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Benthic Macroinvertebrate Communities as Indicator of the Water Quality of a Suburban Stream in the Littoral Region of Cameroon

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Abstract: As bioindicators, benthic macroinvertebrates are often used to assess stream quality. Based on standard hydrobiological study techniques, the physicochemical and biological health status of the Missolé stream was assessed. Waters of the Missolé stream were found to be slightly acidic (pH: 6.23–6.26) and well-oxygenated (O_2: 69.80–76.80%), with low values of temperature (T°: 23.60–24° C), turbidity (49.40–88.40 FTU) and mineralized ions (NH_4^+: 0–1.19 mg/L; NO_2^-: 0–1.61 mg/L; NO_3^-: 0.02–6.80 mg/L). Concerning aquatic invertebrate communities, a total of 489 individuals, grouped in two classes, eight orders and 35 families, all belonging to the phylum Arthropoda, were collected and identified. The class of Insecta was the most diversified, with seven orders and 32 families, while that of Crustacea had only one order and three families. Overall, Insecta accounted for 52.35% of the total abundance, and Decapod Crustacea was 47.65%. The three predominant families were Palaemonidae, Dytiscidae and Atyidae. Shannon and Weaver (H') and Piélou's evenness (J) indices were high at all stations and showed a slight decrease from upstream to downstream. In the same vein, the Hilsenhoff Biotic Index (HBI) classified the water quality of the Missolé stream as medium. Overall, this suburban aquatic ecosystem offers moderately favorable living conditions for aquatic biota.

Keywords: benthic macroinvertebrates; biotic indices; Missolé stream; organic matter load; physicochemical water quality

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1. Introduction

The preservation of water quality is a major issue for the sustainable management of the environment, but also for that of biodiversity [1,2]. Indeed, aquatic ecosystems are greatly threatened because of their vulnerability due to strong and increasing anthropogenic pressures [3,4]. In addition, streams play a special role in biodiversity conservation, aquatic ecosystem functioning and organic matter cycling [5–7]. They also produce major ecosystem goods and services for humans [8–10].

The maintenance and sustainability of water resources in sufficient quality and quantity have, therefore, become a major concern for societies anxious to meet the needs of ever-increasing populations [11]. This concern has materialized through the implementation of programs to assess the physicochemical and biological quality of freshwater ecosystems [12–14].

The quality of a stream can be altered as a result of urban sprawl; domestic, municipal and industrial wastewater discharges; intensive land use during agricultural and forestry practices; raw material extraction; energy production; as well as public works infrastructure construction [15–19]. According to Sikati Foko [20], streams are generally used to dispose of urban and municipal wastes in large developing cities [21–23]. This leads to water quality degradation, settlement change, biodiversity loss, and especially ecological problems, such as freshwater pollution and eutrophication [23].

The disturbances generated by anthropogenic activities on aquatic ecosystems are directly felt by the biological communities in place [24,25]. These include benthic macroinvertebrates, which are the most commonly used in biomonitoring of these ecosystems today because of their sedentary nature and, above all, their different levels of tolerance to environmental pollution [26–28].

In streams, there is a whole food chain from algae grazers to voracious predators. Macroinvertebrates play an important role in the degradation of organic matter; many shred and feed on large pieces of material that have settled to the bottom of the stream, while others filter suspended material with small bristles [28,29]. Habitat preferences are also varied, with both calm and faster currents having typical fauna associated with them. Thus, greater habitat diversity promotes greater biodiversity [29,30].

Physicochemical conditions and toxic substances in the water also affect the aquatic biota [18]. Some groups or species of macroinvertebrates have a higher tolerance to pollutants than others [31]. Depending on the diversity, abundance and occurrence of organism types collected when sampling a stream, indices can be calculated to assess the biotic integrity of the environment [29,32].

The streams of the city of Douala, in Cameroon, face serious problems of water pollution due to high population growth and uncontrolled urbanization. The direct consequence of the decrease in their biodiversity and their eutrophication.

With a view to their preservation, knowledge of the eutrophic status of Cameroon's peri-urban streams in general, and those in the littoral zone in particular, is a major concern for the scientific community and public authorities. Additionally, in Cameroon and particularly in the monomodal rainforest zone, the structure of benthic macroinvertebrates remains poorly known in peri-urban areas. Preliminary data currently available are those of Tchakonté et al. [33], Onana et al. [34] and Koji et al. [35]. Indeed, in the Littoral region of Cameroon, the assessment of stream macroinvertebrate communities in forest and peri-urban areas remains a field to explore. In this study, the hypothesis that the macroinvertebrates that populate the Missolé stream are excellent indicators of its pollution level will be tested. The main objective of this study is to assess the water quality of the Missolé stream through its physicochemical variables and its benthic macroinvertebrate communities.

