



Assessment of Habitat Characteristics Influencing Fish Diversity in the Ijo River, Central Java, Indonesia

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Abstract

Freshwater fish populations are highly sensitive to habitat variation, yet information on how habitat characteristics shape fish diversity in Central Java rivers remains limited. The Ijo River is an important natural system for evaluating ecological factors that determine fish communities. This study aims to assess the physical and chemical characteristics of the Ijo River and evaluate their influence on fish diversity. Research was conducted using survey methods and purposive random sampling at nine stations across three zones: upstream, middle, and downstream. The results obtained are that the environmental parameters varied across river zones. The downstream zone recorded the highest temperature (29.14°C), greatest depth (2.54 m), widest channel (32.97 m), and highest free CO₂ (12.64 ppm). The upstream zone showed the greatest light penetration (74.43 cm), fastest Current Velocity (0.75 m/s), highest dissolved oxygen (5.28 ppm), and highest pH (8.31). Fish diversity also differed between zones. The downstream zone had the highest abundance (4,885 individuals) and greatest dominance (0.17), whereas the upstream zone exhibited the highest Shannon-Wiener diversity index (2.46) and evenness (0.36). These results indicate that upstream zones, with lower temperatures, faster currents, higher dissolved oxygen, and stable pH, support greater species diversity and evenness. Downstream zones, with higher temperatures, elevated free CO₂, and wider river width, show greater abundance but are dominated by a few adaptive species. This pattern, consistent with other rivers, confirms that physical and chemical water characteristics shape distribution, abundance, and dominance of freshwater fish. Thus, fish diversity is a key indicator of river ecosystem health.

1. Introduction

Rivers support the life of fish populations, especially in relation to the diversity and abundance of species that occupy different parts of the river (Gustiano *et al.*, 2025). Such diversity not only reflects the number of species that exist but also indicates the balance of ecosystems that depend on stable environmental conditions. The quality of river water, including temperature, dissolved O₂, pH, and light penetration, is the main factor that determines the presence and abundance of fish, as each of these parameters plays a direct role in the physiological processes and behavior of fish. For example, temperature affects metabolism and growth rate, dissolved O₂ is essential for respiration, pH determines the physiological suitability of fish, while light penetration affects the primary productivity that forms

the basis of the food chain (Napit, 2024; Pratami *et al.*, 2018).

Natural river ecosystems maintain the continuity of river flows so that fish can utilize various microhabitats according to their life needs, because maintained flows allow fish to move freely from upstream to downstream to seek feed, shelter, and reproduce (Sofi *et al.*, 2020). Water physicochemical factors, including variations in current, depth, and substrate, play an important role in determining fish distribution patterns along river flows (Chemagin *et al.*, 2025; Pichon *et al.*, 2016). These natural conditions favor a more balanced interaction between species. The existence of different habitat types also enriches the structure of fish communities in rivers (Scholl *et al.*, 2023; Elviana *et al.*, 2019).



The Ijo River, located in Kebumen Regency, Central Java, is a natural river approximately 36 km long and 14-41 m wide. It covers an area of about 32,902 hectares and includes several tributaries, one of which is the Pringtutul, Kecepek, Tambak, Gumelar, Bulu, Bodo, Demangsari, and Logending Rivers. The Ijo River has relatively stable environmental conditions that support high fish diversity, including species such as Milkfish (*Chanos chanos*), goby (*Glossogobius circumpectus*), barramundi (*Lates calcarifer*), two-spot catfish (*Mystus nigriceps*), Nile tilapia (*Oreochromis niloticus*), Pangas catfish (*Pangasius pangasius*), and mudskipper (*Periophthalmus sp.*) (BPDAS Serayu Opak Progo, 2015). The stability of water quality allows sensitive fish species to survive, while maintaining the balance of freshwater ecosystems in a sustainable manner (Hutapea et al., 2019). The existence of natural rivers is important as a reference for freshwater ecology. An understanding of water quality and its relationship to fish diversity is indispensable for designing sustainable aquatic management strategies (Vyas et al., 2025; Nasriyah & Anas, 2018).

Changes in water physicochemical can affect habitat preferences, fish behavior, and interactions between fish species in their natural habitat (Pahrela et al., 2023). Good water conditions are the basis for the balance of river ecosystems, allowing fish to move freely and maintaining diverse populations (Inwati et al., 2025). Water quality factors also determine the ability of fish to adapt to environmental dynamics; thus, natural river water quality is the main key in maintaining the

sustainability of freshwater ecosystems (Mamun & Kwang, 2022). Freshwater fish populations are highly sensitive to habitat variation, yet information on how physicochemical habitat characteristics shape fish diversity in the Ijo River remains limited. Therefore, this study aimed to evaluate the physical and chemical characteristics of the Ijo River and their influence on fish abundance, diversity, evenness, and dominance across different river zones.

2. Material and Methods

2.1. Study Area

The Ijo River is approximately 36 km long, flowing from the north (Mahameru Mountains) to the south (South Coast) and passing through three districts: Banyumas, Kebumen, and Cilacap. It covers a large area of about 32,902 hectares and includes five sub-districts: Rowokele, Ayah, Tambak, Sumpiuh, and Nusawungu (BPDAS Serayu Opak Progo, 2015). This research collected samples from the Ijo River from November 2022 to October 2023, with one sampling conducted each month for a frequency total of 12 times. The survey method was applied using purposive random sampling. The purposive aspect involved dividing the river into 9 stations across three zones the upstream (stations 1-3), the middle part (stations 4-6), and the downstream (stations 7-9). Random sampling was conducted by collecting fish samples from riverbank and midstream habitats to obtain representative data. The study area is shown in Figure 1, and detailed sampling site characteristics are provided in Table 1.

