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Research Article

DIVERSITY OF BENTHIC MACROINVERTEBRATES IN THE TILE RIVER IN THE FORESTED REGION OF GUINEA

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ABSTRACT

Benthic macroinvertebrate communities, widely recognized as excellent biological indicators, are commonly used to assess the ecological status of freshwater ecosystems. The objective of this study is to describe the structure of the benthic fauna of the Tilé River, located in the forested region of Guinea. To this end, bimonthly sampling was conducted from April to November 2025 at five stations distributed from upstream to downstream, using a Surber-type sampling net. The collected samples were sorted, identified, and counted under a stereomicroscope. In total, 1,788 benthic macroinvertebrate individuals belonging to 3 classes, 12 orders, and 22 genera were recorded. Faunal analysis revealed a clear dominance of insects, which accounted for 86.36% of the total abundance, mainly from the Diptera, Ephemeroptera, and Coleoptera orders. Fisher's test, applied to analyze spatial variations in taxon distribution among stations, showed no significant differences in abundance ($F = 0.48$; p-value = $0.75 > 0.05$). Furthermore, the evaluation of ecological parameters including species richness (mean SR = 18), Shannon diversity index (H' = 2.14 bits), Pielou's evenness index (J'= 0.77), trophic structure, and the proportion of EPT taxa (Ephemeroptera-Plecoptera-Trichoptera), indicated an increasing imbalance in macroinvertebrate communities from upstream to downstream, reflected by generally low index values. These preliminary results constitute an essential baseline for future bioindication studies, aimed at preserving the ecological integrity of the Tilé River and ultimately contributing to the protection of public health in surrounding communities.

Keywords: Diversity, Benthic macroinvertebrates, Water quality, Tilé River, Guinea.

INTRODUCTION

Continental freshwater ecosystems provide a wide range of essential goods and ecosystem services to humans, conferring on them an irreplaceable ecological and economic value (Costanza *et al.,* 1997). However, these environments are increasingly threatened by anthropogenic activities, particularly the discharge of domestic and industrial effluents, which disrupt aquatic communities and lead to biodiversity loss (Aguilar, 2004). In this context, continuous and systematic monitoring of the health and functioning of these ecosystems is indispensable. Traditionally, water quality assessment has relied primarily on physicochemical descriptors. Although these parameters are effective in detecting certain anomalies, they do not allow for evaluating the ecosystem's capacity to maintain functional balance or for obtaining a comprehensive view of its biological and ecological health (Karr and Chu, 1997). Ecological assessment using relevant and reliable bioindicators is therefore necessary (Diomandé *et al.,* 2009). Among bioindicators, benthic macroinvertebrates are particularly suitable due to their sedentary nature, sensitivity to water quality changes, ability to integrate long-term environmental impacts, and key role in the trophic chain (Ben *et al.,* 2014). Numerous studies on the

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bioindication of freshwater systems have relied on these organisms (Zinsou *et al.,* 2016; Soumaoro *et al.,* 2025). However, the use of benthic macroinvertebrates to monitor the ecological integrity of rivers in Guinea remains limited due to insufficient knowledge. Guinea possesses a dense hydrographic network spanning all regions, with particular importance in the forested zone, which has not yet been the subject of any bioassessment study using these bioindicators. In this context, the present study was initiated to fill this knowledge gap and enhance understanding of the ecological and biological functioning of the Tilé River. The main objective is to provide preliminary data on the diversity of benthic macroinvertebrates, their structuring, and degree of organization. These data will allow an initial assessment of the river's ecological integrity and support the development of strategies for its rational and sustainable management.

MATERIALS AND METHODS

Study area and sampling stations

Located in the forested region of southeastern Guinea, N'Zérékoré is the country's third largest city, after Conakry and Kankan. It lies between 7°32' and 8°22' North latitude and 9°04' West longitude. As the administrative center of N'Zérékoré Prefecture, the city is situated 864.1 km from Conakry and covers an area of 47.3 km². Its population was estimated at 1,806,654 inhabitants in 2019, with 24% living in urban areas and 76% in rural areas (Institut National de la Statistique, 2017). The climate is humid tropical, characterized by a dry season from November to April and a rainy season from May to October. Mean temperatures range from 18°C to 34°C, while average annual rainfall varies between 1,800 and 2,300 mm. Vegetation is dominated by dense forest in the upstream areas, while downstream zones feature riparian vegetation composed of secondary savanna and cultivated plots.