2. Materials and Methods

2.1. Study Area

Five sampling campaigns were carried out in 2022, based on the two main seasons of the year: February and March (dry season); April, May and June (rainy season). Missolé stream is located in the Dibamba Subdivision, Sanaga Maritime Division, Cameroon's Littoral region. With about 20 km in length, the Missolé stream has its source at Lungahe village and flows in an East–West direction until its confluence with the Dibamba River. Missolé catchment is a humid forest zone with monomodal rainfall characterized by a Cameroonian-type climate, which is a variant of the equatorial climate, humid and hot, with rainfall ranging from 2500 to 4000 mm/year [36]. Taking into consideration the representativeness, the accessibility and the presence of microhabitats, three sampling stations were selected along the Missolé stream for this study (Figure 1). Station M1

(3.98502 N–9.99803 E) is located about 3 km from the source of the Missolé in the village of Lungahé and is characterized by a sandy substrate dominated by decaying leaves, branches and tree trunks. The riparian vegetation is abundant, reflecting the low anthropogenic pressure in the basin; this sampling station was then considered as a reference station for this study. Station M2 (4.00831 N–9.91072 E) is located in the middle reaches of the Missolé stream at about 10 km from station M1. Here, the substrate is sandy, and the streambanks are occupied on very large surfaces by palm tree plantations used for the production of raw and refined palm oil. Station M3 (3.99509 N–9.86661 E) is located near the confluence with the Dibamba River, which is downstream from an aluminum processing company.

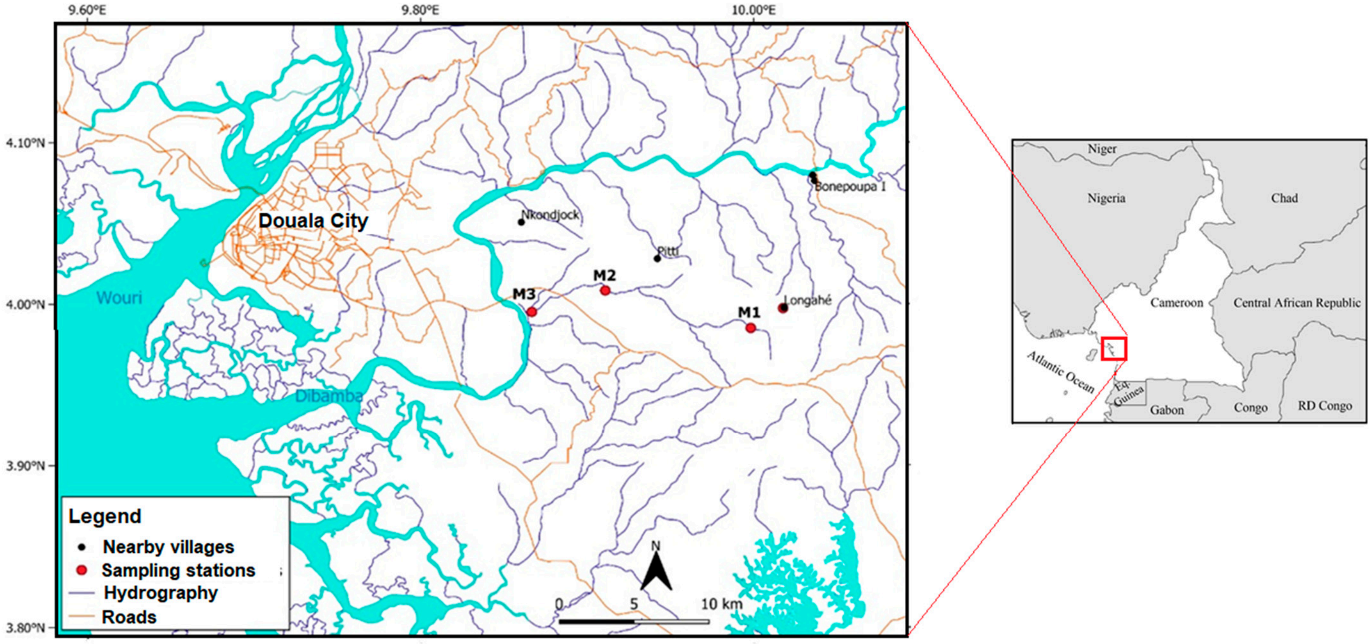

Figure 1. Hydrographic map of the Missolé stream watershed showing sampling stations.

