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Biodiversity of Benthic Macroinvertebrates and water quality as a tool to the ecological study of three forest streams in the littoral zone (Cameroon)

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Abstract

A study of the community dynamics of benthic macroinvertebrates in relation to physicochemical water quality was conducted from December 2022 to December 2023 in the Lepp-Nyock, Ndog-Bissolo, and Ngwei streams within the tropical littoral forest area of the Guinean Gulf (Edéa). Physicochemical analyses were performed and Benthic Macroinvertebrate identified following classical method.

The results indicate that those waters are well-oxygenated (73.72±12.48%), slightly acidic (pH 6.87±0.42 CU) and contain very low concentrations of nitrogen compounds and heavy metals (0.29±0.28 mg/l Cu, 0.8±0.54 mg/l Zn, 0.45±0.27 mg/l Mn, 1.32±0.47 mg/l Fe, 0.81±0.38 mg/l Al, 0.18±0.2 mg/l Cd, and 0.49±0.52 mg/l Cr). Biological analysis revealed a total of 8,699 Benthic Macroinvertebrates belonging to 4 Phyla, 5 Classes, 12 Orders, 55 Families and 117 Genera. Arthropods were the most abundant, accounting for 86.67% of the total, with the insect Class (86,56%) being dominant (8 Orders, 42 Families, and 68 Genera). Gastropods (13,27%) were the second most abundant group, represented by 2 Orders, 5 Families, and 16 Genera. The Atyidae family was particularly dominant within the benthic community, with *Caridina africana* identified as the most prevalent species.

The Shannon-Weaver diversity index (H') and Piélou equitability index (J) indicated low taxonomic diversity, while the Organic Pollution Index (OPI) suggested a less disturbed environment. Together, these findings reflect the good ecological quality of the water in the studied streams.

Keywords: Benthic macroinvertebrates; Ecological quality; Tropical littoral forest; Lepp-Nyock; Ndog-Bissolo; Ngwei; Edéa

1. Introduction

For decades, freshwater issues have been a growing concern. The prevention and rational, efficient management of this vital resource is a global priority for both quantitative and qualitative perspectives (1). The Sustainable Development Goals (SDGs), particularly Goal 6 on drinking water and sanitation, emphasize the importance of this resource. Indeed, water serves as food, habitat, a means of production, transportation, and a market commodity (2). Water also provides a living environment for numerous aquatic organisms. Aquatic communities play a crucial role in matter and energy cycles. However, these communities, which represent both biodiversity and the driving force behind ecosystem functioning (3), remain poorly understood in tropical regions. It is estimated that 70% of aquatic organisms are yet to be catalogued (4). Thus, undertaking studies on aquatic communities and the ecological status of hydrosystems is essential for gaining better insights. Nevertheless, the functioning of aquatic ecosystems is increasingly affected by rapid

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urbanization, coupled with population growth, which disrupts many ecological processes and leads to a decline in biodiversity (5). Anthropogenic activities are a major source of solid and liquid waste production, followed by significantly degrades water quality (6). Aquatic environments face real threats, many of which arise from environmental changes and anthropogenic pollution. The impacts of these threats are not always immediately perceptible (7; 8). In Cameroon, the discharge of liquid and solid waste from towns and industries into watercourses is the primary cause of water quality degradation (9). The implementation of sustainable management strategies for these ecosystems must be an ongoing effort to reduce disturbances (10). Biological monitoring methods focus on organisms such as benthic macroinvertebrates, whose diverse life cycles, wide distribution, sedentary nature, and variant sensitivity to different stressors allowed them excellent bioindicators of the ecological health of hydrosystems (6).

Several studies have explored the benthic macroinvertebrates of some forested rivers in Cameroon. Notable examples include studies carried out on the streams in the Southern region, Eastern region, and on streams in the Central region (11; 12; 13). Studies of urban and peri-urban watercourses include research by (14) on the Mfoundi hydrographic network, (8) on urban and periurban streams in Douala, (15) on streams and mangroves in the Littoral region, and (16) on streams and ponds in the South region. While urban watercourses are subject to intense organic pollution from human activities, forest watercourses are less impacted by anthropogenic factors. However, watercourses in the Littoral region, particularly in the Sanaga Maritime department, remain largely unexplored. This study, which examines the biodiversity of benthic macroinvertebrates in three forest streams within this region (Lepp-Nyock, Ndog-Bissolo, and Ngwei), aims to address this knowledge gap.