The Tilé River originates in Oulé, Northeast of N'Zérékoré, and flows into the Diani River South of the city. Its watershed covers an area of 317 km² (Figure 1). The river has several tributaries that irrigate all the city's neighborhoods, including Belle Vue, Dorota, Wéssoua, Tilepoulou, Commercial, Gbanghana, Mohomou, and Nakoyakpala (Lamah *et al.,* 2022). The river also receives domestic and industrial effluents, representing a constant risk to the environment and the health of local populations. Its waters are used for livestock watering, crop irrigation, bathing, and other community activities. For this study, five sampling stations were selected based on year-round accessibility, potential pollution sources, and the river's longitudinal gradient :

S1: Upstream reference station located outside direct human influence, characterized by dense vegetation and a coarse substrate composed of stones, pebbles, and rocks.

S2: Slightly impacted upstream station near a zone with minor anthropogenic activity. The substrate consists of rocks, sand, and mud.

S3: Intermediate station close to a confluence area, with a heterogeneous substrate, sparse vegetation cover, and the presence of agricultural plots.

S4: Impacted station receives domestic wastewater and livestock effluents. It is also subjected to significant pressure from forestry and mining activities.

S5: Downstream station located beyond the accumulation zone, reflecting the cumulative effects of upstream anthropogenic activities.

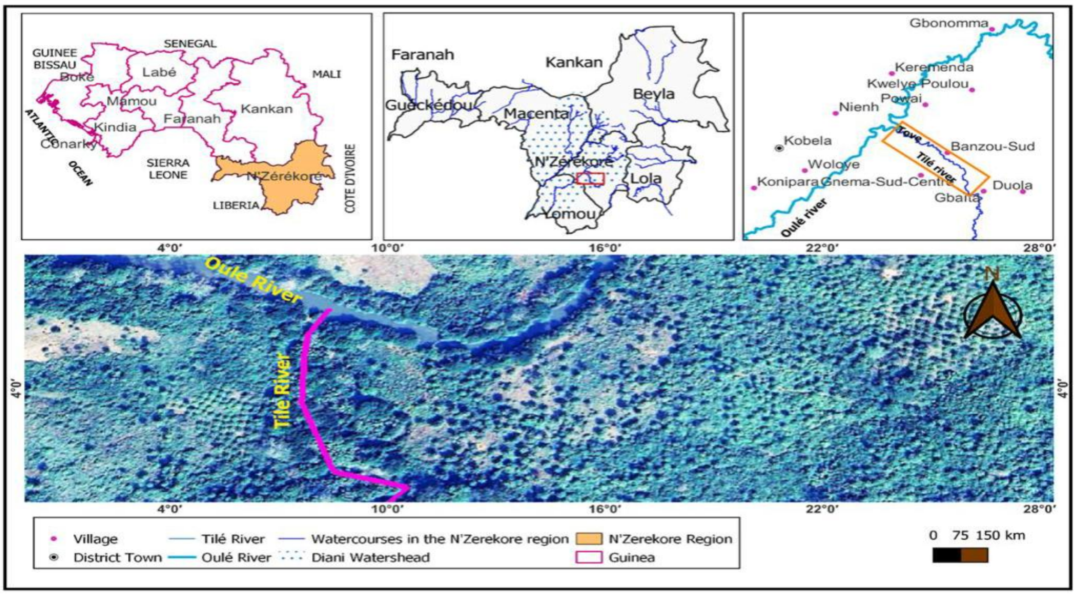

Figure 1. Location map of the study area and sampling stations along the Tilé River, N'Zérékoré, Guinea.

Sampling, identification, and enumeration of benthic acroinvertebrates

Sampling was conducted between April and November 2025 at a bimonthly frequency. Benthic fauna was collected using a rectangular framed Surber net with a 500 µm mesh and a depth of 50 cm. Four net sweeps were performed per station per sampling campaign, following the protocol of Gay *et al.* (2000), representing a total of 20 samples. This quantitative collection was complemented by qualitative sampling using a 300 µm mesh sieve to dislodge invertebrates living under rocky substrates, particularly in the upstream stations. Samples were initially coarse-sorted in the field, placed in sample vials, preserved in 5% formalin, and transported to the laboratory for further sorting and identification.

