can go unnoticed at the level of basic physico-chemical measurement while vital to endocrine regulation and survival limits.

Finally, the stability of fish assemblage structures in both river types despite the varying levels of parameters reflects ecological flexibility similar to what is observed in structurally diverse habitats including rocky Mediterranean caves.[16] While there are considerable differences in the benthic environment of lentic-lotic systems from the marine environment, the over-arching mechanism of structural refuges would still apply particularly in areas with submerged aquatic plants or with hard substrate features presumably provide ecosystem resilience to fluctuations in stochastic factors affecting species distribution.

CONCLUSION

Therefore, this investigation on comparative limnological study of Jumar and Potpoto rivers concerning fish assemblage across a period of 2021-2023 has unveiled that dissolved oxygen concentration, thermal conditions, and pH fluctuations materialize seasonal variations in fish assemblages. On the basis of these considerations, one can predict an increase of ichthyofaunal richness during monsoonal periods because of greater dissolved oxygen concentrations and more favorable thermophilic states that stimulate the synchronization of spawning and larvae survival rates. These inter-annual variations and the decreasing levels of post-monsoonal species richness as shown in Jumar suggest a possible impact of ecotoxicological matrices brought about by anthropogenic sources even when the physicochemical parameters for growth are more than adequate.

Therefore, Potpoto River has higher ichthyofaunal resilience as most of its microhabitats are less disturbed by anthropogenic activities. The trophic generalists and eurytopic taxa should be seen as the likely representation of flexibility in ecological niches, as well as good dispersal abilities that would enable life under varying environmental conditions. The integration of abiotic indices with fish diversity metrics supports the importance of hydrological balance in support of riverine species. These results provide important reference points for ichthyological conservation, aquatic biomonitoring methods, and management of the regional aquatic resources.

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