2. Material and methods

2.1 Study environment

The Littoral region of Cameroon is situated in south western Cameroon, between 4°00' north latitude and 10°00' east longitude. Covering an area of 20,239 km², it comprises a low-lying sedimentary plain with altitudes ranging between 0 and 50 m, occasionally reaching up to 80 m (17) (Figure 1). The region has a humid tropical climate of the northern coastal type, characterized by two distinct seasons: a long rainy season (March–November) and a short dry season (december–february) (18). Rainfall is abundant and regular, with annual precipitation ranging between 3,000 and 4,000 mm. Temperatures are high, with a monthly average of approximately 27°C. The hydrographic network is dense, featuring numerous permanent streams. Vegetation in the region corresponds to the coastal Atlantic forest type, while soils, from a petrographic perspective, vary from sandy to sandy-loam (19).

Three watercourses—Lepp-Nyock, Ndog-Bissolo, and Ngwei—and nine sampling stations were selected based on their representativeness, accessibility, and the nature of surrounding human activities (Table 1).

Table 1 Some characteristics of the sampling stations on the Lepp-Nyock, Ndog-Bissolo and Ngwei streams

Water course studied	Code of the station	GPS coordinates			Nature du Of substrate	Human activities
		Latitude °N)	Length (°E)	Altitude (m)		
Lepp- Nyock	L1	03°47’49.2’’	010°13’16.1’’	112	Sands and mud	Subsistence farming
	L2	03°47’55.0’’	010°13’17.4’’	88	Sands, Gravel, rock de blocks	Swimming, consurption
	L3	03°48’08.8’’	010°13’29.4’’	76	Sables, graviers	Breeding
Ndog-Bissolo	N1	03°47’46.5’’	010°14’14.8’’	107	Sands, Gravel	None
	N2	03°47’46.2’’	010°14’15.4’’	96	Sands, Gravel	Extraction Palm oïl
	N3	03°48’10.4’’	010°14’26.9’’	91	Rock, sands, Gravel	Bathing, Laundry and dishes
Ngwei	G1	03°47’49.9’’	010°14’46.4’’	89	Sands, Mud and Gravel	None
	G2	03°47’52.8’’	010°14’51.8’’	99	Mud, Sandy	Palm wine extraction
	G3	03°48’12.9’’	010°14’47.6’’	80	Rock, Sands, Gravel	None

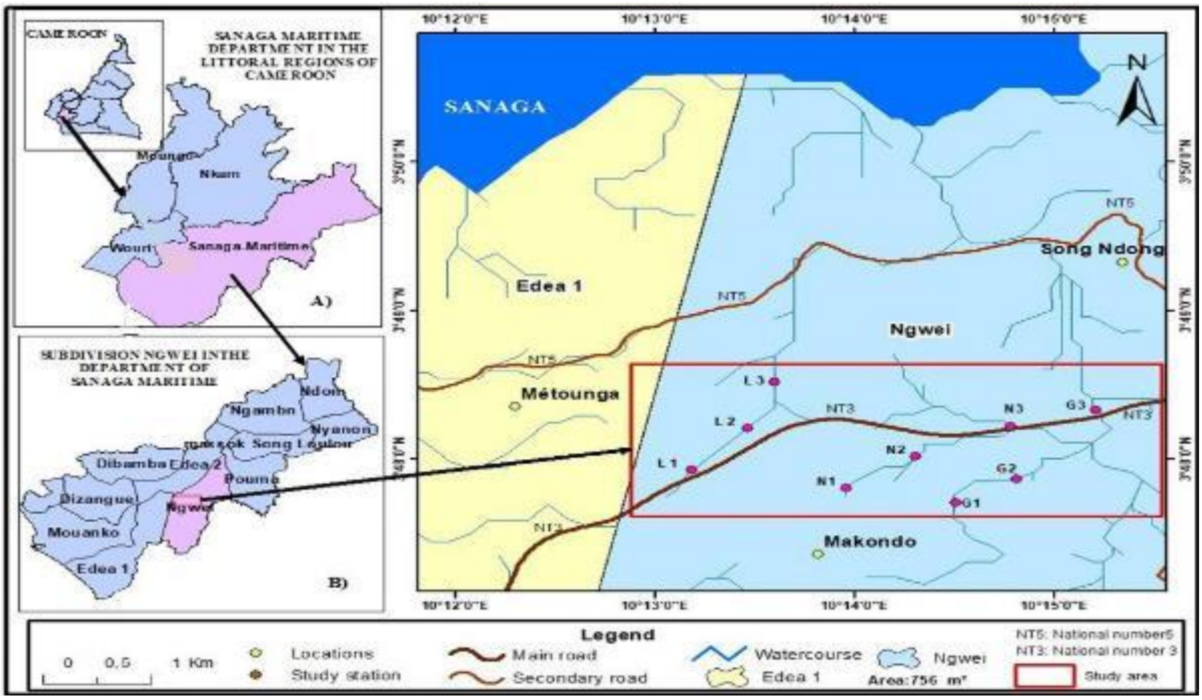

Figure 1 Geographical map of the study area showing sampling stations (Source Image SRTM, 2017)

