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Field-Based Evaluation of Water Quality, Macroinvertebrates and Sediment in the Downstream Segment of the Upper Konto Sub-Watershed, Indonesia

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ABSTRACT

As the last self-purification zone before inflow enters Selorejo Reservoir, the downstream reach of the Upper Konto Sub-watershed is critical for controlling pollutant and sediment transfer. An integrated ecohydraulic approach was used in this study to evaluate the water quality, sediment characteristics, and ecological condition under organic pollution pressure. Water quality was assessed at six sites and deposited sediments at four sites during the dry and rainy seasons. The Pollution Index (PI) and Family Biotic Index (FBI) were used to assess physicochemical water quality and biological condition, respectively; sediment grain-size distribution and nutrient contents were also examined. The flow velocities ranged from 0.37–0.68 m s^{-1} in the dry season and from 0.54–1.15 m s^{-1} in the rainy season, controlling erosion, transport, and deposition processes. PI results showed that the downstream reach was classified as lightly to moderately polluted in the dry season, and mostly moderately polluted in the rainy season. Conversely, the FBI showed worse biological conditions, characterized by moderately poor to very poor conditions, especially during the rainy season. TSD1–TSD3 sediments were mainly sandy, but TSD4 was composed of finer silt and mud-rich deposits. The high nitrogen concentration in TSD1 may be related to adsorption and retention of nitrogen-bearing compounds on sediment particles. Overall, ecological degradation was pronounced due to interactions among organic pollutant loads, flow dynamics, and sediment characteristics, indicating the need for integrated management of water quality, riparian conditions, and sedimentation to reduce pollutant and sediment inflows to Selorejo Reservoir.

1. INTRODUCTION

River ecosystems are among the most dynamic ecosystems on Earth, but they increasingly face threats from anthropogenic pressures such as land-use change, intensified agricultural and livestock activity, domestic waste discharge, and flow alteration that can impact water quality, sediment transport, and aquatic communities (Dudgeon et al. 2006, Gregory et al. 1991, Walsh et al. 2005, Poff et al. 2010). These pressures impair ecological functioning at the watershed scale and induce downstream impacts by propagating nutrients, organic matter, and sediment, which collectively influence reservoir systems (Uday Kumar & Jayakumar 2020, Chanapathi & Thatikonda 2020, Das et al. 2022).

In agricultural catchments, sediment and nutrient delivery are exacerbated by land degradation and erosion, leading to progressive ecological deterioration of both rivers and downstream reservoirs (Kumar et al. 2026, Biggs et al. 2025). The Upper Konto Sub-watershed is one such catchment, with the Konto River

as a major inflow to the Selorejo Reservoir multipurpose system (irrigation, fisheries, and tourism). The expansion of agricultural and residential areas increases inputs of organic matter and suspended solids, which may compromise the self-purifying capacity of rivers and degrade water quality in reservoirs (Patel & Jariwala 2023, Hu et al. 2021, Gong et al. 2023). Consequently, the downstream reach represents a key transition zone that integrates upstream pressures and associated in-stream biological responses, and faces the risk of pollutant and sediment transfers into the reservoir (Nan et al. 2025, Hu et al. 2021).

More recently, studies have highlighted that integrating physicochemical and biological indicators, specifically macroinvertebrates, can better capture ecological stress (Carrasco-Baquero et al. 2025, Munyai et al. 2025, Hegab et al. 2025, Akindele et al. 2025). Sediments also act as sinks for contaminants and play a significant role in secondary pollution through processes of storage and re-release (Baker et al. 2025, Tomić et al. 2025), while riparian vegetation enhances bank stabilization, runoff retention, and the provision of habitat depending on the flow regime and channel morphology (Granitto et al. 2025, Ji et al. 2024, Assal et al. 2021, Biggs et al. 2025). These interactions reveal that an ecohydraulic approach, which integrates flow, habitat, sediment, vegetation, and biotic responses, can provide insights into river functioning (Gibbs et al. 2023, Harris et al. 2024, Mulatu et al. 2018).

Recent studies in tropical river systems have further shown that aquatic macroinvertebrates provide a useful ecological signal of water-quality degradation, particularly in streams affected by agricultural, livestock, and domestic pressures. For example, Paredes-Agurto et al. (2024) reported that macroinvertebrate-based assessments in La Gallega-Morropón Creek, Peru, were able to reflect variations in water quality across sampling stations, highlighting their value as bioindicators in human-impacted freshwater systems.

