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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 occurred before the inflow entered the Selorejo Reservoir, the downstream reach of the Upper Konto Sub-watershed is critical for controlling pollutant and sediment transfer. An integrated ecohydraulic approach was employed in this study to evaluate the water quality, sediment characteristics, and ecological condition in response to organic pollution pressure. Water quality was sampled at five sites and deposited sediment at four sites during the dry and rainy seasons. Pollution Index (PI) and Family Biotic Index (FBI) were used for water quality assessment, grain size distribution, and nutrient Contents. The flow velocities during the dry season ranged from 0.38–0.68 m/s, and those in the rainy season from 0.54–1.15 m/s, controlling erosion, transport, and deposition processes. PI results showed that the downstream reach was classified as lightly to moderately polluted in the dry season, while mostly moderately polluted in the rainy season. Conversely, the FBI showed worse biological conditions, characterized by a moderately poor to very poor state, especially in the rainy periods. TSDs 1–3 were dominated by sand sediments, while TSD4 has silt–mud deposits with retained nitrogen. Ecological degradation was overall significant due to interactions among organic pollutant loads, flow dynamics, and sediment characteristics, indicating the need for prior integrated management of water quality, riparian conditions, and sedimentation to prevent inflow into Selorejo Reservoir.

## 1. INTRODUCTION

River ecosystems are some of 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 and Jayakumar 2020); (Chanpathi and 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 of them, 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 and Jariwala 2023); (Hu et al. 2021); (Gong et al. 2023). Consequently, the downstream reach represents a key transition zone that accumulates total upstream pressures, exhibits stream bioassessments with 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 flow regime and channel morphology effectiveness (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, has much to learn about flow (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.

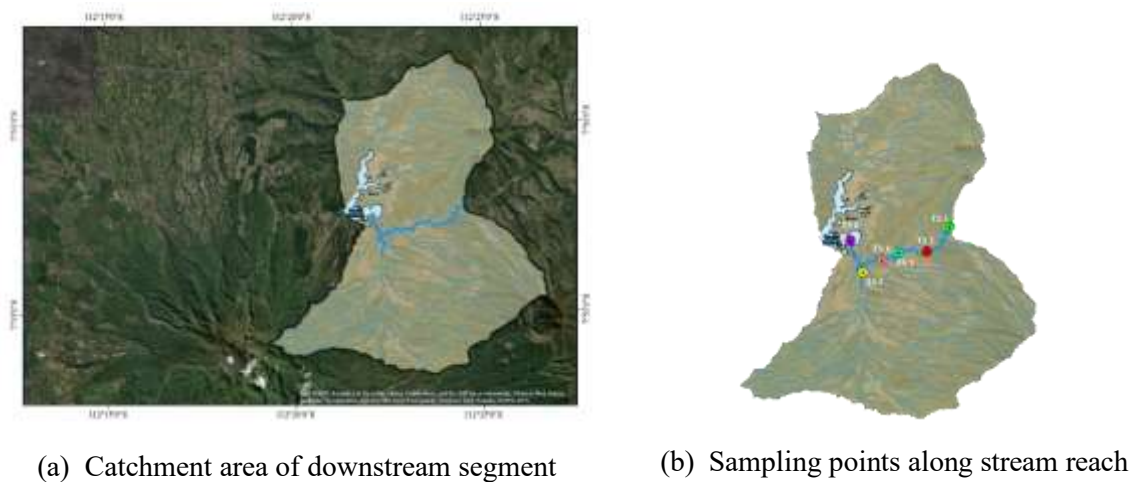
Yet few integrative studies focus on tropical downstream river reaches that can serve as the final self-purification zone before entering reservoirs. Thus, this study investigates water quality, sediment characteristics,

and ecological condition in the downstream Upper Konto Sub-watershed to develop an integrated ecohydraulic framework across two seasons. It is novel in that it incorporates 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 the 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  $7.868742^{\circ}$ – $7.877462^{\circ}$  S and  $112.371939^{\circ}$ – $112.410077^{\circ}$  E, while the main river has a length of approximately 8 km. This location directly flows to the Selorejo Reservoir and is the last zone of the self-purification process.