In the laboratory, sorted samples were transferred to 70% ethanol for preservation, then identified and counted under a stereomicroscope. Taxonomic identification was carried out to the genus level and, where possible, to species level, using identification keys from Day *et al.* (2002), Tachet *et al.* (2010), McCafferty (1981), and Durand and Lévêque (1981). This process allowed the establishment of a complete inventory of the benthic fauna and the enumeration of abundances for each taxon at each sampling station.

Community structure analysis

To analyze the specific structure of macroinvertebrate communities, several synthetic biological indices were calculated. Taxonomic richness was assessed by determining the number of taxa per station and for the entire river. Diversity was quantified using the Shannon-Wiener index (1948), Simpson's index (1949), and Pielou's evenness (1966). The EPT index (Ephemeroptera-Plecoptera-Trichoptera) was calculated to evaluate the sensitivity of taxa to pollution and to characterize the ecological quality of the sampling stations. Community similarity was assessed using the Jaccard index (1908). Regarding functional feeding groups, trophic classification followed the approaches of Cummins and Klug (1979) and Cummins and Wilzbach (1985). Statistically, a chi-square test was applied to taxon abundances to determine variations in community composition among stations. All analyses were performed using PAST (version 2.16) and Statistica 6.0, with a significance threshold set at $p < 0.05$.

RESULTS AND DISCUSSION

The present study recorded a total of 22 benthic macroinvertebrate taxa (families and genera), belonging to 21 families, 10 orders, 3 classes, and 3 phyla (Table 1). Insects dominated the assemblage, with 7 orders, 18 families, and 19 genera, representing 86.36% of all collected fauna. Within the insect class, the orders Diptera, Ephemeroptera, and Coleoptera were the most diverse, each contributing four taxa. Gastropods accounted for 9.09% of the assemblage with two taxa, while Oligochaetes represented 4.54%, with a single taxon.

Table 1. Taxonomy of benthic macroinvertebrates of the Tilé River

Class	Order	Family	Genus
Insects	Diptera	Chironomidae	*Chironomus sp.*
		Simuliidae	*Simulium sp.*
		Culicidae	*Culex sp.*
		Tipulidae	*Eriocera sp.*
	Trichoptera	Hydropsychidae	*Hydropsyche sp.*
		Leptoceridea	*Leptocerus sp.*
	Plecoptera	Perlidae	*Neoperla sp*
	Ephemeroptera	Baetidae	*Baetis sp.*
			Cloeon sp.
		Caenidae	*Caenis sp.*
		Heptageniidae	*Notonurus sp.*
	Heteroptera	Corixidae	*Corixa sp.*
		Naucoridae	*Laccocoris sp.*
	Coleoptera	Elmidae	*Stenelmis sp.*
		Hydrophilidae	*Hydrophilus sp.*
		Noteridae	*Noterus sp.*
		Dytiscidae	*Hydroporus sp.*
	Odonata	Libellulidae	*Zygonyx sp.*
		Coenagrionidae	*Coenagrion sp.*
Gastropods	Mesogastropods	Thiaridae	*Melanoides sp.*
	Basommatophora	Lymnaeidae	*Lymnaea sp.*
Oligochaetes	Haplotaxida	Tubificidae	*Tubificinas sp.*

Pairwise similarity analysis between stations using the Jaccard similarity index (1901) yielded values ranging from 0.50 to 0.84. The lowest similarities were observed between S1-S5 (0.50) and S3-S5 (0.50). The highest similarities occurred between S1–S2 (0.84) and S1–S3 (0.76) on the one hand, and S2-S3 (0.67) and S4-S5 (0.67) on the other, indicating a certain degree of faunal affinity among these stations. Furthermore, the percentage of occurrence derived from the presence-absence matrix provided the frequency distribution of taxa in the river. Overall, 86.36% of the taxa (16 insects, 2 gastropods, and 1 oligochaete) were classified as constant. Conversely, 13.64% of the taxa (3 insect taxa) were considered accessory, and no accidental taxa were recorded. A total of 1,788 individuals were recorded across all sampling stations. Based on the relative abundances of the identified taxa, insects dominated the assemblage with 1,363 individuals (76.23%) of the total count. They were followed by gastropods with 372 individuals (20.80%), and oligochaetes with 53 individuals (2.96%). Spatial distribution of abundance showed that stations S4 and S5, both located downstream, harbored the highest number of individuals, with a combined total of 967. Figure 2a illustrates the relative abundance of the different faunal orders recorded in the study stations. The order Diptera was the most represented (44.35%), followed by Ephemeroptera (13.76%), Odonata (10.01%), Coleoptera (4.75%), Trichoptera (1.96%), Plecoptera (0.78%), and Heteroptera (0.62%). Similarly, Mesogastropoda accounted for 16.94%, Basommatophora for 3.86%, and Haplotaxida for 2.96% of the total abundance.