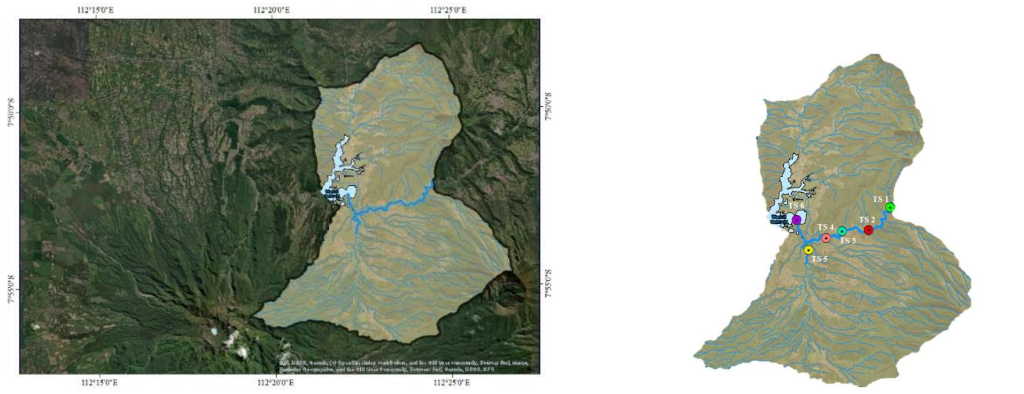
Yet few integrative studies focus on tropical downstream river reaches that can serve as the final self-purification zone before entering reservoirs. Thus, this study investigates water quality, sediment characteristics, and ecological condition in the downstream Upper Konto Sub-watershed to develop an integrated ecohydraulic framework across two seasons. The approach integrates the Pollution Index (PI), Family Biotic Index (FBI), sediment characteristics, and riparian-hydraulic context to aid in the management of water quality, sedimentation, and riparian vegetation in tropical river–reservoir systems under high organic-pollution pressure.

In this study, the ecohydraulic framework refers to the interaction among hydrodynamic conditions, sediment transport and deposition, riparian characteristics, water quality conditions, and macroinvertebrate responses within the downstream river ecosystem. Rather than evaluating these components independently, the framework conceptually integrates physical, chemical, and biological processes to interpret how watershed pressures influence ecological conditions before inflow to Selorejo Reservoir.

2. MATERIALS AND METHODS

The downstream area of the Upper Konto Sub-watershed is administratively located in the Pujon and Ngantang Districts, Malang Regency, with coordinates 7.868742°–7.877462° S and 112.371939°–112.410077° E, while the main river has a length of approximately 8 km. The study reach drains directly into Selorejo Reservoir and is the last zone of the self-purification process.

The study area (Fig. 1) is influenced by irrigation, agriculture, cattle raising, and industrial activities, and



(a) Catchment area of downstream segment (b) Sampling points along stream reach

Fig. 1: The downstream segment of the Upper Konto Sub-watershed.

receives waste inputs, making it suitable for evaluating the relationships between watershed-scale land-use pressures and ecohydraulic processes on water–sediment quality. To obtain the Pollution Index, maximum and mean concentration-to-standard ratios were used.

$$P_{ij} = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_M^2 + \left(\frac{C_i}{L_{ij}}\right)_R^2}{2}} \quad \ldots(1)$$

Where: P_{ij} = Pollution Index for designation j; C_i = concentration of the tested parameter; L_{ij} = concentration permitted under the water-quality standard for designation j; $(C_i/L_{ij})_M$ = maximum value of C_i/L_{ij}; $(C_i/L_{ij})_R$ = average value of C_i/L_{ij}.

The Pollution Index (PI) was calculated based on the maximum and mean concentrations of each parameter relative to their respective quality standards. PI values were divided into the following ranges: 0–1.0 (good quality), 1.1–5.0 (lightly polluted), 5.1–10.0 (moderately polluted), and >10.0 (heavily polluted). Biological condition was based on a biological indicator derived from the Family Biotic Index (FBI) developed by Hilsenhoff (1988). This index may estimate ecological condition, especially in relation to organic pollution, by weighting macroinvertebrate family abundances by their tolerance values. The relatively long life cycles and limited mobility of macroinvertebrates can integrate environmental conditions across space and time, which is why they are widely used as bioindicators. Although the Hilsenhoff Family Biotic Index was originally developed for temperate North American streams, it has been widely applied in tropical freshwater studies where locally calibrated tolerance indices remain limited. In this study, the FBI was used as a comparative ecological indicator to assess relative organic-pollution stress among stations and seasons. The FBI serves as an integrated measure of biological water quality and complements the physicochemical assessment accordingly.

$$FBI = \frac{\sum x_i t_i}{n} \quad \ldots(2)$$

Where: x_i = number of individuals in family i; t_i = tolerance value of family i; n= total number of individuals.

The use of macroinvertebrate assemblages as biological indicators has also been applied in other tropical freshwater studies, where indices such as the Biological Monitoring Working Party modified for Colombia (BMWP/Col) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were used



(a) Horiba U-50 (b) LAQUAtwin NO_3 Nitrate Test Kit (c) Hydrion AM-40 Ammonia Test Kit (d) Filter Paper 100 mm (e) Plankton Net No. 20

(f) Grab Sampler (g) Current Meter (h) USDH-48 (i) Ice Box (j) Sieve Shaker

Fig. 2: Research equipment and instruments.



(a) Field activity for data collection



(b) Laboratory activity

Fig. 3: Field data collection and laboratory testing activities.

to evaluate ecological responses to water-quality conditions (Paredes-Agurto et al. 2024). Although the present study applies the Family Biotic Index, the underlying principle is similar: macroinvertebrate communities can integrate environmental stress over time and provide biological evidence of organic pollution and habitat disturbance.