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

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

$$P_{ij} = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_{M^2} + \left(\frac{C_i}{L_{ij}}\right)_{R^2}}{2}} \quad \dots(1)$$

where:  $P_{ij}$  = Pollution Index for designation  $j$ ;  $C_i$  = Concentration of test results parameters;  $L_{ij}$  = The concentration of parameters according to the water quality standards for  $j$ ;  $(C_i/L_{ij})_M$  = 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 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 measurement of river water biology and complements the physicochemical assessment accordingly.

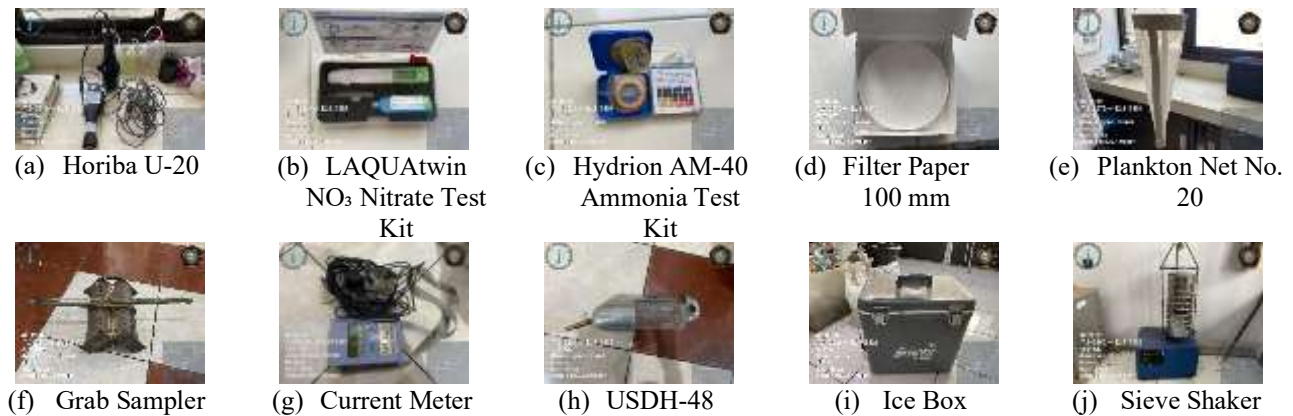
$$FBI = \frac{\sum x_i t_i}{n} \quad \dots(2)$$

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 Biological Monitoring Working Party modified for Colombia (BMWP/Col) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were used 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 via its integrated GPS. Nitrate and ammonia concentrations were measured on site using the LAQUAtwin  $\text{NO}_3$  and Hydriion 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 during 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.



**Fig. 2:** Research equipment and instruments



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

This study employed the Shannon-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:

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

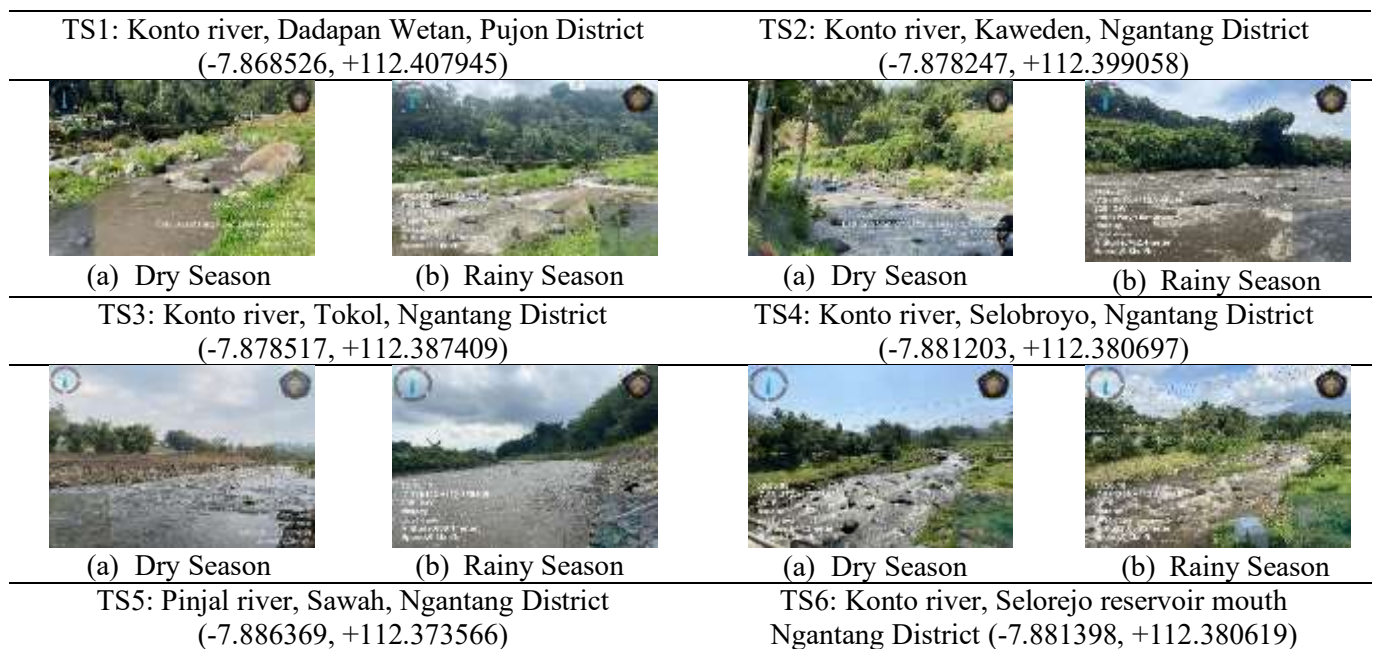
where:  $p_i$  is the proportion of individuals belonging to species  $i$ . The index value typically ranges from 0, indicating no diversity when only one species is present, to about 3–4 in highly diverse ecosystems. In general, values below 1 suggest low diversity and possible ecological stress, values 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  $H'$  indicate greater diversity and ecological stability, 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, biological assessments, and sediment characterization, while four sites (TSD1–TSD4) were designated for deposited sediment analysis. Sampling locations were selected based on accessibility, safety, river physical conditions, and the intensity of surrounding community activity. Water quality data, including physical and chemical parameters, are presented in Table 1. During the dry season, sediment deposits were concentrated in the mid-channel and along riverbanks (Fig. 4 and Fig. 5).

**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 (mS/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 (g/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 (ppt)	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
NO3 (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
NH3 (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