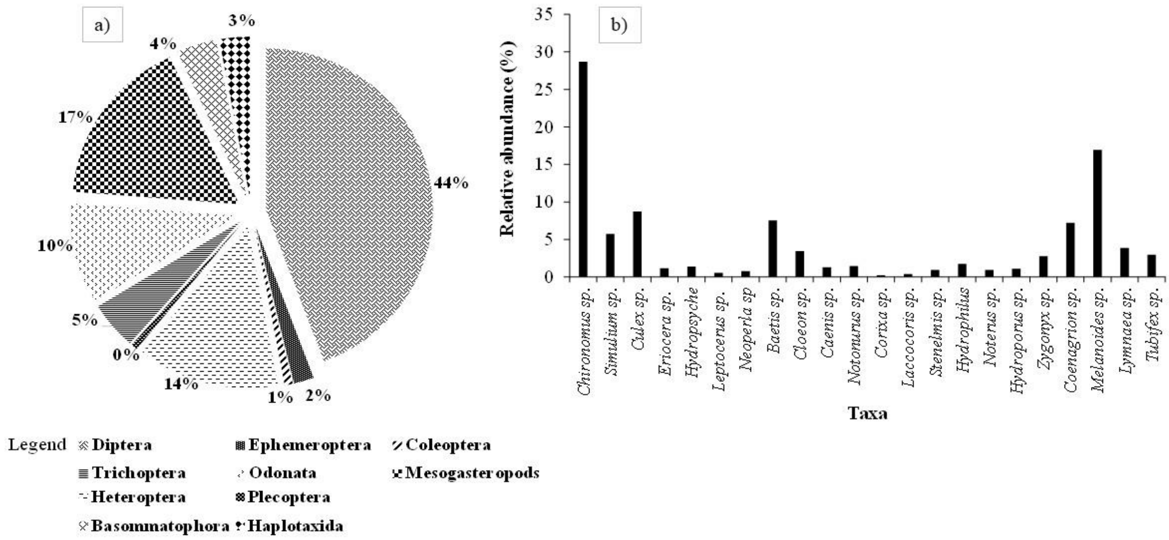

Figure 2. Relative abundance of macroinvertebrate orders (a) and genera (b).