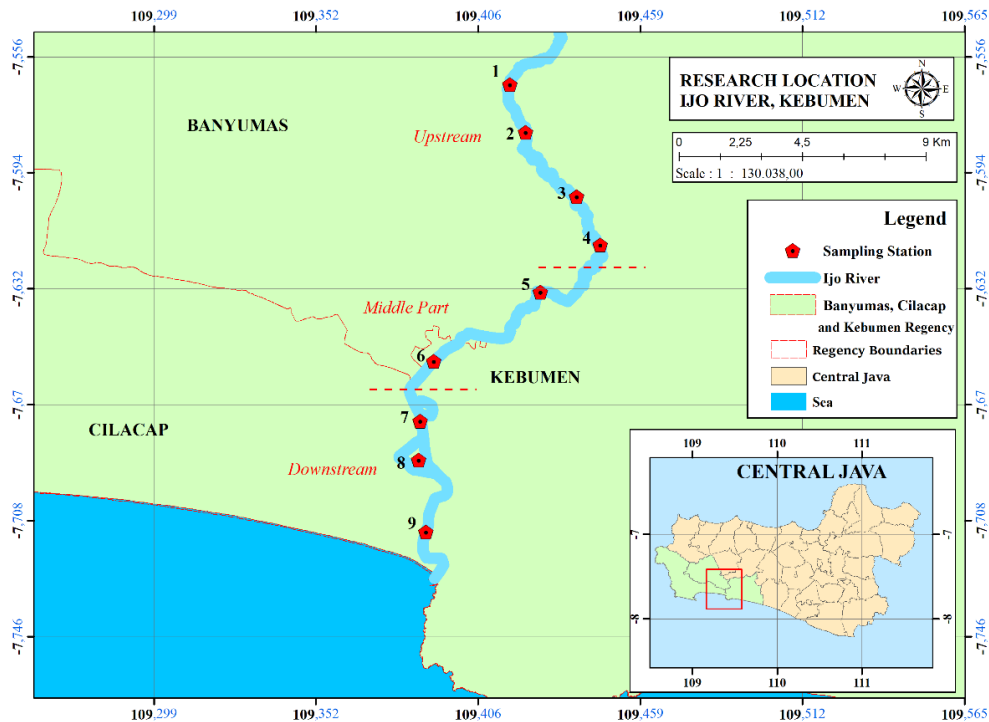


Figure 1. Map of the study area showing the nine sampling stations distributed across the upstream, middle reach, and downstream zones of the Ijo River, Indonesia.

Table 1. Sampling stations, geographic coordinates, and surrounding land use characteristics along the Ijo River, Kebumen Regency, Central Java, Indonesia

| Zone | Station | Geographic Coordinates | Surrounding Land Use |
|--------------|---------|---------------------------|--|
| Upstream | 1 | 7°33'37.8"S 109°25'05.9"E | Forest, rice fields |
| | 2 | 7°34'33.8"S 109°25'07.9"E | Forest, rice fields |
| | 3 | 7°36'22.4"S 109°26'24.2"E | Forest, rice fields, residential area |
| Middle Reach | 4 | 7°37'14.6"S 109°26'46.9"E | Rice fields, plantations, residential area |
| | 5 | 7°37'57.5"S 109°25'36.4"E | Rice fields, plantations, residential area |
| | 6 | 7°39'14.1"S 109°23'33.3"E | Rice fields, plantations, residential area |
| Downstream | 7 | 7°40'32.7"S 109°23'14.6"E | Rice fields, plantations, residential area |
| | 8 | 7°41'15.3"S 109°23'17.9"E | Rice fields, plantations, residential area |
| | 9 | 7°42'48.3"S 109°23'16.5"E | Rice fields, plantations, residential area |

2.2. Sampling of Water Quality Parameters

Water samples were collected directly (in situ) and analyzed for two categories of parameters: physical and chemical. The physical parameters included temperature, water transparency, current velocity, river width, and depth, while the chemical parameters comprised pH, dissolved oxygen (DO), and free carbon dioxide (CO₂). The methods used for water sampling are summarized as follows.

2.2.1. Temperature

Water temperature was measured using a water thermometer (°C). The thermometer was immersed directly into the river for approximately two minutes until a stable reading was obtained. According to APHA (2005), measurement of water temperature is carried out in situ by placing the thermometer in the water body until equilibrium is reached, thereby ensuring accurate representation of the actual river conditions.

2.2.2. Water Transparency

Water transparency was measured using a Secchi disk (cm). The disk was lowered vertically into the river until it was no longer visible, and the depth at which it disappeared was recorded. According to Mikhail & Sergey (2024), water transparency measured using a Secchi disk by slowly lowering the Secchi disk into the water until the black and white pattern on the Secchi disk is no longer visible (D1), then the Secchi disk is slowly lifted again until the black and white pattern is visible again (D2).

$$\text{Water Transparency} = \frac{D1 + D2}{2}$$

2.2.3. Current Velocity

River current velocity was measured using the bottle and rope method (m/s). A weighted bottle was attached to a rope and released into the river, allowing it to drift with the current. The time taken for the bottle to travel a predetermined distance was recorded, and current velocity was calculated by dividing the distance travelled by the elapsed time.

2.2.4. River Width

River width was measured using a measuring tape (m). The tape was stretched across the river from one bank to the other at each sampling station, ensuring that the measurement was taken perpendicular to the flow direction. River width measurement should be conducted in situ by directly spanning the water body with a calibrated instrument, thereby providing an accurate representation of channel morphology.

2.2.5. River Depth

River depth was measured using a calibrated pole with a scale (m). The pole was lowered vertically into the river until it reached the substrate, and the depth was recorded based on the scale markings.

2.2.6. pH

Water pH was measured in situ using a portable pH meter (unitless). The electrode of the pH meter was immersed directly into the river water and allowed to stabilize before recording the value. According to APHA (2005), pH measurement should be conducted by placing the electrode in the water body under field conditions to obtain accurate readings. This parameter is essential for assessing the acidity or alkalinity of the river, which influences chemical processes, nutrient availability, and the suitability of aquatic habitats.

2.2.7. Dissolved Oxygen

DO concentration was measured in situ using a Water Quality Checker (WQC) and expressed in parts per million (ppm). The probe was immersed directly into the river water and allowed to stabilize before recording the value. According to APHA (2005), DO measurement should be conducted under field conditions to ensure accurate representation of oxygen availability in the aquatic environment.