2.1. Methods

Physicochemical analyses were conducted both in the field and in the laboratory, following the methods described by (20) and (21). In the field, water temperature (°C) and pH (UC) were measured in situ using a HANNA HI 98130 multiparameter, while dissolved oxygen was measured with a HACH HQ14d oximeter. In the laboratory, color, turbidity, nitrogen forms, and orthophosphate ions were analyzed using a Hydro Test HT 1000 spectrophotometer. Heavy metals, including copper, zinc, manganese, iron, aluminum, chromium, and cadmium, were measured with a HACH HDR/3900 spectrophotometer. The organic matter load was assessed using the organic pollution index (IPO) (table 2).

Table 2 Interpretation of the class average obtained in the above table, according to (22).

Parameter / Class	NH4+ (mg/L)	NO2- (µg/L)	PO43- (µg/L)	Organic pollution level
5	< 0,1	≤ 5	≤ 15	Nil
4	0,1 - 0,9	6 – 10	16 – 75	Low
3	1 - 2,4	11 – 50	76 – 250	Moderate
2	2,5 – 6	51 – 150	251 -900	Strong
1	> 6	> 150	> 900	Very strong

Sampling of benthic macroinvertebrates was conducted monthly using the multihabitat approach described by (23). At each station, 20 samples, corresponding to an area of 3 m², were collected from different microhabitats. The contents of each sample were transferred into polyethylene bottles containing 10% formalin. In the laboratory, the samples were rinsed with tap water, and the organisms were sorted using a 400 µm mesh sieve. Identification was carried out under a Research Bresser binocular microscope using the identification keys provided by (24), (25), (26), (27), and (28).

Organic pollution was assessed both physiochemically, using the Organic Pollution Index (IPO) (Tables 2), and biologically, using the indices developed by (29) and (30) (Table 3).

Table 3 Interpretation grid for (29) and (30)

Echelle	Water quality class
0,00 à 3,75	Excellent: no organic pollution
3,76 à 4,25	Very good: slight organic pollution possible
4,26 à 5,00	Good: probable organic pollution
5,01 à 5,75	Average: fairly substantial organic pollution
5,76 à 6,50	Fairly poor: substantial organic pollution
6,51 à 7,25	Poor: substantial organic pollution
7,26 à 10,00	Very bad: serious organic pollution

The Kruskal-Wallis test was used to assess normality, and the Mann-Whitney test was applied to evaluate differences between stations. The Shannon-Weaver diversity and Piélou equitability indices were calculated to determine organism diversity and distribution. Sorensen's similarity index was then used to determine the degree of similarity between populations at different stations. Organic pollution was assessed physiochemically using the Organic Pollution Index (IPO) and biologically through the Hilsenhoff Index. The EPT, EPTH, EPTD, and EPTC indices were used to evaluate the taxonomic richness of various benthic macroinvertebrate orders associated with water quality.

3. Results

3.1. Physicochemical parameters

During the study period, water temperature ranged from 24.84°C at stations L1, L2, and L3 in April to 29°C at station L1 in March, with an average of 26.43±1.05°C (Figure 2A). Spatially, no significant differences ($p>0.05$) were observed between stations. However, temporally, significant differences were observed across months ($p<0.05$), with February recording the highest temperature values.

Water turbidity varied from 0 FAU at stations L1 (January, February), L2 (May), L3 (February, May, June), N1 (June), N2 (May, June), N3 (February), G1 (May, June, December 2023), G2 (May, June, August, December 2023), and G3 (December 2023), to 892 FAU at station G1 in March, with a mean of 58.98±278.30 FAU (Figure 2B). Spatially, no significant differences were observed between stations ($p>0.05$). Temporally, significant differences were noted ($p<0.05$), with March showing the highest turbidity values.

Water color ranged from 0 Pt-Co at stations L1 (December 2022, January, May), L3 and N2 (March), G1 and G2 (May), and G3 (February), to 488 Pt-Co in October, with a mean of 103.55±88.14 Pt-Co (Figure 2C). Spatially, no significant differences were noted between stations ($p>0.05$). Temporally, significant differences were observed ($p<0.05$), with February and October recording the highest values.