2.2. Physicochemical Variables

At each sampling station, 15 physicochemical parameters were measured monthly [37,38]. Temperature (°C), electrical conductivity (µS/cm), pH, TDS (mg/L) and dissolved oxygen (%) were measured in situ using a portable multi-parameter (Hanna-9839, Hanna Instruments, Woonsocket, RI, USA) and an optical oximeter (EUTECH-CSDO 110, Eutech Instruments, Pioneer, Singapore), respectively. For the parameters measured in the laboratory, water samples were collected in counter-current using 1000 mL double-capped polyethylene bottles and transported to the laboratory in a refrigerated chamber. Suspended solids (mg/L), turbidity (FTU) and color (Pt.Co) were measured by colorimetry with a spectrophotometer (Hanna/HI9829, Hanna Instruments, Woonsocket, PI, USA); nitrates (mg/L), ammonia nitrogen (mg/L) and orthophosphates (mg/L) were measured with a photometer (Pallintest-7500, Pallintest, Tyne and Wear, UK). Oxygen concentration (mg/L) and alkalinity (mg/L) were measured volumetrically, while aluminum content (mg/L) was determined by a Shimadzu atomic absorption spectrophotometer.

2.3. Collection, Identification and Enumeration of Benthic Macroinvertebrates

Based on the multi-habitat approach proposed by Stark et al. [39], five sampling campaigns were carried out. Organisms were collected using a 30 cm square dip net with a 400 µm mesh size conical net at 50 cm depth. At each study station, about twenty dip net strokes were made in the different micro-habitats identified. The collected organisms were fixed with a 10% formalin solution and preserved in a sampling container. In the laboratory, the samples were rinsed with running water and then preserved in a 70° ethanol solution. Organisms were identified at the family level and counted under a binocular stereomicroscope (Wild M5). The identification keys used were those proposed by De Moor et al. [40] and Tachet et al. [41].

2.4. Data Processing

2.4.1. Organic Pollution Index (OPI)

In order to evaluate the organic matter load at each station, the organic pollution index (OPI) was calculated following the protocol described by Leclercq [42]. The OPI was obtained by a mathematical computation of the mean values of ammonium, nitrite and orthophosphate. The principle of the calculation is to assign the mean value of each of these three parameters to the corresponding quality class number (as shown in Table 1) and then compute the arithmetic mean value of the number assigned to each class to have the OPI value, which ranges from 1 to 5 (Table 1).

Table 1. Class limits of the organic pollution index [42].

Class	NH_4^+ (mg/L)	NO_2^- (µg/L)	PO_4^{3-} (µg/L)	OPI Quality Class
(5) No organic pollution	<0.1	<5	<15	4.6–5.0
(4) Low organic pollution	0.1–0.9	6–10	16–75	4.0–4.5
(3) Moderate organic pollution	1–2.4	11–50	76–250	3.0–3.9
(2) High organic pollution	2.5–6	51–150	251–900	2.0–2.9
(1) Very high organic pollution	>6	>150	>900	1.0–1.9

2.4.2. Macroinvertebrate Community Structure Indices

To characterize the structure of the macroinvertebrate community, we used taxonomic metrics such as taxonomic richness, EPT richness index (Ephemeroptera–Plecoptera–Tricoptera), abundance of individuals, percentage of Chironomids, Sorensen's similarity coefficient. As ecological indices, we calculated the Shannon and Weaver diversity index (H′) and the Piélou evenness index (J) with the PAST® Software version 1.0.0.0 [43]. The Hilsenhoff Biotic Index (HBI) was also calculated using the following formula:

$$HBI = \sum_{i=1}^{n} \frac{XiTi}{n}$$

Xi = number of individuals of the i -th taxon; Ti = tolerance of the *i*-th taxon; n = number of individuals in the sample.

HBI characterizes the sensitivity of organisms to organic pollution.