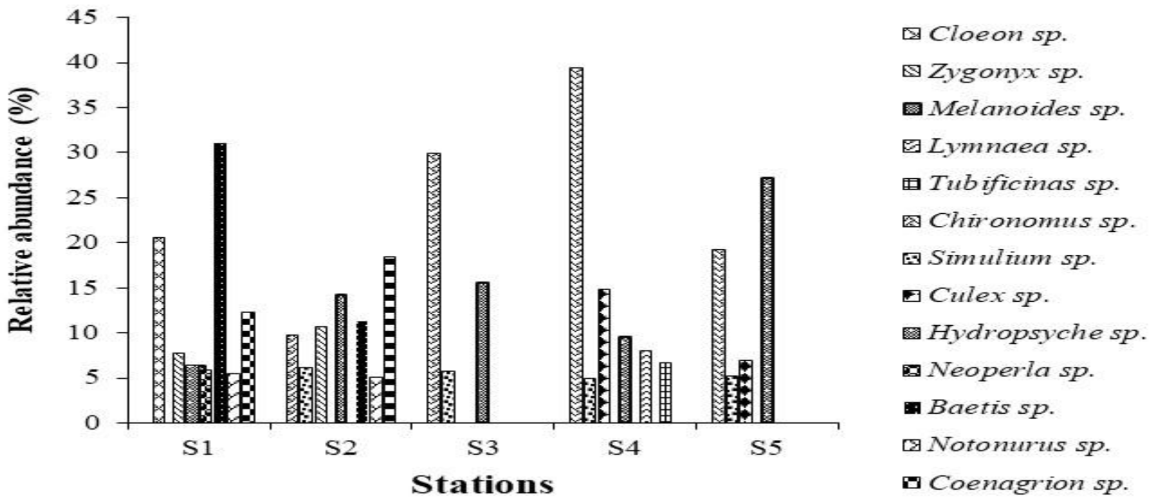

Figure 3. Spatial variations in macroinvertebrate genera with 5%

Furthermore, six families accounted for the majority of the macroinvertebrate individuals collected during the study. These were the Chironomidae (28.69%), Thiaridae (16.94%), Baetidae (11.69%), Culicidae (8.72%), Coenagrionidae (7.21%), and Simuliidae (5.76%). Other identified families each represented less than 5% of the relative abundance. Regarding the relative abundance of genera (Figure 2b), Chironomus sp. (28.69%) was the most dominant, followed by Melanoides spp. (16.94%), Culex sp. (8.72%), Baetis sp. (7.55%), Simulium sp. (5.76%), Lymnaea sp. (3.86%), and Cloeon sp. (3.46%). All other genera identified contributed less than 2% of the total abundance.

Figure 3 illustrates the spatial variations of genera with relative abundances above 5% at each station. At station S1, the assemblage was dominated by Baetis sp. (31.02%), Cloeon sp. (20.55%), and Coenagrion sp. (12.34%). At station S2, the most abundant genera were Coenagrion sp. (18.37%), Melanoides sp. (14.29%), Baetis sp. (11.22%), and Zygonyx sp. (10.71%). At station S3, Chironomus sp. (29.94%) and Melanoides sp. (15.56%) represented the majority of individuals. Station S4 was mainly dominated by Chironomus sp. (39.40%) and Culex sp. (14.8%), while station S5 was composed primarily of Chironomus sp. (19.21%) and Melanoides sp. (27.16%). A Fisher test conducted to analyze variations in taxon distribution among stations revealed no significant differences in abundances between the sites (F=0,48; p-value= 0,75 > 0,05).

The metrics describing the structure of benthic macroinvertebrate communities are presented in Table 2. The spatial distribution of taxonomic richness showed that stations S1, S2, and S3 were richer in taxa, with 22, 18, and 17 taxa, respectively, whereas stations S4 and S5 recorded lower richness, with 11 and 13 taxa, respectively. The Shannon-Wiener diversity index ranged from 2.56 bits at S2 to 1.84 bits at S4, with a mean of 2.14 ± 0.36 bits. Similarly, Pielou's evenness averaged 0.77 ± 0.08, fluctuating between 0.66 at S3 and 0.89 at S2. The Simpson dominance index varied between 0.75 at S3 and 0.91 at S2, with a mean of 0.82 ± 0.07. Regarding the EPT index (Ephemeroptera-Plecoptera-Trichoptera), the highest proportions were recorded at stations S1 (92%), S2 (89.43%), and S3 (91.88%), whereas lower proportions were observed at stations S4 (68.37%) and S5 (76.82%). An analysis of variance (ANOVA) on the mean values of these indices revealed no significant variation among stations (p>0,05).

Table 2. Values of metrics describing the structure of macroinvertebrate communities

	Stations				
Metrics	**S1**	**S2**	**S3**	**S4**	**S5**
Taxonomic richness	22	18	17	11	13
Shannon–Wiener index (H')	2,53	2,56	1,88	1,84	1,91
Pielou's evenness (J')	0,82	0,89	0,66	0,77	0,74
Simpson's dominance (1–D)	0,88	0,91	0,75	0,77	0,78
EPT index (%)	92,02	89,43	91,88	68,37	76,82

Functional diversity was characterized by the presence of five trophic groups: shredders, filterers-collectors, gatherers-collectors, scrapers, and predators. Analysis of Figure 4a shows that shredders were the most abundant trophic group, representing 43% of the total. They were followed by gatherers-collectors (18%), filterers-collectors (16%), predators (14%), and finally scrapers (9%). Spatial variations of these trophic groups (Figure 4b) revealed that stations S3 (70.68%), S4 (68.34%), and S5 (71.57%) were dominated by shredders. In contrast, stations S1 (44.54%) and S2 (20.19%) were mainly composed of gatherers-collectors. These same stations, S1 and S2, also concentrated most of the scrapers and predators, particularly in station S2, where predators were more abundant (33,18 %).