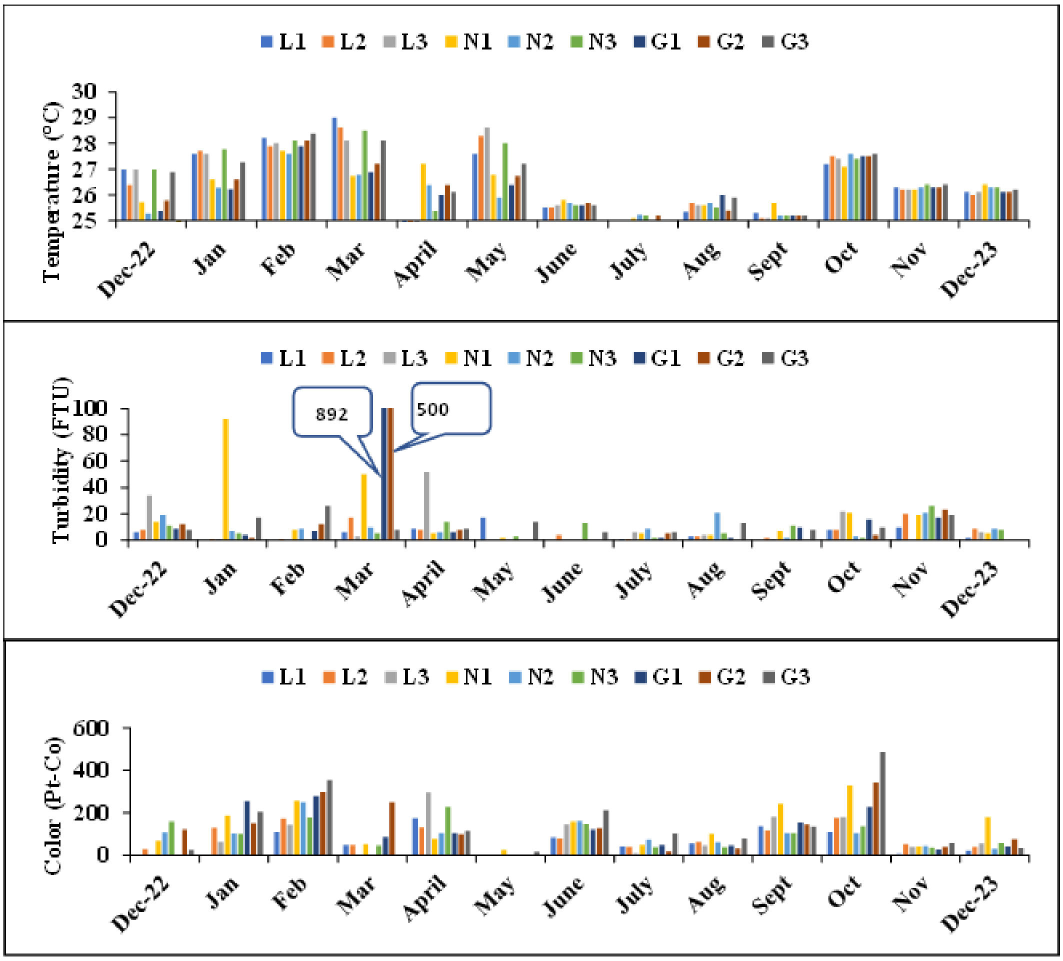

Figure 2 Spatio-temporal variation of water physical parameters: temperature (A), turbidity (B) and color (C) during the study period

Water pH ranged from 6.4 CU at station G1 (June) to 8.7 CU at the same station in December 2023, with a mean value of 6.87±0.42 CU (Figure 3A). Spatially, no significant differences were observed between stations ($p>0.05$). Temporally, significant differences were recorded across months ($p<0.05$), with May and December 2023 showing the highest pH values.

Dissolved oxygen levels ranged from 36.7% at station N2 (December 2023) to 93.9% at the same station in September, with a mean value of 73.72±12.48% (Figure 3B). Spatially, no significant differences were observed between stations ($p>0.05$). Temporally, significant differences were noted across months ($p<0.05$), with December 2022, January, and October recording the highest levels.

Nitrate levels ranged from 0 mg/L at stations L2, N1, N2, N3, G1, G2, and G3 (December 2022) to 6 mg/L in June, with a mean value of 1.20±1.46 mg/L (Figure 3C). Spatially, no significant differences were observed between stations ($p>0.05$). Temporally, significant differences were noted ($p<0.05$), with June and December recording the highest nitrate levels.