3. Results

3.1. Physicochemical Variables

At station M1, water temperature varied from 21 °C in June to 28 °C in February with a thermal amplitude of 7 °C and an average of 23.60 ± 1.33 °C. The warmest waters were observed at station M2 with an average of 24.64 ± 1.32 °C. The electrical conductivity values ranged from 87.3 µS/cm at station M2 in February to 1266 µS/cm at station M3 in March. The highest degree of ion concentration was obtained at station M3 (919.40 µS/cm). It was found that the water was saltier at station M3 with an average of 0.52 ppt. At station M1, pH values ranged from 5.14 in June to 7.14 in May, with an average of 6.23 ± 0.99. Values of TDS ranged from 55 mg/L at station M1 in April to 795 mg/L at station M3 in February. Values of this parameter were higher at station M3 throughout the study period except in June. The maximum dissolved oxygen saturation rate was obtained at station M3 in May, i.e., 92%, while the minimum rate was 56% at the same station in June. The average value was 74.66%, which shows the good oxygenation of the Missolé waters. The values of water oxygen concentration varied from 1.97 mg/L of O_2 at station M2 in February to 19.2 mg/L of O_2 at station M1 in June for an average of 6.81 mg/L of O_2. There was a progressive increase in oxygen concentration values over time (Table 2). For suspended solids, the lowest values (9 mg/L) were recorded in February at stations M1 and M2. The maximum value (204 mg/L) was recorded in June at station M2. The increase was gradual over time.

Table 2. Physicochemical variables of Missolé stream during the study period.

	Station M1				Station M2				Station M3			
Variables	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**
Temperature (°C)	21	28	23.60	1.33	22	27.20	24.64	1.32	21.50	25.50	24	1.22
Conductivity (Ms/cm)	108	1018	358	10.18	87.30	604	238.4	6.44	519	1122	919.40	7.26
Salinity (ppt)	0.07	0.10	0.08	0.01	0.03	0.13	0.55	0.01	0.41	0.68	0.52	0.01
pH	5.14	7.14	6.23	0.99	5.40	6.98	6.24	0.99	5.66	6.66	6.26	0.10
TDS (mg/L)	55	511	187.40	8.58	61	297	121.70	5.10	258	795	506	7.33
Dissolved oxygen (%)	67	90	77.40	3.98	59	77	69.80	2.87	56	92	76.80	2.98
Oxygen concentration (mg/L)	2.37	19.20	6.81	0.65	1.97	4.42	3.49	0.02	2.95	16.65	8.25	0.13
Suspended solids (mg/L)	9	117	52	2.33	9	204	69	2.36	16	87	37.80	1.77
Turbidity (FTU)	8	226	87.60	5.44	10	216	88.40	4.53	10	107	49.40	3.25
Color (Pt.Co)	114	326	187.20	10.11	109	221	150.20	8.32	78	189	113.60	7.20
Ammonia nitrogen (mg/L)	0.01	1.19	0.28	0.01	0.08	0.89	0.45	0.01	0	1.02	0.34	0
Nitrites (mg/L)	0	1.61	0.46	0.01	0	0.68	0.23	0.01	0.02	0.21	0.07	0.01
Nitrates (mg/L)	1.50	6.80	3.6	0.12	1.7	5.80	2.90	0.19	0.77	2.40	1.40	0.02
Orthophosphates (mg/L)	0.08	3.14	1.04	0.01	0.23	2.04	0.90	0.01	0.11	4.10	1.19	0.01
Alcalinity (mg/L)	10	120	46.6	3.17	10	148	53.30	2.57	11	66	40.20	2.41
Aluminium (mg/L)	1.68	3.17	2.18	0.15	0.76	1.14	0.92	0.01	6.70	11.40	8.03	1.09
OPI	1.66	4.33	2.86	0.12	2	4.33	2.87	0.14	2	3.66	2.86	0.011

Min.: minimum; Max.: maximum; SD: standard deviation.

Turbidity ranged from 8 FTU at station M1 in February to 226 FTU at the same station in June. The average value was 75.13±4.41 FTU. Like suspended solids, values were found to increase gradually over time. Color ranged from 78 Pt-Co. at station M3 in April to 326 Pt-Co. at station M1 in June.

Ammonia nitrogen (NH_4^+) ranged from 0 mg/L at station M3 in May to 1.19 mg/L at station M1 in June. The values of Nitrates (NO_3^-) ranged from 0.77 mg/L at station M3 in May to 6.8 mg/L at station M1 in February. Nitrite (NO_2^-) contents also varied from 0 mg/L at station M1 in May and M2 in February to 1.61 mg/L at station M1 in June. The highest value of orthophosphates at the M1 station is 3.14 mg/L, and in general, it is 4.10 mg/L at the M3 station. The lowest value of alkalinity (10 mg/L) was recorded at stations M1 and M2 in February, while the highest value was recorded in June at station M2 (148 mg/L). Aluminum contents in the water varied from 0.76 mg/L in March and May at station M2 to 11.4 mg/L at station M3 in May (Table 2).

The OPI shows that the waters of the Missolé varied from a very high to low organic matter load level with respective values of 1.66 at station M1 in June and 4.33 at stations M1 and M2 in May. The average values were 2.86, i.e., substantial organic matter load.