This study employed a range of instruments to assess water quality, collect sediment samples, and conduct laboratory analyses. In situ measurements were taken using a Horiba U-50 multiparameter analyzer, which recorded temperature, turbidity, dissolved oxygen (DO), conductivity, pH, oxidation–reduction potential (ORP), and water depth, while simultaneously capturing geographic coordinates using its integrated GPS. Nitrate and ammonia concentrations were measured on site using the LAQUAtwin NO_3 and Hydrion AM-40 test kits. Suspended sediment samples were collected with a USDH-48 sampler, designed for shallow waters (<2 m). Sieve and hydrometer tests were used to analyze sediment physicochemical properties and grain-size distribution, which were then classified according to the AASHTO system. Transect-level surveys of macroinvertebrate assemblages served as biological indicators. Additional supporting tools included a shovel, magnifying glass, measuring tape, alcohol sprayer, ice box, grab sampler, wooden stakes, sample bottles, oven, digital balance, weighing scale, glass funnel, beaker, Erlenmeyer flask, measuring cylinder, filter paper, and current meter. Collectively, these instruments facilitated systematic field sampling, sample preservation, and laboratory testing. Fieldwork was conducted in the dry season (August) and rainy season (January), with measurements performed in quintuplicate to reduce observational uncertainty for temperature, pH, DO, conductivity, turbidity, and TDS. Figures 2 and 3 illustrate the instruments, field sampling, and laboratory procedures.

This study employed theShannon–Wiener Index (H'), a statistical measure widely used to describe biodiversity by integrating both species richness (the number of species present) and species evenness (the relative abundance of individuals across species). The index is calculated using the formula:

$$H' = -\sum p_i \ln(p_i) \quad \ldots(3)$$

Where: p_i is the proportion of individuals belonging to species. The index value typically ranges from 0, indicating no diversity when only one species is present, to about 3–4 in highly diverse ecosystems. In general, values below 1 suggest low diversity and possible ecological stress, values between 1 and 3 indicate moderate diversity and a reasonably balanced community, while values above 3 reflect high diversity and ecological stability. Higher values of H' generally indicate greater diversity, while lower values suggest dominance by a few tolerant taxa and potential environmental stress (Yuniari et al. 2025).

3. RESULTS AND DISCUSSION

Six sites (TS1–TS6) were sampled for water-quality and biological assessments, while four sites (TSD1–TSD4) were designated for deposited sediment analysis. Sampling locations were selected based on accessibility, safety, physical river conditions, and the intensity of surrounding community activity. Water quality data, including physical

Table 1: Water quality data (physical and chemical parameters).

Parameter	TS1		TS2		TS3		TS4		TS5		TS6	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
Temperature (°C)	23.05	24.94	25.83	25.81	27.53	27.01	24.71	27.32	27.41	29.09	28.37	28.10
pH	7.95	7.73	8.00	7.80	7.94	7.51	7.82	7.73	7.65	7.68	7.21	7.64
Conductivity (µS/cm)	306.80	228.00	300.40	231.00	305.40	242.40	263.20	228.40	278.40	262.2	274.20	255.00
Turbidity (NTU)	89.24	89.34	176.8	100.82	88.56	73.34	53.00	95.54	39.18	85.22	77.80	126.20
DO (mg/L)	8.23	7.62	7.08	7.15	6.95	6.22	7.95	6.49	6.41	6.02	4.39	6.14
TDS (mg/L)	199.40	148.40	195.40	150.20	198.60	157.60	171.20	148.60	181.00	170.00	178.00	161.60
TSS (mg/L)	110.00	190.00	160.00	200.00	90.00	160.00	50.00	190.00	30.00	180.00	70.00	200.00
TOM (ppm)	25.46	47.77	22.03	48.33	22.03	52.91	22.03	58.06	15.16	73.51	16.88	42.62
NO_3 (ppm)	31.00	25.00	23.00	31.00	22.00	27.00	22.00	33.00	10.00	32.00	22.00	29.00
NH_3 (ppm)	5.00	5.00	5.00	10.00	5.00	10.00	10.00	10.00	10.00	10.00	20.00	10.00
N Total (ppm)	-	63.13	-	47.08	-	68.13	-	81.04	-	58.13	-	52.08
P Total (ppm)	-	34.82	-	26.79	-	37.72	-	57.59	-	33.48	-	27.90
K Total (ppm)	-	28.99	-	26.64	-	25.94	-	28.03	-	30.55	-	22.44