2.2.8. Free-CO₂

Free carbon dioxide (CO₂) concentration was measured in situ using a WQC and expressed in parts per million (ppm). The probe was immersed directly into the

river water and allowed to stabilize before recording the value. According to APHA (2005), free CO₂ measurement should be conducted under field conditions to obtain accurate readings of dissolved carbon dioxide in the aquatic environment. This parameter is important for evaluating the balance of respiration and photosynthesis, buffering capacity, and the overall chemical dynamics of the river.

2.3. Fish Sampling

Fish samples were obtained from the help of fishermen in each predetermined zone. Fish were taken in the upstream zone of the river with traditional fishing gear (rattan fish trap, scoop net, and stocking net). Sampling in the middle and downstream zones using rattan fish traps and gillnets. Installation of fishing gear at 04.00-08.00 WIB (duration 4 hours). The fish specimens (*M. nigriceps*) were put in an ice box, then taken to a base camp (fisherman's house) to be observed measured length and weight. Fish samples were identified by (Froese & Pauly, 2024; Kottelat et al., 1993; Saanin, 1968).

2.4. Data Analysis

Water quality data were analyzed descriptively and quantitatively. Fish community data were assessed using four metrics, assessed using four metrics, which include abundance, the Shannon-Wiener diversity index, Pielou's evenness index, and the Simpson dominance index. The calculation of the Shannon-Wiener diversity index, evenness index, and dominance index followed the references provided by Magurran (1988). The Shannon-Wiener diversity index (H') was calculated as:

$$H' = - \sum_{i=1}^s \left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right)$$

where:

- H' = Shannon-Wiener diversity index;
- s = Total number of fish species caught;
- ni = Number of individuals of species i caught;
- N = Total number of individuals of all species caught;
- ln = Natural logarithm.

Pielou's evenness index (E) was calculated as:

$$E = \frac{H'_a}{\ln (s)}$$

where:

- E = Pielou's evenness index;
- H' = Shannon-Wiener diversity index;
- s = Total number of species.

Simpson's dominance index (C) was calculated as:

$$C = \sum \left(\frac{ni}{N}\right)^2$$

where:

- C = Simpson's Dominance index;
- ni = Number of individuals of species i;
- N = Total number of individuals of all species.

Fish diversity data obtained in this research were analyzed in relation to water quality parameters using Canonical Correspondence Analysis (CCA). This multivariate method was applied to explain the relationship between fish community structure and environmental variables. Analyses of fish communities and CCA were conducted using PAST software, version 5.0.

3. Material and Methods

3.1. Habitat Characteristics

The habitat characteristics measured, consisting of the physics and chemistry of the water, can be seen in Table 2. Water quality parameters in the Ijo River display distinct spatial gradients from upstream to downstream reaches. The upstream zone has the lowest temperatures (25.2-25.8°C), which increase in midstream sections (28.8-29.5°C) and remain high downstream (28.1-28.8 °C). Transparency shows an inverse pattern, with the highest values upstream at 67.9-80.0 cm and the lowest downstream at 30.3-36.9 cm. River depth and width increase progressively, from the lowest values upstream (0.8-1.3 m deep; 13.6-18.4 m wide) to the highest downstream (2.3-2.8 m deep; 26.2-41.4 m wide). Flow velocity decreases along this gradient, from the highest at 0.83 m/s upstream to the lowest at 0.35-0.47 m/s downstream. Chemical profiles reinforce these trends: DO reaches the highest levels upstream (4.7-6.1 mg/L) and the lowest downstream (2.8-3.4 mg/L), while free CO₂ shows the opposite, with the lowest upstream (2.5-6.8 mg/L) and the highest downstream (11.6-13.7 mg/L). pH follows suit, highest upstream (8.1-8.5) and lowest downstream (6.7-7.2). Overall, upstream zones maintain the highest oxygen and transparency levels with the lowest temperatures and CO₂, while downstream areas show the opposite patterns.

Increasing water temperature accelerates the metabolism and respiration of aquatic organisms, thereby raising oxygen demand and contributing to a decrease in dissolved oxygen (Sarkar et al., 2017; Rouf et al., 2022). The brightness results obtained in Ijo River were higher than previous research in Logawa River, Banyumas, which obtained a brightness value ranging from 13.6-58.6 cm. The brightness range obtained supports fish life in the Logawa River because the brightness can trigger sunlight to enter the river waters, helping the fish move to forage and grow well. Water-soluble substances often block the penetration of light, limiting photosynthesis zones for aquatic habitats (Susanto & Novitasari, 2017). The width of the Ijo River is higher than previous research on the Towkak River, India, with a width of 24.38 - 30.48 m (Dutta, 2016). The range obtained supports the life of more fish in the habitat of the Pakil River because the wider river supports a greater variety of habitats compared to narrow rivers, so that the longer and wider the size of the river, the more fish inhabit it (Zulfikri et al., 2016; Dutta, 2016). The depth in the Ijo River is lower than the previous study in the Lok Ulo River,

Kebumen; the depth was obtained in the range of 4.00-6.00 m (Prakoso & Wahyuni, 2019). The depth of the river will increase if it rains and the depth of the water affects the light penetration of a water, the deeper a water, the lower the light intensity. Increasing depth will result in a decrease in dissolved oxygen levels, because the

photosynthesis process decreases and the existing oxygen levels are widely used for respiration and oxidation of organic and inorganic materials (Syahrul et al., 2021).