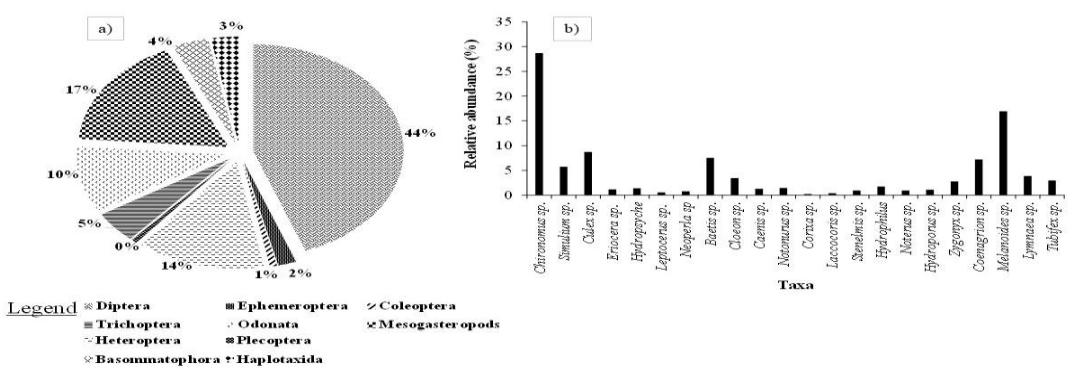

Figure 4. Abundance (a) and spatial variation (b) of benthic macroinvertebrate trophic groups.

In the present study, the taxonomic resolution adopted was at the genus level. According to Jacob (2000), when the taxonomic level is too "high" in the systematic hierarchy (i.e., ending at the species level), rare taxa (Cao *et al.,* 1998) are often insufficiently considered in bioassessment. Consequently, the current trend is to adopt a genus-level identification for macroinvertebrates, particularly for pollution-sensitive taxa. In line with recent studies and anticipating the recommendations of the European Water Framework Directive (Usseglio-Polatera and Wasson, 2006), we opted for this refined systematic level (genus for all taxa), despite the increased time required for identification. The study of benthic macroinvertebrates, conducted for the first time in the Tilé River in the forested region of Guinea, recorded 22 taxa from the sampling efforts. Compared to studies by Ben Moussa *et al.* (2014) and Tchamadeu *et al.* (2017), the overall taxonomic richness observed in this study is relatively low. This result may be attributed to the methods, sampling periods, and logistical difficulties, as well as the short duration of sampling, the discharge of domestic effluents downstream, and the specific taxonomic resolution adopted.

Furthermore, the low taxonomic diversity could also result from anthropogenic activities in the watershed, which contribute to pollution and consequently reduce both taxonomic richness and organism distribution (Pan *et al.,* 2013 ; Samson *et al.,* 2019). Analysis of the composition of collected macroinvertebrates revealed that insects were the dominant group, followed by gastropods and, to a lesser extent, oligochaetes. The proportion of insects recorded in this study is comparable to that reported by Alhou *et al.* (2014) in the Niger River, where insects represented 80% of the assemblage. Similarly, in the Toho-Todougba lagoon complex in Benin, insects accounted for 85.10% of the collected taxa (Capo-Chichi *et al.,* 2018). Likewise, Rukahusa *et al.* (2022) reported that the class Insecta was the most abundant and diverse, representing 94.32% of the assemblage. These results highlight the dominance of insects over other taxonomic groups, reflecting their ubiquitous nature (Tchakonté, 2016), as well as the heterogeneity of aquatic habitats in the river, which favors the colonization of insect larvae and provides suitable conditions for other faunal groups, albeit less abundant. In terms of abundance, insects dominated all sampled stations. Their high abundance is primarily due to the prevalence of Diptera, as well as Ephemeroptera. Specifically, Diptera were the most numerous, representing 76% of all individuals collected, largely due to the abundance of the Chironomidae family (28%). Ephemeroptera, mainly the Baetidae, accounted for 15% of the total individuals.

According to Dejoux *et al.* (1981), Chironomidae are the most dominant group in freshwater ecosystems, and their importance in hydrobiology is well recognized due to their role in the trophic chain, often being a major contributor to benthic production. Other authors (Agblonon Houélomè *et al.,* 2022 ; Zinsou *et al.,* 2016) have correlated the dominance of these taxa with the availability of food resources in the studied ecosystems. Furthermore, the presence of pollution-tolerant taxa, such as Chironomidae in high proportions at stations S4 and S5, indicates an enrichment in organic matter originating from anthropogenic activities and domestic effluents impacting these parts of the river. According to Robert (2015), anthropogenic pressures homogenize urban sites and favor the development of the most resistant taxa.