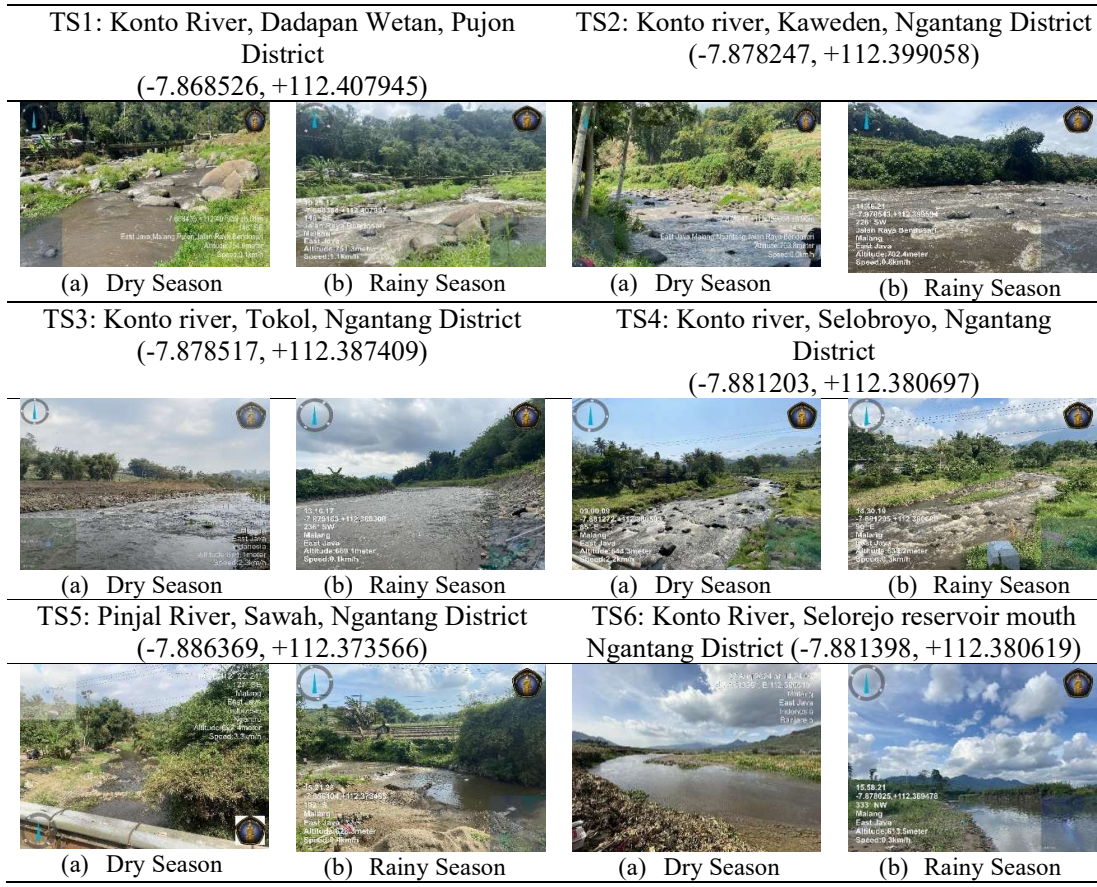


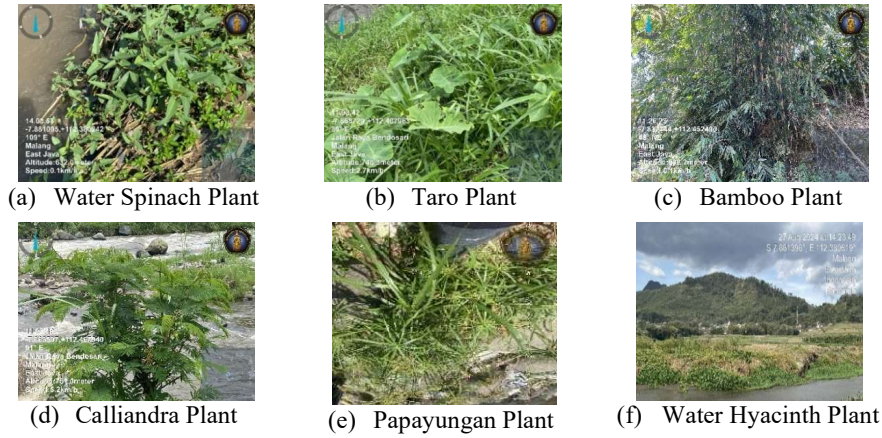
Fig. 4: River condition at the sampling points.



Fig. 5: Stream reach conditions at sediment-deposit sampling sites.

and chemical parameters, are presented in Table 1. During the dry season, sediment deposits were concentrated in the mid-channel and along riverbanks(Figs. 4 and 5).