Nitrite levels ranged from 0 mg/L at stations L1 (December 2022 and May), N1 (December 2022, January, February, and March), N2 (January and February), N3 (December and March), G1, G2 (December 2022 and February), and G3 (January, February, and September), to 0.12 mg/L at station N1 in November, with a mean value of 0.20±0.02 mg/L (Figure 3D). Spatially, no significant differences were observed between stations ($p>0.05$). Temporally, significant differences were recorded ($p<0.05$), with April and June showing the highest nitrite levels.

Ammonium levels ranged from 0 mg/L at stations L1 (December 2022, May), L2 (February and May), L3 (May), N1, G2 (December 2022), N2, N3, G1 (February), and G3 (December 2022, February, March, and May), to 3.59 mg/L at station

G2 in August, with an average of 0.34±0.51 mg/L (Figure 3E). Spatially, no significant differences were observed between stations (p>0.05). Temporally, significant differences were recorded (p<0.05), with August, September, and October showing the highest ammonium levels.

Orthophosphate levels ranged from 0 mg/L at stations N2 (January and February), N3 (January), and G2 (January and September), to 6.5 mg/L at station N1 in March, with a mean value of 0.66±1.05 mg/L (Figure 3F). Spatially, no significant differences were observed between stations (p>0.05). Temporally, significant differences were recorded (p<0.05), with December 2022 and March showing the highest levels.