3.2. Benthic Macroinvertebrates Community Structure

This ecological survey of the Missolé stream makes it possible to inventory 489 individuals of benthic macroinvertebrates, all belonging to the phylum Arthropoda. These individuals were divided into two classes (Insecta and Crustacea), eight orders and 35 families. The class of Insecta was presented with the highest taxonomic richness, with seven orders and 32 families; it was followed by the class of Crustacea, with only one order and three families. Overall, Odonata and Diptera were the most represented orders, with seven families each. They were followed by Coleoptera with six families and Heteroptera with five families. Decapoda and Plecoptera came next with three families each, and Ephemeroptera and Trichoptera with two families each. Concerning the spatial distribution, station M1 was the most diversified, with eight orders and 26 families. It was followed by station M2 with six orders and 19 families and, finally, station M3 with five orders and 11 families.

In terms of total abundance, Insecta represented 52.35% and Crustacea 47.65% of the individuals counted (Figure 2). Decapoda was the most abundant order (47.96%), followed by Coleoptera (34.83%) and Diptera (6.29%). The least represented were Heteroptera (2.22%), Plecoptera (0.6%) and Trichoptera (0.4%). Of the 35 families identified, those with the highest number of individuals were as follows: Palaemonidae (143 individuals), Dytiscidae (128 individuals) and Atyidae (76 individuals).

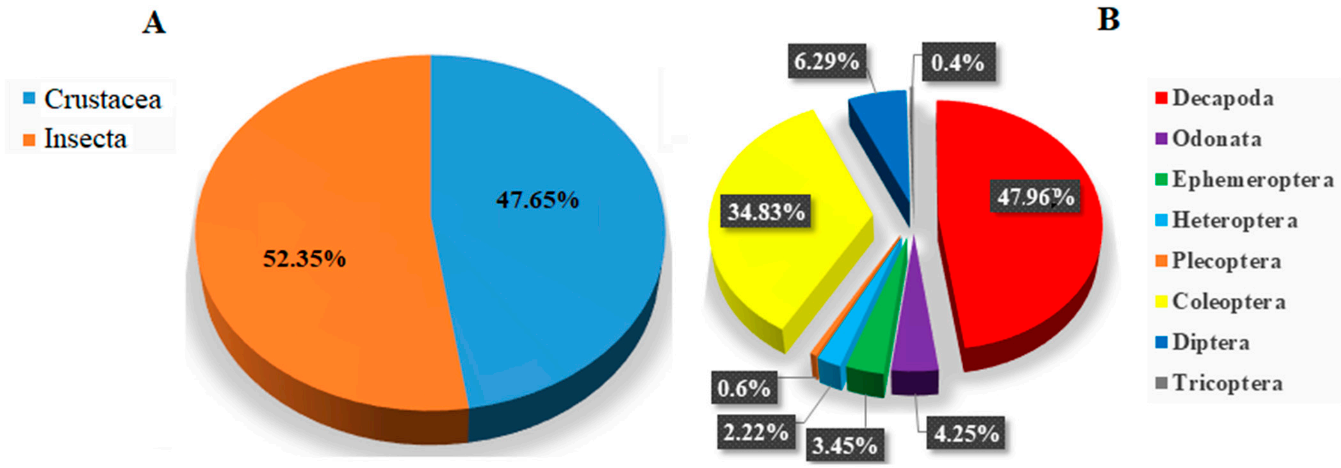

Figure 2. Relative abundance of organisms collected: (**A**) classes; (**B**) orders.

3.3. Spatial Variation in Abundance and Sorensen's Coefficient

Spatially, a total of 159 (32.4%), 245 (49.94%) and 85 (17.31%) individuals were identified and counted in the upper stream, middle stream and downstream, respectively. Decapods dominate at station M1 with 75 individuals. They were followed by Coleoptera with 38 individuals and Odonata with 15 individuals. Diptera, Ephemeroptera, Heteroptera, Plecoptera and Trichoptera represent only 6.28% of the total abundance at this station. Unlike at station M1, Coleoptera (127 individuals), Decapoda (90 individuals) and Diptera (12 individuals) dominate at station M2. As at station M1, Palaemonidae, Dytiscidae and Atyidae have the highest relative abundance at station M2 with 49, 95 and 41 individuals, respectively. In this respect, the result of Sorensen's similarity coefficient calculated thanks to the families (S = 53.33) shows that there is a faunal resemblance between M1 and M2. At station M3, the order Decapoda dominates with 68 individuals, followed by Diptera (7 individuals) and Coleoptera (6 individuals). Palaemonidae (51 individuals), Potamonidae (11 individuals) and Atyidae (6 individuals) are the most abundant families (Table 3). However, Sorensen's similarity coefficient between M2 and M3 (S = 46.66) and between M1 and M3 (S = 48.64) shows average faunal similarity at all three stations.