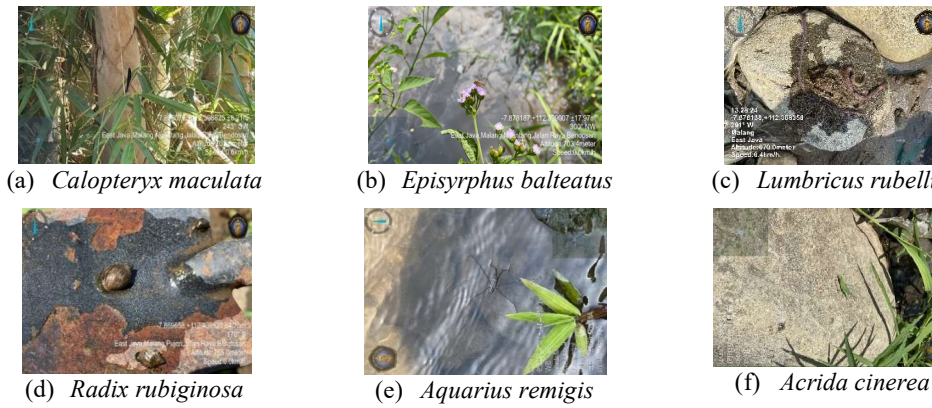
The vegetation along the lower segment of the Upper Konto Sub-watershed is very diverse. Vegetation in the lower reach consists primarily of water spinach plant, taro plant, bamboo plant, Calliandra plant, Papayungan plant, and water hyacinth plant (Fig. 6). The macroinvertebrate communities in the downstream segment were dominated by *Gerridae* and *Lumbricidae*. *Radix rubiginosa* (also known as Onga in Javanese) was dominant during the dry season but declined in abundance during the rainy season, suggesting that *Radix rubiginosa* prefers environments with low flow



(a) Water Spinach Plant (b) Taro Plant (c) Bamboo Plant

(d) Calliandra Plant (e) Papayungan Plant (f) Water Hyacinth Plant

Fig. 6: Riparian vegetation along the river course.



(a) *Calopteryx maculata* (b) *Episyrphus balteatus* (c) *Lumbricus rubellus*

(d) *Radix rubiginosa* (e) *Aquarius remigis* (f) *Acrida cinerea*

Fig. 7: Terrestrial insects and macroinvertebrates along the downstream segment.

conditions. This pattern also occurred for *Gerridae*, as would be expected given their association with slow-flowing clear waters. *Lumbricidae* also dominated sediment deposits, suggesting organic-enriched substrate conditions (Fig. 7).

3.1. River Hydraulic Conditions

The river hydraulic parameters during the dry and rainy seasons at each location are presented in Table 2. Variations in river discharge illustrate the impact of flow variability on water quality and sediment dynamics in the downstream segment of the Upper Konto Sub-watershed. Flow velocity measured with a current meter ranged from 0.37–0.68 m s^{-1} in the dry season and increased to 0.54–1.15 m s^{-1} in the rainy season. Higher flow rates enhance erosion, whereas lower flow rates favor the deposition of finer sediment particles. In the downstream segment, a check dam helps retain sediment and slow the flow before the river enters the reservoir. This pattern aligns with the ecohydraulic framework, in which habitat quality is determined by flow velocity, residence time, and habitat connectivity (Gibbs et al. 2023, Chanapathi & Thatikonda 2020).

3.2. River Water Quality Based on the Pollution Index (PI)

Water quality was assessed against designated uses and maximum allowable standards using the Pollution Index

Table 2: River hydraulic parameters.

Location	Flow velocity (m s^{-1})	Discharge (m^3 s^{-1})	Flow velocity (m s^{-1})	Discharge (m^3 s^{-1})
	Dry Season		Rainy Season	
TS1	0.38	4.04	0.75	5.70
TS2	0.56	8.04	1.15	9.83
TS3	0.68	2.88	0.88	4.90
TS4	0.68	3.50	0.92	3.61
TS5	0.37	0.95	0.54	1.75
TS6	Still water	-	Still water	-

(PI). The spatial mapping of water quality was performed to describe the distribution of water quality in the downstream section of the Konto Hulu Sub-Watershed. The Inverse Distance Weighting (IDW) interpolation method was used to estimate the spatial distribution of water and sediment quality parameters according to the distances between sampling locations. This method is based on the assumption that spatial influence decreases with distance. Thus, sampling points closer to an unsampled location will have a larger influence on estimated values than those at a further distance. Hence close observations are given more weight, and distant ones less, as one move farther away from the point of interest (Tables 3-4, and Figs. 8-9). The water in the downstream Upper Konto Sub-watershed was classified as lightly to moderately polluted according to the PI, with more severe conditions during the rainy season: 43.46% slightly polluted and 56.54% moderately polluted during the dry season versus 13.86% and 86.14%, respectively, in the rainy season (Fig. 8). Most direct pollution originated from livestock, agriculture, and domestic waste, especially untreated runoff and drainage discharges that directly entered the river.

These observations suggest that increased discharge did not improve water quality, because pollutant inputs from agricultural, livestock, and domestic runoff exceeded the river's dilution and self-purification capacity. This trend confirms the findings of Patel and Jariwala (2023) and Whittinghill et al. (2023), which associated nutrient-rich runoff with deteriorating water quality, including higher nitrate, ammonia, phosphorus, conductivity, and turbidity.