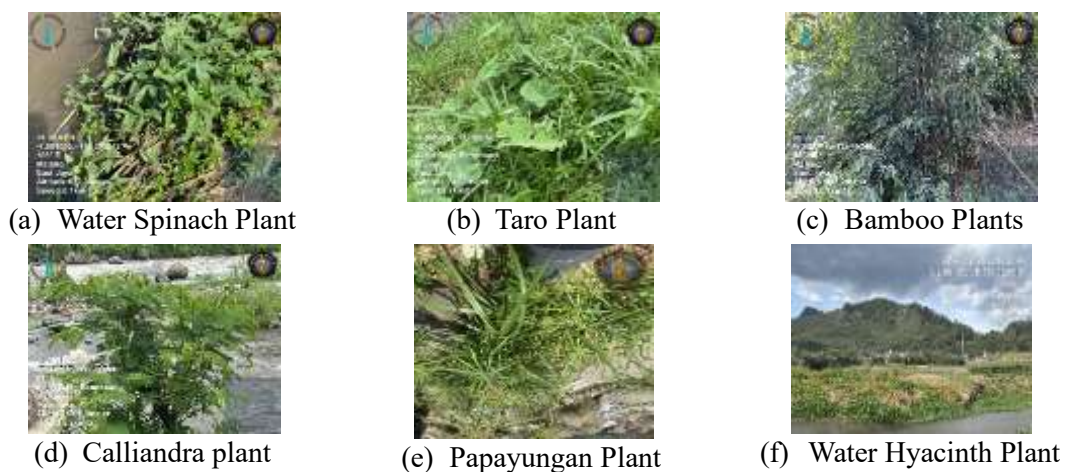


**Fig. 4:** River condition at the sampling points



**Fig. 5:** Stream reach condition of sediment deposits sampling

The vegetation along the lower segment of Upper Konto sub-watershed is very diverse. The Lower part vegetation is composed primarily of Bamboo, Vetiver, Piptadenia Gonoacantha, Taro and Ludwigia Grandiflora (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 numbers around rainy season, suggesting that *Radix Rubiginosa* prefers environments with low flow 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).



**Fig. 6:** Riparian vegetation along the river course



**Fig. 7:** Macroinvertebrates along the downstream segment

### 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 was 0.38–0.68 m/s using a current meter in the dry season and became elevated to 0.54–1.15 m/s in the rainy season. In contrast, higher flow rates enhance erosion, while lower flow rates encourage siltation by compacting smaller sediment particles. In the downstream segment, a check dam helps retain sediment and slow the flow before inflow to 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 and Thatikonda 2020).

**Table 2:** River hydraulic parameters

Location	Flow velocity (m/s)	Discharge (m <sup>3</sup> /s)	Flow velocity (m/s)	Discharge (m <sup>3</sup> /s)
	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	-

### 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 (PI) (Table 3). The water in the downstream Upper Konto Sub-watershed was indicated as light to moderately polluted by PI, with a more severe condition for the rainy season: 43.46% slightly polluted and 56.54% moderately polluted during the dry season versus 13.86% and 84.14%, 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.

**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 Upper Konto Sub-Watershed

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)

Seasonal patterns in water quality have been observed in the downstream segment of the Upper Konto Sub-watershed (as reported by the FBI, Table 4). In the dry season, 46.66% of sampling points were Moderately Poor (heavily polluted with organic matter) and 53.34% was Poor (heavily polluted with organic matter). Conversely, in the rainy season, at 15.93% Poor status, 12.93% Moderately Poor, and 71.14% Very Poor, which is suggestive of heavy organic pollution (Fig. 9).

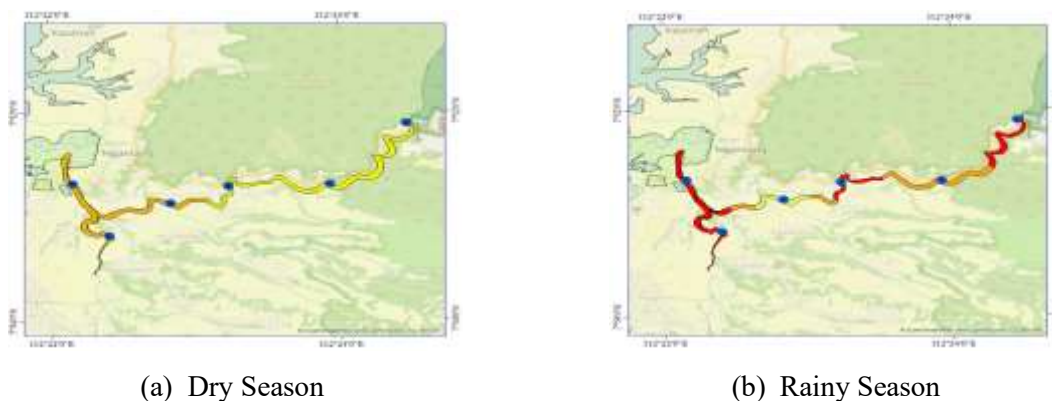
This discordance suggests chronic, not episodic, organic pollution in the bottom reach. The relative dominance of tolerant taxa and absence of sensitive taxa might indicate long-term alterations to the community, leading to persistent habitat degradation, which is in agreement with the comprehensive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