Table 1. Physicochemical characteristics of water across sampling stations in the Ijo River

| Zone | St | Temperature (°C) | Water Transparency (cm) | Depth (m) | Current Velocity (m/s) | River Width (m) | Dissolved Oxygen (mg/L) | Free-CO ₂ (mg/L) | pH |
|-------------|----|--------------------------|-------------------------|-----------------------|------------------------|-------------------------|-------------------------|-----------------------------|----------------------|
| Upstream | 1 | 25.05 - 25.48 (25.24) | 78.5 - 81.2 (80.0) | 0.78 - 0.82 (0.8) | 0.81 - 0.85 (0.83) | 13.5 - 13.7 (13.63) | 6 - 6.15 (6.08) | 2.4 - 2.6 (2.5) | 8.45 - 8.55 (8.5) |
| | 2 | 25.39 - 25.71 (25.53) | 75.1 - 76 (75.6) | 0.81 - 0.85 (0.83) | 0.69 - 0.73 (0.71) | 18 - 18.22 (18.14) | 5 - 5.1 (5.05) | 4.6 - 4.8 (4.7) | 8.25 - 8.35 (8.3) |
| | 3 | 25.68 - 25.95 (25.83) | 67.5 - 68.2 (67.88) | 1.28 - 1.35 (1.32) | 0.68 - 0.72 (0.70) | 18.3 - 18.48 (18.4) | 4.65 - 4.75 (4.7) | 6.65 - 6.85 (6.75) | 8.1 - 8.15 (8.13) |
| Middle Part | 4 | 28.65 - 28.95 (28.80) | 55.5 - 56.2 (55.9) | 1.32 - 1.37 (1.34) | 0.57 - 0.61 (0.59) | 20.8 - 21.08 (20.96) | 4.6 - 4.68 (4.64) | 7.7 - 7.95 (7.84) | 7.75 - 7.8 (7.78) |
| | 5 | 29.05 - 29.28 (29.15) | 48.8 - 49.5 (49.15) | 1.65 - 1.72 (1.69) | 0.49 - 0.53 (0.51) | 22.1 - 22.45 (22.28) | 4.18 - 4.25 (4.22) | 7.95 - 8.2 (8.09) | 7.5 - 7.6 (7.55) |
| | 6 | 29.38 - 29.55 (29.46) | 42 - 42.5 (42.25) | 1.9 - 1.97 (1.94) | 0.46 - 0.5 (0.48) | 22.5 - 22.85 (22.68) | 3.7 - 3.75 (3.73) | 8.6 - 8.9 (8.78) | 7.4 - 7.45 (7.43) |
| Downstream | 7 | 28 - 28.25 (28.11) | 36.8 - 37.1 (36.95) | 2.22 - 2.28 (2.25) | 0.45 - 0.49 (0.47) | 26 - 26.45 (26.24) | 3.35 - 3.4 (3.38) | 11.5 - 11.8 (11.65) | 7.15 - 7.25 (7.2) |
| | 8 | 28.3 - 28.5 (28.43) | 34.8 - 35.1 (34.95) | 2.5 - 2.6 (2.56) | 0.34 - 0.38 (0.36) | 31 - 31.4 (31.20) | 3.17 - 3.22 (3.2) | 12.5 - 12.8 (12.56) | 7.05 - 7.1 (7.08) |
| | 9 | 28.65 - 28.85 (28.75) | 30 - 30.5 (30.25) | 2.75 - 2.88 (2.82) | 0.33 - 0.37 (0.35) | 41.2 - 41.55 (41.39) | 2.72 - 2.77 (2.75) | 13.5 - 13.8 (13.65) | 6.65 - 6.75 (6.7) |

Data are presented as range values, with mean values shown in parentheses.

Current Velocity is grouped into 5 categories, namely very fast (>1 m/s), fast (0.5-1 m/s), medium (0.25-0.5 m/s), slow (0.1-0.2 m/s), and very slow (<0.1 m/s) (Kamboj et al., 2020). Based on the results, the flow speed obtained in the Ijo River is classified as moderate to fast. Current Velocity in the Ijo River decreases from upstream (0.83 m/s, classified as fast) to downstream (0.35-0.47 m/s, moderate), consistent with river hydrology. This pattern arises because upstream sections are narrower (13.6-18.4 m) and shallower (0.8-1.3 m) with steeper gradients, concentrating discharge into higher current velocity. Downstream widening (26.2-41.4 m) and deepening (2.3-2.8 m), combined with reduced slopes and increased bed roughness from sediments and vegetation, slow the water. The results obtained in this study are higher than the research in the Lamunde River, Southeast Sulawesi, the current velocity is obtained in the range of 0.105 - 0.388 m/s (Jukri et al., 2013). However, the results obtained in the Ijo River were lower than the research in the Cikawung River, Cilacap, the current velocity was obtained in the range of 0.06-1.0 m/s, which is relatively fast (Nuryanto et al., 2015).

Dissolved oxygen in the Ijo River decreases from upstream (4.7-6.1 mg/L) to downstream (2.8-3.4 mg/L), lower overall than in the Cikawung River (3.8-9.8 mg/L), where levels support diverse fish life (Nuryanto et al., 2015). This downstream decline stems from reduced atmospheric reaeration due to lower flow velocities (0.83 m/s upstream vs. 0.35-0.47 m/s downstream), warmer

temperatures (25.2-25.8 °C upstream vs. 28.1-28.8 °C downstream). Slower current velocity limits turbulence-driven gas exchange at the air-water interface, while temperature inversely affects dissolved oxygen solubility (Olopade et al., 2017). Conversely, free CO₂ rises downstream (2.5-6.8 mg/L upstream to 11.6-13.7 mg/L), though lower than in the polluted Ampenan River (Idrus, 2018). This increase results from elevated respiration by biota, organic matter decomposition, and groundwater inputs in low-velocity, warmer downstream zones—processes amplified by physical factors like reduced flow, which hinders CO₂ off-gassing. Flow velocity directly influences both: high upstream speeds enhance aeration (boosting dissolved oxygen, venting free-CO₂), while low downstream speeds trap respiratory gases. Optimum DO for fish survival and growth varies by species and life stage but generally ranges from 5-8 mg/L for most tropical freshwater fishes; levels below 3-4 mg/L cause stress, reduced growth, and mortality.