Table 3. Total abundance of taxa collected.

Phylum	Class	Orders	Families	Station M1	Station M2	Station M3
Arthropoda	Crustacea	Decapoda	Atyidae	29	41	6
			Palaemonidae	43	49	51
			Potamonidae	3	0	11
	Insecta	Odonata	Gomphidae	6	3	0
			Libellulidae	3	1	0
			Coenagrionidae	1	0	0
			Cordulegasteridae	4	0	0
			Aeshnidae	0	1	0
			Caloterygidae	0	1	0
			Corduliidae	1	0	0
		Ephemeroptera	Leptophlebidae	6	5	2
			Undetermined	3	0	1
		Heteroptera	Gerridae	3	3	0
			Pleidae	1	0	0
			Nepidae	1	0	0
			Veliidae	1	1	0
			Mesoveliidae	0	1	0
		Plecoptera	Nemouridae	1	0	0
			Perloidae	1	0	0
			Undetermined	1	0	0
		Coleoptera	Dytiscidae	33	95	0
			Hydrophilidae	3	18	3
			Elmidae	1	12	1
			Chrysomelidae	0	2	0
			Haliplidae	0	0	2
			Curculionidae	1	0	0
		Diptera	Chironomidae	3	4	2
			Ceratopogonidae	7	5	5
			Blephariceridae	0	1	0
			Limoniidae	1	0	0
			Dolichopodidae	0	1	0
			Simuliidae	1	0	0
			Dixidae	0	1	0
		Tricoptera	Polycentropodidae	0	0	1
			Ecnomidae	1	0	0

3.4. Biocenotic Indices

The spatial evolution of the Shannon and Weaver index is regressive. Indeed, this index varied from 2.33 bits/ind. at station M1 to 1.46 bits/ind. at station M3. The Piélou evenness index followed the same regressive trend, going from 0.72 bits/ind. at station M1 to 0.61 bits/ind. at station M3 (Table 4). The high Shannon and Weaver index value at station M1 reveals that this station was more diversified, which is not the case at station M3, where the living conditions are less favorable, as shown by physicochemical variables. All values of the Piélou evenness index indicate that the stand is made up of species with similar abundances (Figure 3).

Table 4. Values of H', J, EPT, EPT/Chironomidae and HBI of each sampling site.

	Station M1	Station M2	Station M3
H' (bits/ind.)	2.33	1.88	1.46
J (bits/ind.)	0.72	0.64	0.61
EPT (%)	2.65	1.02	0.81
EPT/Chironomidae	4.33	1.25	2.00
HBI	1.83	1.90	1.03

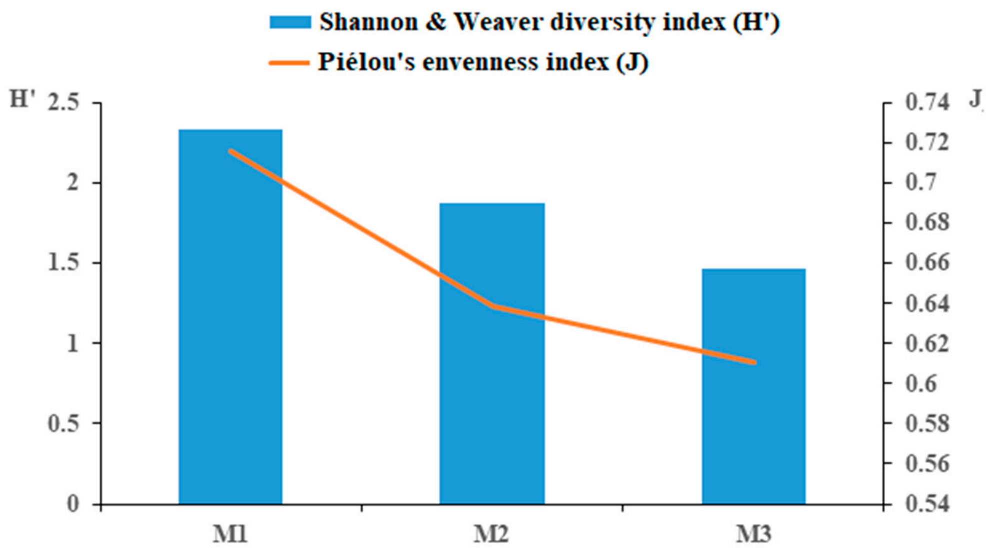

Figure 3. Spatial variation in Shannon and Weaver diversity and Piélou evenness indices.