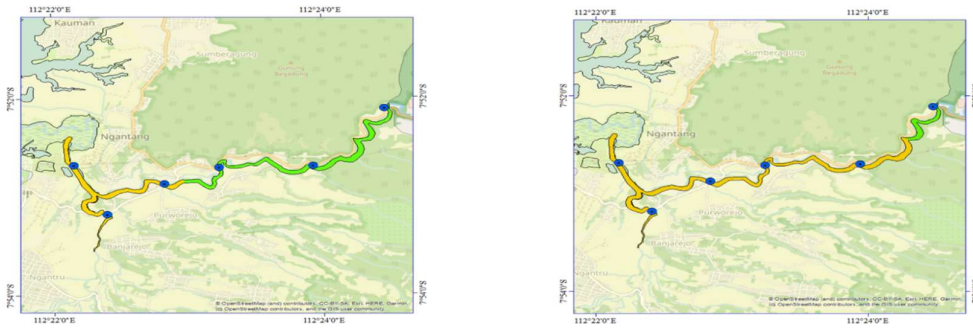
3.3. Water Quality Based on the Family Biotic Index (FBI)

The seasonal difference in water quality of the downstream part of the Upper Konto sub-watershed was assessed by the IDW interpolation method and supported by the Family Biotic Index (FBI) results as given in Table 4 and Fig. 9. In the dry season, 46.66% of sampling points were Moderately Poor (heavily polluted with organic matter) and 53.34% were Poor (heavily polluted with organic matter). In the rainy season, 15.93% was classified as Poor, 12.93% as Moderately Poor, and 71.14% as Very Poor, suggesting heavy organic pollution.

This discordance suggests chronic, not episodic, organic pollution in the downstream reach. The relative dominance of tolerant taxa and absence of sensitive taxa might indicate long-term alterations to the community, leading to persistent habitat degradation, which is in agreement with

Table 3: Summary of Pollution Index values during the dry and rainy seasons.

Location	Dry Season		Rainy season	
	PI Value	Status	PI Value	Status
TS1	4.45	Slightly polluted	4.47	Slightly polluted
TS2	4.47	Slightly polluted	5.54	Moderately polluted
TS3	4.43	Slightly polluted	5.52	Moderately polluted
TS4	5.44	Moderately polluted	5.56	Moderately polluted
TS5	5.41	Moderately polluted	5.58	Moderately polluted
TS6	6.52	Moderately polluted	5.56	Moderately polluted
Total	43.46 %	Slightly polluted	13.86 %	Slightly polluted
	56.54 %	Moderately polluted	86.14 %	Moderately polluted

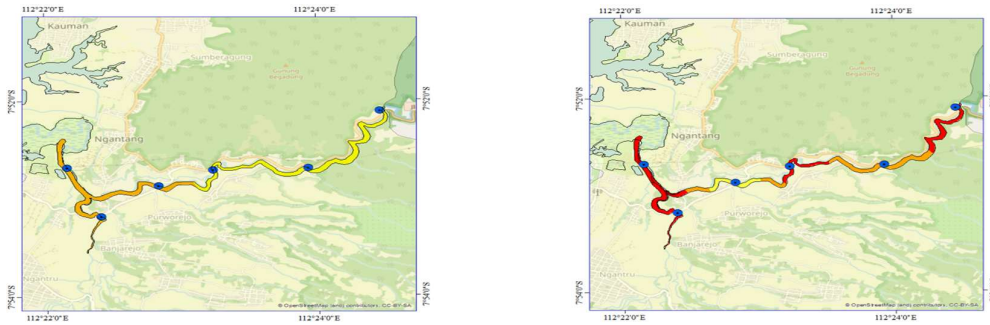


(a) Dry Season (b) Rainy Season

Fig. 8: Pollution index mapping in the downstream segment of the Upper Konto Sub-watershed.

Table 4: Summary of Family Biotic Index values during the dry and rainy seasons.

Location	FBI Dry Season	Status	FBI Rainy Season	Status
TS1	6.11	Moderately poor	8.50	Very poor
TS2	5.78	Moderately poor	7.14	Poor
TS3	6.22	Moderately poor	8.00	Very poor
TS4	6.82	Poor	5.80	Moderately poor
TS5	6.76	Poor	8.00	Very poor
TS6	7.12	Poor	7.40	Very poor
Total	46.66 %	Moderately poor	15.93 %	Poor
	53.34 %	Poor	12.93 %	Moderately poor
			71.14 %	Very poor



(a) Dry Season (b) Rainy Season

Fig. 9: Mapping of water quality using the Family Biotic Index method in the downstream segment of the Upper Konto Sub-watershed.

the comprehensive responses observed by Carrasco-Baquero et al. (2025) and also the sediment–water chemistry effects described by Munyai et al. (2025). A lower-than-expected occurrence of the Gerridae during the rainy season also demonstrates declining resilience under compounded hydrological pressure (Sarremejane et al. 2024).

A similar ecological response was observed by Paredes-Agurto et al. (2024) in La Gallega-Morropón Creek, where low macroinvertebrate diversity was associated with anthropogenic disturbance along the stream. Their findings support the interpretation that a community dominated by tolerant taxa may indicate long-term ecological stress, even when some physicochemical parameters still appear acceptable. In the downstream Upper Konto Sub-watershed, the dominance of tolerant macroinvertebrate groups and the absence of highly sensitive taxa therefore suggest that organic pollution and habitat alteration have affected the biological integrity of the river beyond what is captured by short-term water-quality measurements.