The pH values recorded in the Ijo River tend to decline from upstream to downstream, reflecting increased organic matter decomposition and CO₂ accumulation in slower-flowing downstream waters. In comparison, the Aur Lemau River in Bengkulu maintains a stable pH of 6.6-6.8, which falls within the acceptable quality standard (6-9). This decline in pH downstream is ecologically significant, as excessively low values can increase heavy metal solubility and threaten aquatic life, while excessively high values can elevate ammonia

concentrations (Febrian et al., 2022). For most freshwater fish, the optimum pH for survival and growth lies between 6.5 and 8.5, with near-neutral conditions (around 7.0-7.5) being most favorable (Milbrath et al., 2025).

3.2. Fish Diversity

Table 3 summarizes fish abundance and ecological indices, including the Shannon-Wiener diversity, evenness, and dominance indices, across the Ijo River. A

total of 11,096 fish individuals were recorded gradually increasing from the upstream zone (1,663 individuals) to the downstream zone of 4,885 individuals. Similarly, in the Opak River, Yogyakarta, fish were more abundant in the downstream zone, with 2,295 individuals and the lowest in the upstream zone, with as many as 1,204 individuals, the results obtained are suspected because downstream of the river usually has a deeper water depth, a varied substrate (Yudha et al., 2020).

Table 2. Fish community abundance and ecological indices in the upstream, middle reach, and downstream zones of the Ijo River

| Ecological Indices | Ijo River | | |
|-------------------------------|-----------|--------------|------------|
| | Upstream | Middle Reach | Downstream |
| Number of Species | 32 | 41 | 41 |
| Abundance | 1,663 | 4,548 | 4,885 |
| Shannon-Wiener Diversity (H') | 2.46 | 2.43 | 2.37 |
| Pielou's Evenness (E) | 0.36 | 0.28 | 0.26 |
| Simpson's Dominance (C) | 0.14 | 0.16 | 0.17 |

The ecological index in the Ijo River consists of 3 types. The highest Shannon-Wiener diversity index is in the upstream zone (2.46) and the lowest in the downstream zone (2.37). The Pielou's evenness index shows the same value as the Shannon-Wiener diversity index, which is the highest in the upstream zone (0.36) and the lowest in the downstream zone (0.26). The Simpson's dominance index shows the difference between the two indices above with the highest value in the downstream zone (0.17) and the lowest in the upstream zone (0.14). The upstream zone of the Ijo River exhibited the highest Shannon-Wiener diversity index and Pielou's evenness, a pattern likewise reported in the Keriau River, West Kalimantan, and the Batang Uleh River, Jambi. Variations in fish species diversity are strongly associated with habitat features, including river width and substrate composition, which determine the degree of diversity (Prayogo et al., 2022; Budiman et al., 2021).

The higher Simpson's dominance index in the downstream zone of the Ijo River indicates that several fish species dominate this area. A similar pattern was observed in the waters of Krueng Raya, Aceh, where the downstream zone recorded a Simpson's dominance index (C) of 0.21. These findings suggest that a high Simpson's dominance index reflects the predominance of certain species in the downstream zone. Moreover, an increase in Simpson's dominance index is typically associated with lower Shannon-Wiener diversity and evenness values (Ulfah et al. 2019).

3.3. The Relationship of Habitat Characteristics to Fish Diversity

Canonical Correspondence Analysis (CCA) is a multivariate statistical method used in ecology to explore

and quantify the relationships between biological communities (such as fish diversity) and environmental variables (such as habitat characteristics). It essentially links species composition data with environmental gradients, allowing researchers to see how differences in habitat conditions influence the distribution and diversity of species is obtained in the CCA diagram (Figure 2).

Based on the in Figure 2, CCA in Ijo River revealed that Shannon-Wiener diversity and Pielou's evenness are closely associated with upstream parameters such as water transparency, current velocity, dissolved oxygen, and pH. Conversely, fish abundance and Simpson's dominance index show affinity with downstream parameters including river width, depth, temperature, and free CO₂. These findings indicate that the upstream zone supports a more equitable distribution of species, while the downstream zone is characterized by high abundance and dominance of species adapted to warmer, deeper waters with elevated CO₂. Comparable patterns have been documented globally. In the Wampu River, North Sumatra, higher Shannon-Wiener diversity and Pielou's evenness in upstream zones were linked to cooler temperatures, faster flows, and higher dissolved oxygen (Desrita et al., 2019). Similarly, in the Bichom River, India, upstream habitats with greater light penetration and current velocity supported more diverse fish assemblages (Nimasow et al., 2025). In China's Lijiang River, CCA analysis confirmed that upstream zones with high current speed and dissolved oxygen were significantly correlated with Shannon-Wiener diversity and Pielou's evenness. These parallels highlight a consistent ecological principle: habitat heterogeneity drives fish diversity across river systems (Huang et al., 2019).