The percentage of EPT decreases from upstream to downstream: 2.65% at station M1, 1.02% at station M2 and 0.81% at station M3. The percentage of Chironomidae varied from 0.4% at station M3 to 0.81% at station M2. The ratio of EPT density to Chironomidae density was 4.33 at station M1, 1.25 at station M2 and 2.00 at station M3 (Table 4).

Overall, the Hilsenhoff Biotic Index (HBI) varied from one station to another: 1.83 (M1), 1.90 (M2) and 1.03 (M3). It can be seen that all these values correspond to the class where the water quality is excellent. Temporally, this index varied between 0.19 and 4.29, showing that the waters of the Missolé ranged between the good and excellent quality ranges during the study period (Figure 4).

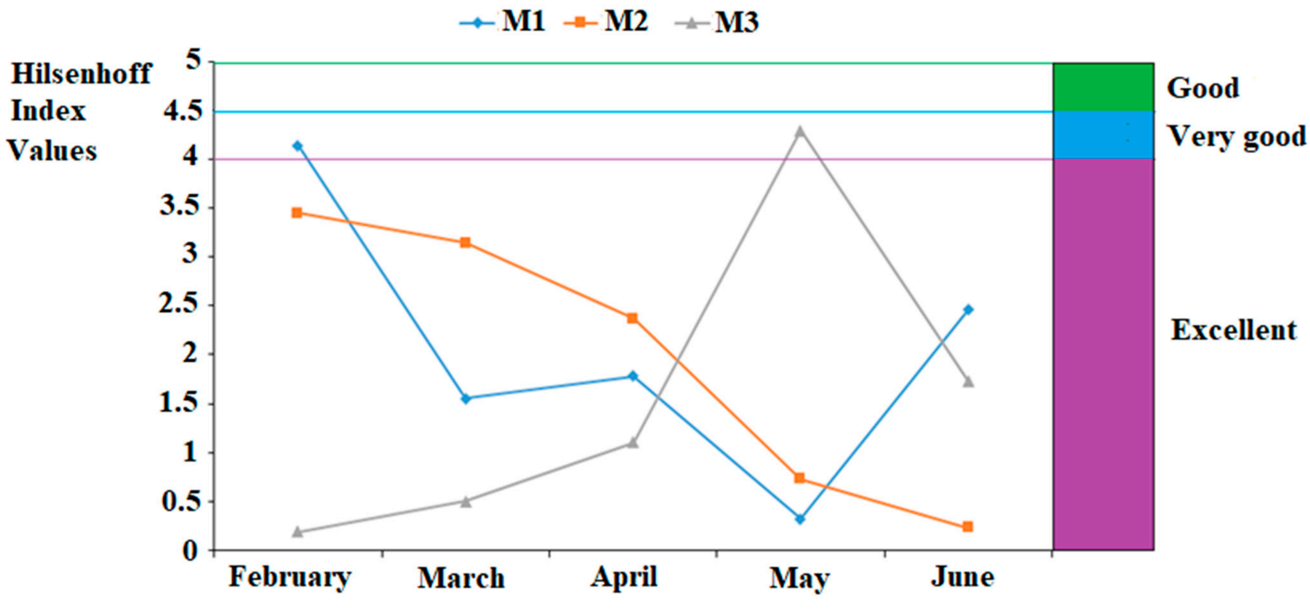

Figure 4. Temporal variation in the Hilsenhoff Biotic Index over the study period.

In order to study the degree of dissimilarity between the different sampling stations from a faunal point of view, ordination based on the Bray–Curtis distance was carried out. This showed that the degree of dissimilarity between the three stations (M1, M2 and M3) was 0.2.

4. Discussion

4.1. Abiotic Variables

Temperature and dissolved oxygen, which are two of the most important hydro-climatic factors for aquatic life, have low and high values, respectively, similar to those of rivers located in the forest zone in Cameroon [33,44,45]. These values show that the waters of the Missolé are suitable for the development of benthic macrofauna. However, the high values of certain physico-chemical parameters (electrical conductivity, ammonia nitrogen, orthophosphates and turbidity) indicating organic pollution in stations M2 and M3 are an alarm bell for its level of degradation. Indeed, these values are contrary to those obtained by Tchakonté et al. [33], Foto Menbohan et al. [13] and Huang et al. [14], who showed that waters located in forest areas are poorly mineralized.