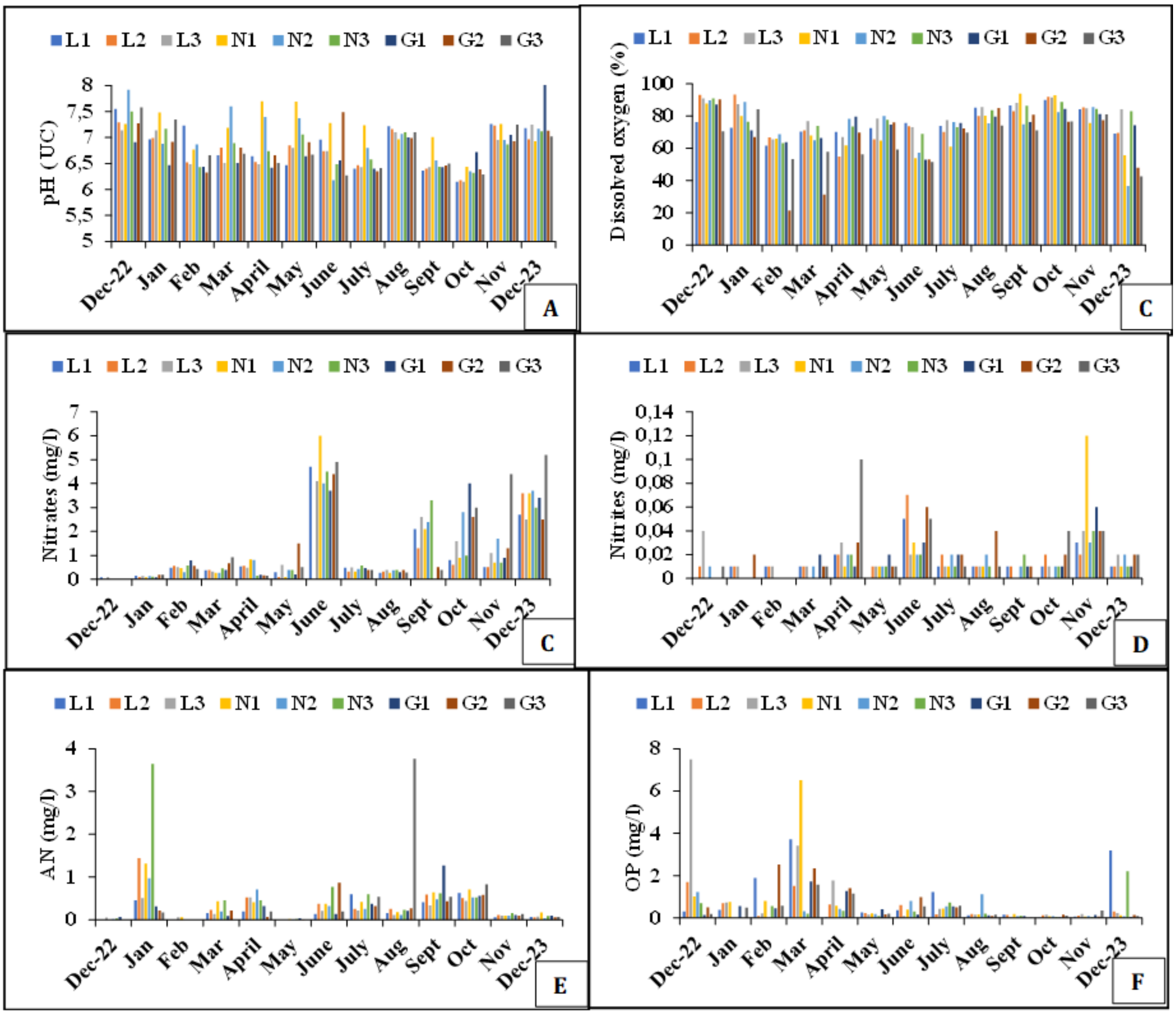

Figure 3 Spatio-temporal variations in pH (A), dissolved oxygen (B), nitrate (C), nitrite (D), ammoniacal nitrogen (AN)(E): and orthophosphates (OP) (F)

Although overall heavy metal levels remained low, station L2 on the Lepp-Nyock stream exhibited relatively higher concentrations, notably copper (0.93 mg/l), zinc (1.82 mg/l), manganese (0.9 mg/l), and chromium (1.73 mg/l). Iron and aluminum peaked at station N1 on the Ndog-Bissolo stream, with concentrations of 1.88 mg/l and 1.26 mg/l, respectively. At station G3 on the Ngwei stream, cadmium levels were slightly elevated at 0.61 mg/l (Table 4). Significant differences were noted between stations (p < 0.05).

Table 4: Heavy metal values at various river stations during the study period

Stations	Copper (mg/l)	Zinc (mg/l)	Manganese (mg/l)	Fer (mg/l)	Aluminium (mg/l)	Chrome (mg/l)	Cadmium (mg/l)
L1	0,22	0,21	0,06	0,77	0,25	0,39	0,14
L2	0,93	1,82	0,9	1,85	1,03	1,73	0
L3	0,09	0,63	0,5	1,34	0,84	0,16	0,47
N1	0,48	0,54	0,6	1,88	1,26	0,74	0
N2	0,03	0,54	0,2	0,88	0,47	0,05	0,25
N3	0,32	0,52	0,5	0,63	0,27	0,37	0
G1	0,02	0,36	0,7	1,32	0,95	0,05	0,03
G2	0,18	1,26	0,2	1,39	1,01	0,32	0,13
G3	0,32	1,32	0,4	1,78	1,19	0,57	0,61

IPO values (Figure 4) ranged from 2.33 at stations G2 (June) and G3 (April) to 5 at station N2 (February), reflecting low to high water pollution. Significant differences were found between stations and months ($p<0.05$).

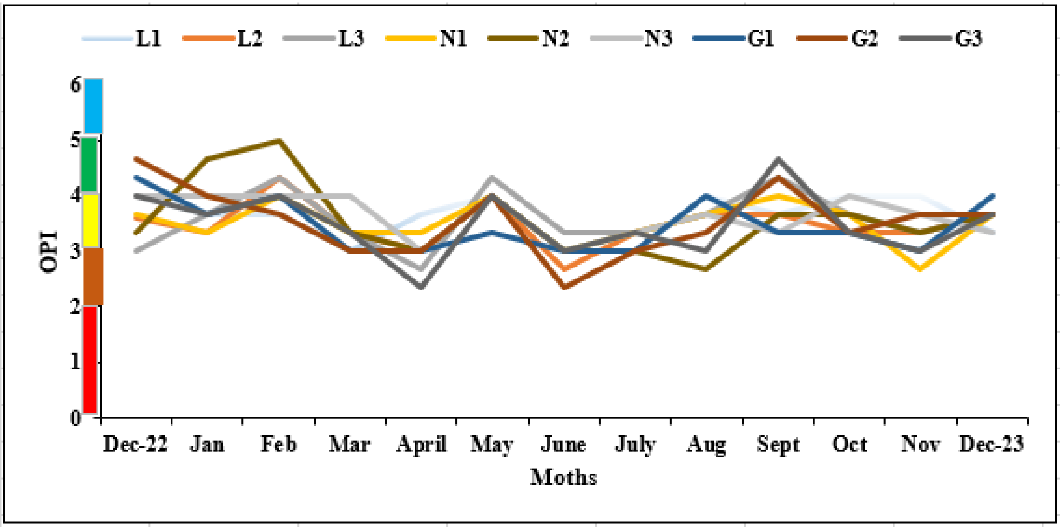

Figure 4 Spatio-temporal variation in the OPI of the waters of various rivers during the study period

2.2. . Biological parameters

During the study period, a total of 8,699 organisms belonging to 4 Phyla, 5 Classes, 12 Orders, 55 Families, and 117 Genera were collected. The phylum Arthropoda dominated with 7,539 individuals, representing 86.67% of relative abundance, followed by Mollusca with 1,165 individuals, or 13.39% of relative abundance. The class Insecta (86,56%) was the most dominant, comprising 8 orders, 42 families, and 68 genera, followed by Gastropoda (13,27%), which included 2 Orders, 5 Families, and 16 Genera. The Atyidae family had the highest abundance, with 4,763 organisms (54.75% relative abundance), followed by Thiaridae with 967 organisms (11.12% relative abundance).