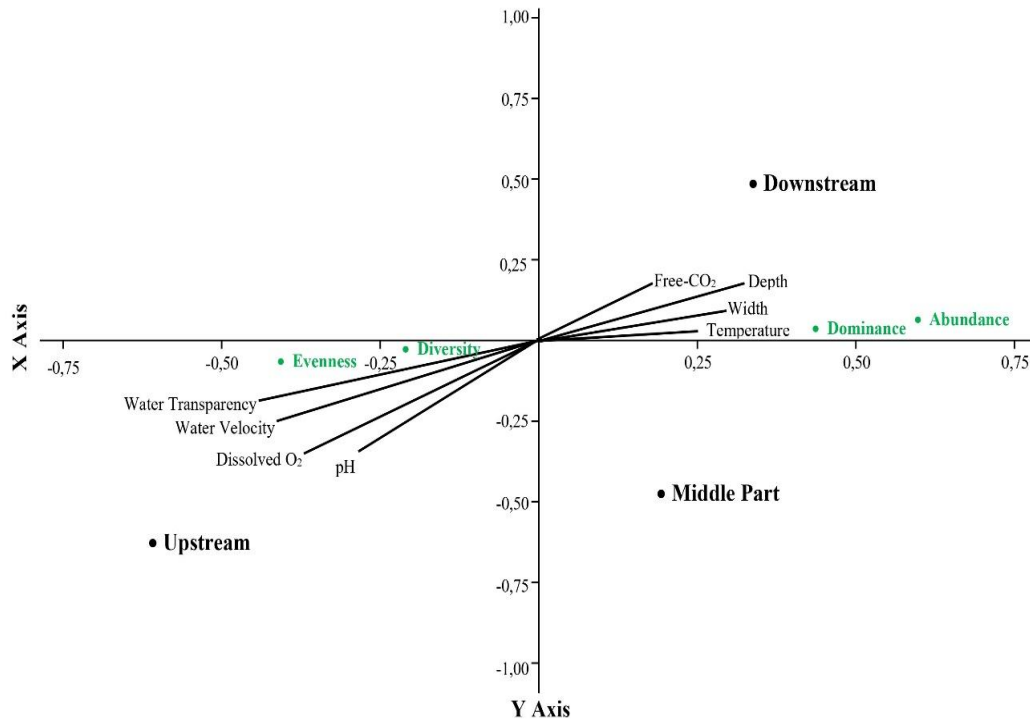


Figure 1. Canonical Correspondence Analysis (CCA) showing the relationships between physicochemical water parameters and fish community indices across river zones in the Ijo River.

Beyond local and regional contexts, these findings carry global implications. Freshwater ecosystems are increasingly threatened by anthropogenic pressures such as dam construction, pollution, acidification, and climate change. Rising temperatures and altered flow regimes can shift habitat suitability, often favoring a few tolerant species while reducing overall diversity. This has cascading effects on ecosystem services, including nutrient cycling, food security, and livelihoods dependent on inland fisheries. The observed relationship between habitat characteristics and fish diversity underscores the importance of conserving upstream habitats, which often act as biodiversity reservoirs. Protecting these zones contributes not only to local ecological balance but also to global efforts in maintaining freshwater resilience under climate change. Moreover, indices such as Shannon-Wiener diversity, Pielou’s evenness, and Simpson’s dominance provide sensitive bioindicators of ecosystem health, offering valuable insights for monitoring and managing rivers in the face of global challenges such as acidification and warming.

In the downstream zone of the Ijo River, a higher Simpson’s dominance index indicates that several fish species dominate the community. The dominant taxa recorded in this study include Long-whiskered catfish (*Mystus gulio*), two-spot catfish (*Mystus nigriceps*), climbing perch (*Anabas testudineus*), Nile tilapia (*Oreochromis niloticus*), snakeskin gourami (*Trichogaster pectoralis*), and flathead grey mullet (*Mugil cephalus*). This pattern reflects their ability to

adapt to downstream habitats characterized by wider and deeper channels, higher temperatures, and the presence of free CO₂. Comparable findings have been reported in other rivers, such as the Garonne River in France, where species like *European grayling* (*Thymallus thymallus*), *common barbel* (*Barbus barbus*), and *common bream* (*Abramis brama*) dominate downstream zones (Santoul et al., 2025). In the Bengawan River, Solo, species such as Nile tilapia (*Oreochromis niloticus*), Pangas catfish (*Pangasianodon hypophthalmus*), suckermouth catfish (*Pterygoplichthys pardalis*), Patin juaro (*Pangasius polyuranodon*), and enoplos barb (*Cyclocheilichthys enoplos*) are prevail (Aida et al., 2022). These dominances are linked to adaptive traits such as tolerance to habitat variability, flexible foraging strategies across water columns and benthic zones, and reproductive strategies suited to downstream environments.

4. Conclusion

This study demonstrates that spatial variations in physicochemical water characteristics along the Ijo River strongly influence fish community structure and ecological distribution patterns. Upstream zones, characterized by lower temperatures, faster current velocity, higher dissolved oxygen concentrations, greater water transparency, and more stable pH conditions, supported higher Shannon-Wiener diversity and Pielou’s evenness indices, indicating a more balanced and diverse fish assemblage. In contrast, downstream zones, which exhibited higher

temperatures, elevated free CO₂ concentrations, and greater river width and depth, showed higher fish abundance but were dominated by a limited number of adaptive species, as reflected by the higher Simpson's dominance index. These findings confirm that habitat heterogeneity and physicochemical conditions are key determinants of freshwater fish distribution, abundance, diversity, and dominance in tropical river ecosystems.

Our study further demonstrates that ecological indices such as Shannon-Wiener diversity, Pielou's evenness, and Simpson's dominance are effective bioindicators for evaluating river ecosystem health. The upstream zone functions as an important biodiversity reservoir, whereas downstream areas indicate ecological pressure that favors tolerant and opportunistic species. This ecological differentiation has important implications for conservation prioritization and sustainable freshwater resource management.

More broadly, the study provides a practical ecological framework for river ecosystem monitoring using fish community indices and environmental parameters. The observed patterns also suggest that increasing temperature and hydrological alteration associated with climate change may intensify downstream environmental stress, potentially reduce biodiversity and increase species dominance. Furthermore, the findings are consistent with global freshwater challenges, including habitat degradation, eutrophication, and ecological fragmentation, which continue to threaten riverine ecosystems worldwide. Therefore, the integration of fish diversity indices with physicochemical assessments can support evidence-based policy development, adaptive river management strategies, and long-term freshwater conservation planning.

5. Data Availability Statement

All data utilized in this study are openly accessible and do not contain any confidential or ethically sensitive information

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7. Conflict of Interest

This manuscript has no declarations or potential conflicts of interest among the authors.