The low relative abundance of Ephemeroptera in these stations reflects the disturbed state of the river, as their abundance typically declines with increasing pollution (Arimoro and Ikomi, 2009). Regarding gastropods, particularly the genus Melanoides, their predominance at stations S3, S4, and S5, located in the midstream and downstream sections of the river, is likely due to the substrates composed of silt and sand, which provide a suitable habitat for these taxa. These organisms thrive in sediments rich in organic matter, which is crucial for their growth and development (Lecerf, 2005 ; Adandédjan, 2012). The spatial variation of structural parameters and diversity indices (taxonomic richness and diversity indices) shows that there is no significant relationship between the number of taxa and the number of individuals, indicating that the stations are largely influenced by numerically dominant taxa, which control variability within the studied assemblages. The presence of these dominant taxa across the community explains the low values of diversity indices obtained.

Indeed, the Shannon–Wiener index displayed low values, ranging from 1.84 to 2.56 bits, with a mean of 2.14 bits for the entire river. Similarly, the overall Pielou's evenness was 0.77. The highest values for these two indices were recorded at stations S2 and S3 in the upstream section of the river, reflecting their good ecological status and even distribution of benthic macroinvertebrate taxa, in contrast to stations S4 and S5, which showed lower diversity. Stations S3 (midstream) and S4/S5 (downstream), located in commercial and highly agricultural zones, likely exhibit lower taxonomic diversity due to the loss of microhabitats necessary for optimal colonization. According to Ngoay-Kossy *et al.* (2018), low diversity index values are associated with a lack of natural trophic resources in sites impacted by anthropogenic activities.

In correlation with the EPT index (Ephemeroptera-Plecoptera-Trichoptera), the values obtained reflect the low diversity of pollution-sensitive taxa in downstream stations, confirming the progressive imbalance observed from upstream to downstream. These results are consistent with previous observations (Ouma *et al.,* 2015; Mesa *et al.,* 2025; Onana *et al.,* 2019), which indicate that organic matter enrichment leads to sediment clogging, reducing biodiversity and altering macrobenthic communities particularly Ephemeroptera, Plecoptera, and Trichoptera in favor of pollution-tolerant taxa. Similarly, the Simpson dominance index reinforces the trends observed with other diversity indices, indicating an unbalanced assemblage. Furthermore, the faunal dissimilarity among river stations, highlighted by the Jaccard coenotic affinity index, is likely due to ecological factors such as substrate type, vegetation, and current velocity, suggesting similar conditions between stations S1/S2 and S4/S5. This observation aligns with the trends recorded for the diversity indices.

Regarding functional diversity, shredders were the most abundant trophic group, indicating a well-preserved forest canopy over the river, which provides substantial amounts of dead vegetation as food, particularly in the midstream and downstream stations. They were followed by gatherers-collectors, whose abundance is likely linked to the distribution of available trophic resources in the environment. These groups are closely associated with the nature of organic matter inputs from riparian communities and the timing of their deposition (Cornut, 2010). As for predators, despite their relatively high taxonomic richness, they were numerically scarce compared to other trophic groups. This suggests a lack of interspecific competition, as noted by Adandédjan (2012), where the dominance of this trophic group tends to decline, particularly during the rainy season.

CONCLUSION

The study of benthic macroinvertebrate diversity in the Tilé River, located in the forested region of Guinea, significantly improved the understanding of the composition and structuring of benthic communities. The taxonomic structure of the assemblages shows that downstream stations, subjected to pressures from agricultural activities and domestic effluent inputs, are predominantly dominated by Diptera and gastropods. In contrast, upstream stations, less impacted by pollution, are mainly structured around insects, particularly Coleoptera and Ephemeroptera. Regarding taxonomic richness, no clear spatial gradient was observed. The low Shannon diversity and Pielou's evenness values indicate a structural imbalance of benthic communities, likely linked to anthropogenic pressures and variations in habitat quality along the river. Overall, this study provides a first reliable dataset for the bioassessment of the Tilé River. Further research, including seasonal measurements and more detailed longitudinal analyses, will help better understand the spatio-temporal dynamics of macroinvertebrate communities and strengthen tools for sustainable ecological management of freshwater ecosystems in Guinea.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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