Positive and significant correlations were observed between dissolved oxygen and Atyidae ($r = 0.567$; $p = 0.01$), as well as oxygen and Gomphidae ($r = 0.549$; $p = 0.01$). Strong correlations were also found between pH and Chironomidae ($r = 0.369$; $p = 0.01$) and pH and Belostomatidae ($r = 0.305$; $p = 0.01$). Other significant correlations included nitrites and Chironomidae ($r = 0.468$; $p = 0.01$), Blaberidae and Hydropsychidae ($r = 0.321$; $p = 0.01$), Thiaridae and Atyidae ($r = 0.383$; $p = 0.01$), Palaemonidae and Hydrotillidae ($r = 0.391$; $p = 0.01$), and Atyidae and Calopterygidae ($r = 0.654$; $p = 0.01$).

Significant negative correlations were found between pH and Calopterygidae (r = -0,316; p = 0,01), dissolved oxygen and Chironomidae (r = -0,641; p = 0.01), and ammoniacal nitrogen and Atyidae (r = -0,324; p = 0,01). Additional correlations were observed between Hydropsychidae and Chironomidae (r = 0,273; p = 0,01), Thiaridae and Chironomidae (r = -0,351; p = 0,01), Chironomidae and Gomphidae (r = -0,466; p = 0,01), Calopterygidae and Chironomidae (r = 0,568; p = 0,01), and Atyidae and Chironomidae (r = 0,613; p = 0,01).

The calculation of the Sörensen similarity index revealed higher values between stations N1 and N2 (84,21%), N2 and N3 (83,33%), G1 and G2 (81,36%), and between L3 and N2 (73,02%) (Table 5).

Table 5 Sorensen's similarity index values between selected stations on different rivers during the study period

Stations	N1-N2	N2-N3	G1-G2	L3-N2
Sörensen similarity index (%)	84,21	83,33	81,36	73,02

In all the rivers, the Shannon-Weaver diversity index decreases slightly from upstream to the middle zone, before beginning to rise significantly downstream (2,76 bits/ind at station N3). The same applies to Piélou equitability index, which takes on higher values at station N3 in the same Ndog-Bissolo stream.

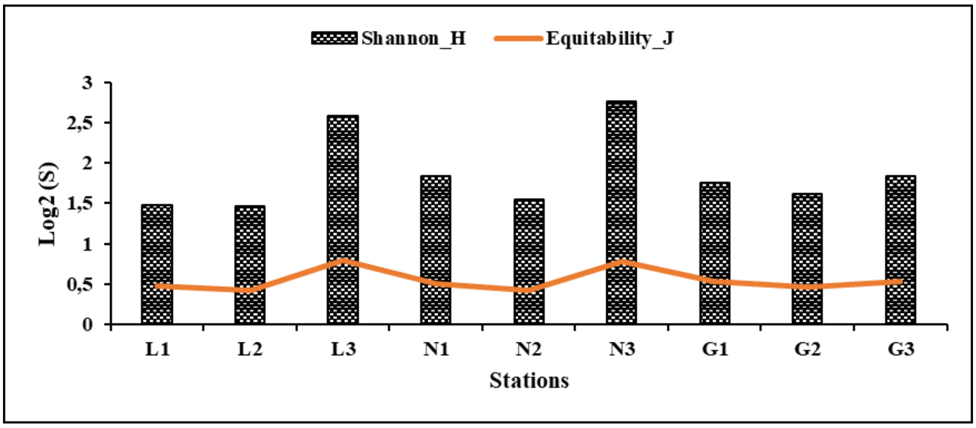

Figure 5 Spatio-temporal variation in Shannon-Weaver diversity index and Piélou equitability at different river stations during the study period

Hilsenhoff index values ranged from 4,93 at station L3 to 6,83 at stations L1 and L2 on the same river, reflecting water quality ranging from good to poor.