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References

- Aida SN, Utomo AD, Anggraeni DP, Ditya YC, Wulandari TNM, Ali M, Caipang CMA, Suharman I. 2022. Distribution of Fish Species in Relation to Water Quality Conditions in Bengawan Solo River, Central Java, Indonesia. *Polish Journal of Environmental Studies* 31: 5549–5561. DOI: 10.15244/pjoes/152167
- APHA. 2005. 3111 B. Metals by Flame Atomic Absorption Spectrometry. *Standard Methods for the Examination of Water and Wastewater* 552
- BPDAS Serayu Opak Progo. 2015. *Perencanaan Luas DAS BPDAS Serayu Opak Progo*. Available at: <http://bpdas-serayuopakprogo.dephut.go.id/kegiatan/perencanaan>. (Accessed 14 May 2026) *in Bahasa*
- Budiman, Syafrialdi, Hertati R. 2021. Keanekaragaman Jenis Ikan di Perairan Sungai Batang Uleh Kabupaten Bungo Provinsi Jambi. *Journal Pengelolaan Sumberdaya Perairan* 5: 24–33. DOI: 10.36355/semahjpsp.v5i1.524 *in Bahasa*
- Chemagin AA, Popova EI, Schletterer M. 2025. Effects of Flow Velocity on the Dynamics of Juvenile Fish Habitats in River Meanders of the Irtysh River. *Diversity* 17: 1–19. DOI: 10.3390/d17010068
- Desrita, Tamba IS, Muhtadi A, Ariyanti J, Leidonald R. 2019. Diversity and Habitat Condition of Tor Fish (Tor spp.) in the Upstream of Wampu Waters, North Sumatra, Indonesia. *IOP Conference Series: Earth and Environmental Science* 260. DOI: 10.1088/1755-1315/260/1/012102
- Dutta B. 2016. The Fish Catching Devices with their Efficacy and Cost-benefit Analysis in the Towkang River in Assam and Nagaland, India. *Fisheries and Aquaculture Journal* 07. DOI: 10.4172/2150-3508.1000156
- Elviana S, Maturbongs MR, Sunarni S, Burhanuddin Al. 2019. Keragaman jenis ikan di Sungai Maro pada musim peralihan I. *Depik* 8: 97–107 *in Bahasa*
- Febrian I, Nursaadah E, Karyadi B. 2022. Analisis Indeks Keanekaragaman, Keragaman, dan Dominansi Ikan di Sungai Aur Lemau Kabupaten Bengkulu Tengah. *Bioscientist: Jurnal Ilmiah Biologi* 10: 600. DOI: 10.33394/bioscientist.v10i2.5056
- Froese R, Pauly D. 2024. FishBase. World Wide Web Electronic Publication Available at: www.fishbase.org (Version 03/2024)
- Gustiano R, Haryono, Wahyudewantoro G, Krismono, Rusdianto, Nur FM. 2025. Assessment of Fish Biodiversity of the Cimandiri Watershed, West Java, Indonesia. *Makara Journal of Science* 29. DOI: 10.7454/mss.v29i1.2450
- Huang J, Huang L, Wu Z, Mo Y, Zou Q, Wu N, Chen Z. 2019. Correlation of Fish Assemblages with Habitat and Environmental Variables in a Headwater Stream Section of Lijiang River, China. *Sustainability (Switzerland)* 11: 1–14. DOI: 10.3390/su11041135
- Hutapea LS, Haryuni, Kembarawati. 2019. Struktur Komunitas Ikan yang Tertangkap di Sungai Sebangau Kota Palangka Raya. *Journal of Tropical Fisheries* 14: 44–49. DOI: 10.36873/jtf.v14i2.7753 *in Bahasa*
- Idrus SW Al. 2018. Analisis Kadar Karbon Dioksida di Sungai Ampenan Lombok. *Jurnal Pijar MIPA* 13: 167–170. DOI: 10.29303/jpm.v13i2.760 *in Bahasa*
- Inwati P, Yadav B, Aitwar V, Yadav B, Verma DK, Bohare H. 2025. Review on Fish as Bio-Indicators: Assessing the Health of River Ecosystems. *Uttar Pradesh Journal of*