**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



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

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

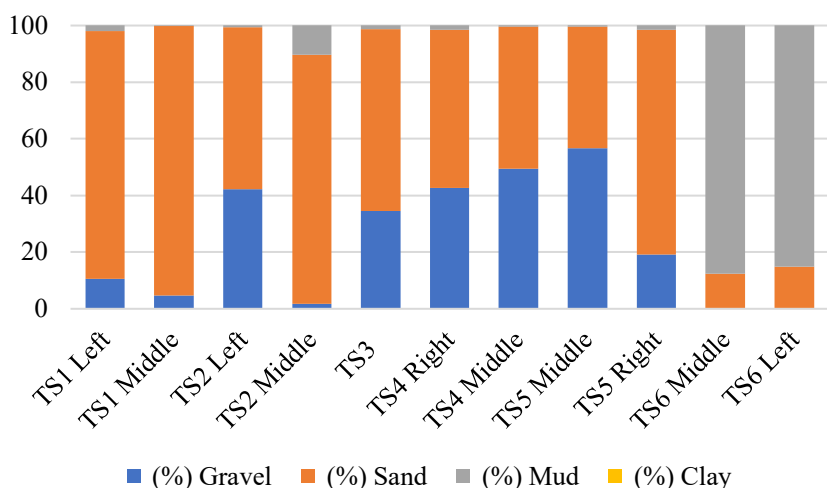
The contrast between the Pollution Index and Family Biotic Index highlights the importance of a multi-metric assessment. Physicochemical parameters capture instantaneous conditions, whereas macroinvertebrate communities integrate cumulative stress over time. This pattern is consistent with the findings 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).

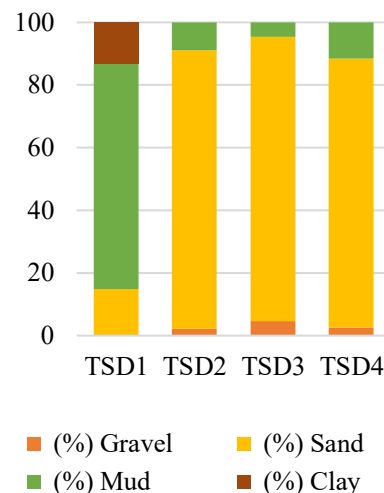
### 3.5. Sediment Characteristics and Management Implications

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 medium; 85.10% on the left-hand side), with silt more prevalent than clay (Fig. 10 and Fig. 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: TSDs 1–3 were predominantly sandy, while TSD 4 had muddy silt. These differences influenced macroinvertebrate abundance. Substrate condition 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 TSD 1 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 textures 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 characteristic



**Fig. 11:** Sediment deposit characteristic

A total of 33 macroinvertebrate families were detected, but only 18 were listed in the Family Biotic Index (FBI). Macroinvertebrate families represented in Table 5. None of the highly sensitive taxa were detected, while moderately tolerant ones (e.g. *Gerridae* and *Leptoceridae*) were sampled on relatively few occasions in certain sites and seasons. In contrast, the *Syrphidae* were dominant species that tolerated organic pollution. Seasonal fluctuations in potential indicators, including *Aquarius remigis*, *Ceraclea dissimilis*, *Episyrphus balteatus*, and *Volucella pellucens*, also indicate that the community's dynamics are influenced by both hydrological seasonality and pollutant pressure. Because PI and FBI assess different indicators of river condition (PI assesses physicochemical water quality, while the FBI quantifies biological responses to organic pollution), they yield divergent classifications. In both seasons, PI showed a light to moderate degree of pollution, and FBI showed an index result indicating moderate to severe degradation, highlighting that pollutants have accumulated in sediment and riparian zones beyond the river's self-purification and buffering capacity.

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

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

No.	Family	Species		Proportion		No	Family	Species		Proportion	
		Dry	Rainy	Dry	Rainy			Dry	Rainy	Dry	Rainy
17	Libellulidae	4	15	0.024	0.176	<b>Total Species</b>		170	85	1.000	1.000

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 area of the Upper Konto Sub-watershed is an affected ecological condition driven by 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 potentially function as temporary reservoirs for nutrient and contaminant accululation and could contribute to pollutant re-release under changing environmental conditions. Thus, water quality assessment should better 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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