The average aluminum content obtained in the Missolé is higher than that obtained by Foto Menbohan et al. [46] in the Mabounié watershed in Gabon. Indeed, the values obtained in the Missolé are strongly influenced by inputs from the aluminum processing company located near the Missolé stream, more precisely upstream of station M3 [21,23]. This would also explain the higher aluminum levels at this station, constituting an overall threat to aquatic fauna.

The average OPI values at each station indicate high organic pollution in the Missolé. This result is contrary to the one obtained by Tchakonté et al. [47] in the Nsapè, located in the forest zone where the average OPI values showed low organic pollution. The application of this index to the Missolé stream shows that there is a discrepancy with the biological indices and even with the observations made in the field. This discrepancy further confirms that physicochemical analyses only report on the point state of health of streams [12,14]. In addition, there is a need to calibrate these indices that were developed in temperate regions [48]. This would explain the incongruities observed when they are applied in tropical areas [49].

4.2. Benthic Macroinvertebrate Community

The diversity and abundance of macroinvertebrates observed in the Missolé would reflect the little anthropized character of this watershed and the good quality of its waters [34,35]. Indeed, the majority of aquatic insects are very sensitive to pollution and/or habitat modification and, as such, are the first to disappear in a disturbed environment [41,50].

The complete absence of mollusks and annelids in our sample is further evidence that the waters of the Missolé are of good quality. In polluted hydrosystems, the benthic macrofauna is largely dominated by saprophilic and saprobiontic taxa such as Chironomids, Hydrobiids, Physids, and Tubificids [41,50]. However, the presence of Diptera, particularly Chironomidae (1.81%), which has a high tolerance rating, could reflect an ecosystem undergoing disturbance.

Station M1, located upstream of the river, was found to be the richest, with 26 families and the highest percentage of EPT taxa. Therefore, it can be considered a reference station because, according to Moisan and Pelletier [50], the benthic community of a reference station is expected to be composed of a good variety of EPT taxa. Furthermore, the abundance observed at station M2 can be explained by the strong presence of the seagrass bed on the banks of the river. Indeed, the vegetation favors the abundance of invertebrates [26–28,51]. The low taxonomic richness obtained at station M3 would probably be due to the impact of the industrial activity upstream and the developments (Hydraulics and housing estates) that take place in this station. Indeed, these hydraulic developments often interrupt the upstream–downstream gradient and can cause biotic characteristics (taxonomic diversity indices) to shift in a direction that tends to decrease them [18,52].

4.3. Biocenotic Indices

The values of the Shannon and Weaver and Piélou evenness indices were higher at stations M1 and M2, respectively, probably because of the abundance of microhabitats at these stations. This result is consistent with the principle that a diversity index is higher when environmental conditions favor the establishment and maintenance of a balanced, integrated biological community capable of adapting to environmental variations [53,54].

The highest value of the Hilsenhoff Biotic Index was obtained at station M2, which could be explained by the abundance of pollution-tolerant taxa, such as the Chironomidae, which were more abundant at this station. This index is all the higher as taxa with tolerance scores that tend towards 10 are abundant [55,56]. The low value of the EPT index and the decrease in the EPT/Chironomidae density ratio at station M2 indicate that this station is under environmental stress. This biotope would receive organic matter laterally (certainly due to the agricultural practices carried out in the palm grove plantation located at the banks of the course at this station). Overall, anthropic activities and increasing urbanization observed downstream of this watercourse would be at the origin of the progressive deterioration of this ecosystem.

5. Conclusions

The main objective of this study was to characterize the waters of the Missolé stream based on physicochemical and biological analyses. The low values of the dissolved oxygen saturation rate, the low water temperatures, as well as the taxonomic richness and abundance of insects obtained show that the waters of the Missolé stream are fair quality and slightly favorable to the development of the benthic macrofauna. Nevertheless, the high values of the parameters indicating organic pollution, such as electrical conductivity, ammonium, orthophosphates, nitrates, nitrites and turbidity, as well as the emergence of taxa with high tolerance coasts, such as the Chironomidae, reveal that the Missolé watershed is in the process of anthropization. This level of degradation of the Missolé calls on communal authorities, village communities, researchers and organizations in charge of preserving aquatic biodiversity to preserve this important ecosystem and its ecological niche. The discrepancy between the organic pollution index and the biological indices raises the debate on the need to calibrate these indices, which were set up in temperate regions.

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