- Zoology 46: 168–180. DOI: 10.56557/upjoz/2025/v46i74874
- Jukri M, Emiyarti, Kamri S. 2013. Keanekaragaman Jenis Ikan di Sungai Lamunde Kecamatan Watubangga Kabupaten Kolaka Provinsi Sulawesi Tenggara. *Jurnal Mina Laut Indonesia* 01: 23–37 *in Bahasa*
- Kamboj V, Nitin K, Sharma AK. 2020. A review on general characteristics, classification and degradation of river systems. *Environmental Degradation: Causes and Remediation Strategies* 1: 47–62. DOI: 10.26832/aesa-2020-edcrs-04
- Kottelat M, Whitten AJ, Kartika MS, Wiroatmodjo S. 1993. Ikan Air Tawar di Perairan Indonesia Bagian Barat dan Sulawesi. Periplus Edition (HK). Jakarta *in Bahasa*
- Magurran AE. 1988. Ecological diversity and its measurement. Princeton university press
- Mamun M, Kwang GA. 2022. Key Factors Determining Water Quality, Fish Community Dynamics, and the Ecological Health in an Asian Temperate Lotic System. *Ecological Informatics* 72: 101890. DOI: 10.1016/j.ecoinf.2022.101890
- Mikhail G, Sergey G. 2024. Patterns of the relationship between the Secchi disk depth and the optical characteristics of water in the Neva Estuary (Baltic Sea): the influence of environmental variables. *Frontiers in Marine Science* 11: 1–15. DOI: 10.3389/fmars.2024.1265382
- Milbrath M, Lindsteadt A, Tronstad L. 2025. Evaluating How Growth and Diet of Native Freshwater Fishes Change in Response to Salinity and pH in a Semi-Arid Landscape. 1–15
- Napit A. 2024. An Updated Review on the Role of Certain Physicochemical Parameters in Regulating Fish Diversity of Tropical Aquatic Ecosystems. *Bioscience Biotechnology Research Communications* 17: 180–185. DOI: 10.21786/bbrc/17.4.3
- Nasriyah N, Anas P. 2018. Identifikasi Potensi dan Analisis Masalah Sumber Daya Perikanan di Kecamatan Nambo Kota Kendari Provinsi Sulawesi Tenggara. *Jurnal Penyuluhan Perikanan dan Kelautan* 12: 81–94. DOI: 10.33378/jppik.v12i2.102 *in Bahasa*
- Nimasow G, Mahato R, Abujam S, Das DN. 2025. Spatio-temporal Dynamics of Fish Communities and Habitat Conditions in the Bichom River Basin. *Environmental Monitoring and Assessment* 197: 529. DOI: 10.1007/s10661-025-13936-4
- Nuryanto A, Bhagawati D, Abulias MN, Indarmawan. 2015. Fauna Ikan di Sungai Cikawung Kabupaten Cilacap Jawa Tengah. *Jurnal Iktiologi Indonesia* 15: 25–37. DOI: 10.32491/jii.v15i1.73 *in Bahasa*
- Olopade OA, Sinclair NG, Dienne H. 2017. Fish Catch Composition of Selected Small Scale Fishing Gears Used in the Bonny River, Rivers State, Nigeria. *Journal of Fisheries* 5: 455–460. DOI: 10.17017/jfish.v5i1.2017.173
- Pahrela Y, Elvince R, Kembarawati. 2023. Hubungan Antara Kualitas Air dengan Keanekaragaman Ikan di Danau Tahai, Kecamatan Bukit Batu Kota Palangka Raya. *Journal of Tropical Fisheries* 17: 86–96. DOI: 10.36873/jtf.v17i2.8774 *in Bahasa*
- Pichon C Le, Tales É, Gorges G, Baudry J, Boët P. 2016. Using a Continuous Riverscape Survey to Examine the Effects of the Spatial Structure of Functional Habitats on Fish Distribution. *Journal of Freshwater Ecology* 31: 1–19. DOI: 10.1080/02705060.2015.1035345
- Prakoso B, Wahyuni TT. 2019. Analisis Parameter Fisika-Kimia sebagai Salah Satu Penentu Kualitas Air Sungai Lok Ulo, Kabupaten Kebumen. *Jurnal Kridatama Sains dan Teknologi* 1: 12–17 *in Bahasa*
- Pratami VAY, Setyono P, Sunarto S. 2018. Zonasi, Keanekaragaman, dan Pola Migrasi Ikan di Sungai Keyang, Kabupaten Ponorogo, Jawa Timur. *Jurnal Ilmu Lingkungan* 16: 78–85 *in Bahasa*
- Prayogo H, Arbiastutie Y, Yopi Y. 2022. Keanekaragaman Jenis Ikan Air Tawar di Kawasan Hutan Lindung Dusun Nanga Salin Kecamatan Putussibau Selatan Kabupaten Kapuas Hulu. *Jurnal Hutan Lestari* 10: 75–79. DOI: 10.26418/jhl.v10i4.53528 *in Bahasa*
- Rouf MA, Islam MJ, Roknuzzaman M, Siddique MN, Golder MR. 2022. Vertical Profile of Dissolved Oxygen and Associated Water Variables in the Pasur-Rupsha Estuary of Bangladesh. *Heliyon* 8: e10935. DOI: 10.1016/j.heliyon.2022.e10935
- Saanin H. 1968. Taksonomi dan Kunci Identifikasi Ikan 2. Binacipta 508pp. *in Bahasa*
- Santoul F, Cayrou J, Mastrorillo S, Céréghino R. 2025. Spatial Patterns of the Biological Traits of Freshwater Fish Communities in South-West France. *Journal of Fish Biology* 66: 301–314. DOI: 10.1111/j.0022-1112.2005.00579.x
- Sarkar UK, Naskar M, Roy K, Sudeeshan D, Srivastava P, Gupta S, Karnatak G. 2017. Benchmarking pre-Spawning Fitness, Climate Preferendum of Some Catfishes From River Ganga and its Proposed Utility in Climate Research. *Environmental Monitoring and Assessment* 189: 491. DOI: 10.1007/s10661-017-6201-2
- Scholl EA, Cross WF, Guy CS, Dutton AJ, Junker JR. 2023. Landscape Diversity Promotes Stable Food Web Architectures in Large Rivers. *Ecology Letters* 26: 1740–1751. DOI: 10.1111/ele.14289
- Sofi MS, Bhat SU, Rashid I, Kuniyal JC. 2020. The Natural Flow Regime: A Master Variable for Maintaining River Ecosystem Health. *Ecology Letters* 13: 1–12. DOI: 10.1002/eco.2247
- Susanto, Novitasari DI. 2017. Struktur Umur dan Faktor Kondisi Ikan di Sungai Logawa Wilayah Kabupaten Banyumas. *Jurnal Sainteks* 14: 1–10. DOI: 10.30595/sainteks.v14i1.4186 *in Bahasa*
- Syahrul, Nur M, Fajriani, Takril, Fitriah R. 2021. Analisis Kesesuaian Kualitas Air Sungai dalam Mendukung Kegiatan Budidaya Perikanan di Desa Batetangnga, Kecamatan Binuang, Provinsi Sulawesi Barat. *Journal of Fisheries and Marine Science* 3: 171–181 *in Bahasa*
- Ulfah M, Fajri SN, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, Evenness and Dominance Index Reef Fish in Krueg Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science 348. DOI: 10.1088/1755-1315/348/1/012074
- Vyas V, Chandorkar S, Singh S. 2025. Ripples of Ecological Disarray: A Spatio-Temporal Inquiry into River Ecosystem Degradation under Pollution and Climate Stressors". *International Journal For Multidisciplinary Research* 7: 1–10. DOI: 10.36948/ijfmr.2025.v07i03.47850
- Yudha DS, Trijoko, Eprilaruhaman R, Nugraha R, Suranto RDP, Abida FU, Tobing VF, Fathiya RF, Nopitasari S. 2020. Keanekaragaman Jenis Ikan di Sepanjang Sungai Opak Propinsi Daerah Istimewa Yogyakarta, Indonesia. *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati* 5: 81–91 *in Bahasa*
- Zulfikri A, Umroh, Utami E. 2016. Pengaruh Aktivitas Tambang Apung Terhadap Keanekaragaman Ikan di Perairan Sungai Pakil, Bangka. *Jurnal Sumberdaya Perairan* 10: 42–46 *in Bahasa*