3.4. Integration of the Pollution Index (PI) and the Family Biotic Index (FBI)

The contrast between the Pollution Index and Family Biotic Index highlights the importance of a multi-metric assessment. Physicochemical parameters capture instantaneous conditions, whereas macroinvertebrate communities integrate cumulative stress over time. This pattern is consistent with the findings of Paredes-Agurto et al. (2024), who found that physicochemical parameters in La Gallega-Morropón Creek complied with national water-quality standards, while macroinvertebrate-based indices still indicated contrasting ecological conditions among sampling stations. This reinforces the need to combine chemical and biological assessments, since biological communities often reveal accumulated or site-specific stress that may not be fully represented by physicochemical snapshots. Thus, poorer FBI scores indicate greater ecological degradation than chemical snapshots alone suggest, supporting the view that downstream Konto River impairment arises from interacting organic loads, flow dynamics, and habitat degradation (Tomić et al. 2025, Vezi et al. 2020).

3.5. Sediment Characteristics and Management Implications

Granular gradation testing (sieve tests and hydrometers) indicated a substrate composition of gravel, sand, silt, and clay. TS 1–5 consisted mostly of sand and gravel with relatively high flow, whereas TS 6 (Selorejo Reservoir

Mouth) is dominated by silt that occurs at slow, stagnant flows. In TS 4, the bottom sediment consists of 42.72% gravel, 55.83% sand, and 1.46% mud on the right side, and 49.54% gravel, 50.12% sand, and 0.35% mud on the left side. In contrast, TS 6 is dominated by mud (87.70% in the middle; 85.10% on the left-hand side), with silt more prevalent than clay (Figs. 10 and 11).

Pollutants have been supplied from various sources, including agriculture, livestock, and domestic use, in the upstream agricultural region of the Upper Konto Sub-watershed. These pollutants can settle mainly on the macrobenthic substrate, which macroinvertebrates use as habitat. This substrate is ecologically important and provides benthic functions based on the regime. It also acts as a sink for contaminants. Sediment textures differed among sites: TSD1–TSD3 were predominantly sandy, while TSD4 had muddy silt. These differences influenced macroinvertebrate abundance. Substrate conditions may also help explain differences in macroinvertebrate assemblages. Paredes-Agurto et al. (2024) noted that habitat features such as leaf litter and substrate type can support particular macroinvertebrate groups by providing food resources and shelter. In the Upper Konto downstream reach, differences between sandy, gravelly, and fine muddy deposits may therefore contribute to spatial variation in benthic communities, especially where organic-rich sediments provide suitable conditions for tolerant taxa. The higher nitrogen content at TSD1 is likely due to nitrogen's tendency to adsorb onto sediment particles. In contrast, phosphorus may remain relatively mobile in the water column under certain hydrological conditions. Lower nutrient concentrations near cultivated areas may potentially be influenced by nutrient uptake by vegetation. Fine-textured sediment at TSD4 retained higher nutrient concentrations and coincided with the dominance of tolerant macroinvertebrate taxa, suggesting that depositional zones may contribute to long-term habitat degradation. Similar observations were reported by Baker et al. (2025) and Tomić et al. (2025), who identified sediment as an active compartment for contaminant storage and re-release. Shifts in sediment chemistry were correlated with changes in macroinvertebrate community structure, validating these sediment metrics as indicators of benthic habitat degradation (Munyai et al. 2025).

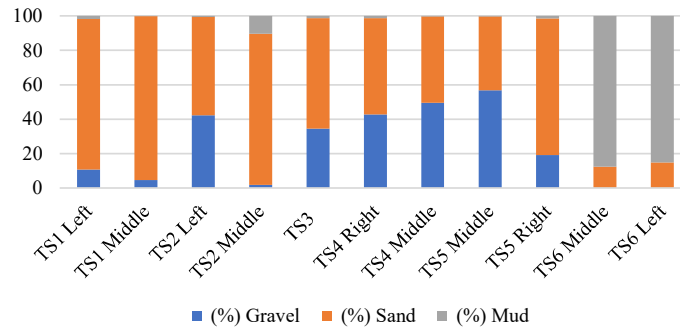


Fig. 10: Sediment characteristics.

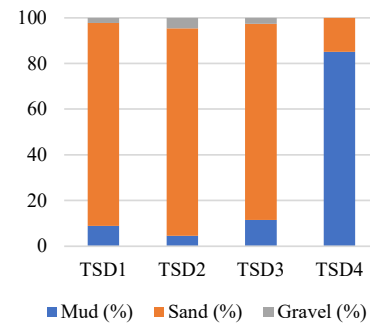


Fig. 11: Sediment deposit characteristics.

Table 5: Summary of macroinvertebrate families during the dry and rainy seasons.

No.	Family	Species		Proportion		No	Family	Species		Proportion	
		Dry	Rainy	Dry	Rainy			Dry	Rainy	Dry	Rainy
1	Acrididae	5	5	0.029	0.059	18	Lumbricidae	31	19	0.182	0.224
2	Asilidae	-	1	-	0.012	19	Lycosidae	1	1	0.006	0.012
3	Blaberidae	1	4	0.006	0.047	20	Lymnaeidae	10	-	0.059	-
4	Bythinellidae	1	-	0.006	-	21	Muscidae	9	7	0.053	0.082
5	Calopterygidae	3	-	0.018	-	22	Nymphalidae	2	2	0.012	0.024
6	Challiporidae	1	2	0.006	0.024	23	Pieridae	-	2	-	0.024
7	Chrysomelidae	18	3	0.106	0.035	24	Platycnemididae	1	-	0.006	0.000
8	Coccinellidae	6	4	0.035	0.047	25	Polydesmidae	-	1	-	0.012
9	Coenagrionidae	2	-	0.012	-	26	Salticidae	2	-	0.012	-
10	Formicidae	-	5	-	0.059	27	Scarabaeidae	-	3	-	0.035
11	Gerridae	47	3	0.276	0.035	28	Silphidae	1	-	0.006	-
12	Gryllidae	-	1	-	0.012	29	Syrphidae	5	1	0.029	0.012
13	Gryllotalpidae	-	3	-	0.035	30	Tabanidae	1	-	0.006	-
14	Issidae	3	-	0.018	-	31	Tetragnathidae	1	-	0.006	-
15	Leptoceridae	2	-	0.012	-	32	Thiaridae	10	-	0.059	-
16	Lestidae	3	-	0.018	-	33	Trigoniulidae	-	3	-	0.035
17	Libellulidae	4	15	0.024	0.176		**Total Species**	170	85	1.000	1.000

A total of 33 macroinvertebrate families were encountered, of which 18 were used for the Family Biotic Index (FBI) assessment. Table 5 shows the macroinvertebrate families and their observed abundances. No highly pollution sensitive taxa were detected but families with moderate tolerance such as Gerridae and Muscidae were observed throughout the sampling sites and seasons. Syrphidae were also present but at a lower abundance than some other families, such as Gerridae and Lumbricidae, suggesting that the Syrphidae were not the dominant group in the macroinvertebrate community. However, the occurrence of pollution tolerant taxa suggests possible ecological responses to organic pollution. The seasonal occurrence of potential indicator taxa such as *Aquarius remigis*, *Ceraclea dissimilis*, *Episyrphus balteatus* and *Volucella pellucens*, may be a result of the combined effects of hydrologic seasonality and environmental stressors on macroinvertebrate community composition.

The Pollution Index (PI) and FBI measure different perspectives of the river water quality. The PI is an indicator of the physicochemical condition while FBI indicates the response of macroinvertebrate community to organic pollution. Therefore, it is not surprising that there are differences in their classifications. Both sampling seasons revealed light to moderate pollution at the PI and moderate to severe organic pollution related impairment at the FBI. This difference may be due to differences in the temporal integration and ecological sensitivity of physicochemical and biological indicators, indicating the need for a combination of both approaches to better assess river ecosystem conditions.

The Shannon–Wiener Index (H') during the dry season was 2.471, while in the rainy season it reached 2.584. These values fall within the moderate diversity range (1–3), indicating that the macroinvertebrate community structure remained relatively balanced across seasons. The slightly higher value in the rainy season suggests a marginal increase in species diversity and evenness, although the difference between seasons is not substantial. Overall, the results imply that the ecosystem maintains moderate stability, with seasonal hydrological variations exerting only limited influence on biodiversity composition (Yuniari et al. 2025).

4. CONCLUSIONS

The downstream reach of the Upper Konto Sub-watershed exhibits ecological impairment associated with organic pollutant inputs, hydrodynamic conditions, and sediment characteristics. Pollution Index values categorize the water as lightly to moderately polluted, with more critical conditions during the rainy season. The biological assessment, using the Family Biotic Index, shows that ecological impairment is more severe than physicochemical measurements alone would indicate: tolerant taxa predominate, while sensitive taxa are absent, indicative of chronic organic pollution and altered macroinvertebrate community structure.

Sediments in depositional zones may function as temporary reservoirs for nutrient and contaminant accumulation and could contribute to pollutant re-release under changing environmental conditions. Thus, water quality assessment should integrate water-column parameters with sediment condition and riparian habitat quality. This downstream section is ecologically significant because it directly affects inflows to Selorejo Reservoir, where declining water quality and sedimentation can further aggravate reservoir conditions. Accordingly, management should implement an integrated approach that minimizes agricultural and livestock-derived pollution, conserves riparian vegetation, and manages depositional sediments to strengthen natural recovery while curtailing pollutant transfer to the Selorejo Reservoir.

These findings are in line with recent tropical stream studies showing that macroinvertebrate-based assessments can provide an important ecological perspective on water-quality degradation, particularly in rivers affected by human activities.

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