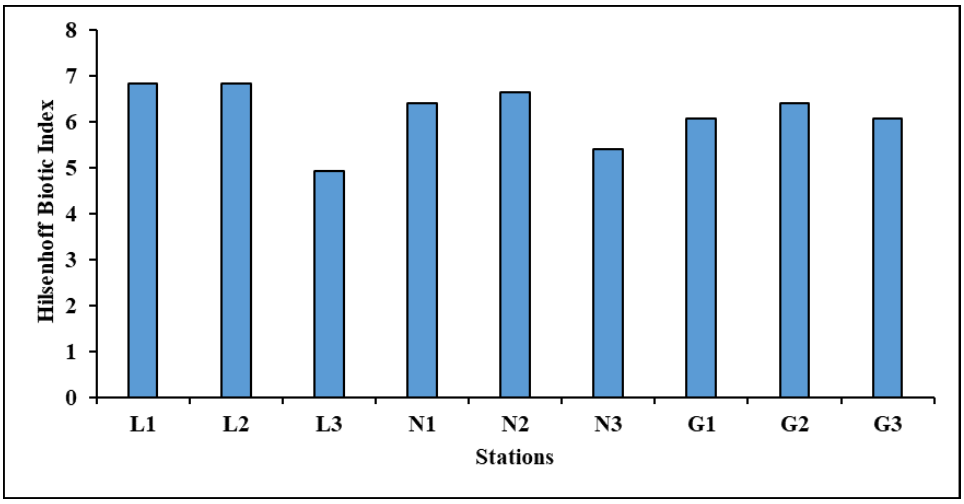

Figure 6 Spatio-temporal variation of the Hilsenhoff index at various river stations during the study period

EPT, EPTD, EPTC, and EPTH index values were highest at station G3, with values of 8, 10, 11, and 15, respectively, followed by station G2 with values of 7, 10, 13, and 12 on the Ngwei stream. Lower values were recorded at station L3 on the Lepp-Nyock stream. TCPS values were consistently higpresh at station G2 on the Ngwei stream (13) and lowest at station L3 (5) on the Lepp-Nyock stream (Figure 7)

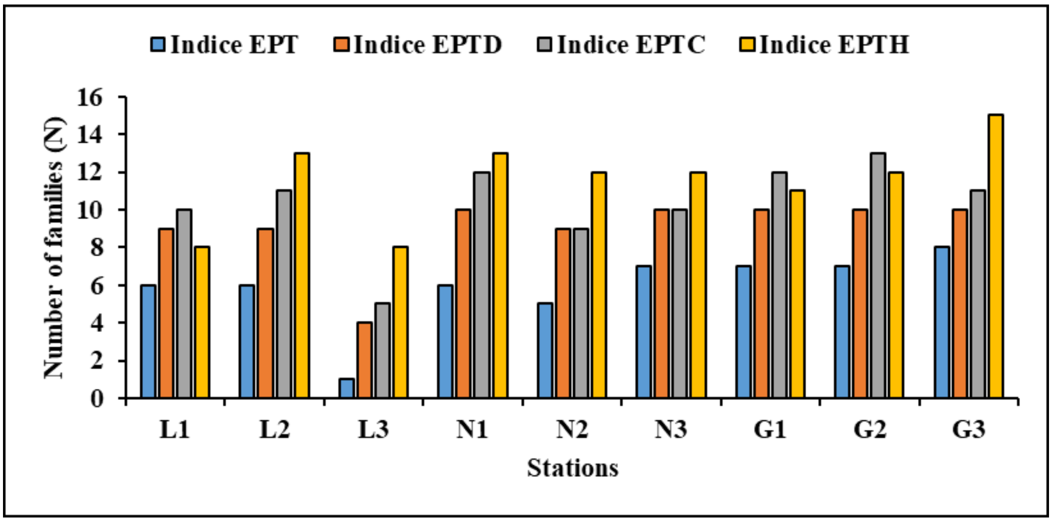

Figure 7 Spatio-temporal variation in EPT, EPTD, EPTC and EPTH indices at various river stations over the study period

3. Discussion

3.1. Water Physicochemical characteristic of study area

The mean temperature value of 26.43±1.05°C observed in the three streams during the study period could be attributed to the limited sunshine caused by the canopy, which forms a natural barrier preventing solar rays from reaching the water. (31) and (12) noted that temperatures in forest streams are generally low and vary very little. This value is comparable to that reported by (32) in the Non stream (26.62±0.61°C) in Douala and by (9) in the Ibe-Mfémé stream in the Centre region (24.78±0.47°C).

The mean values for turbidity (58.98±27.30 FTU) and color (103.55±88.14 Pt-Co) in the various rivers can be attributed to the low organic matter load in the water and the limited contribution of allogenic matter. These results are consistent with those of (11) in the Lo'o stream in the Southern region (160.33 Pt-Co) and (33) (3.8–24 FTU) in springs and some streams in the Central region.

The pH (6.87±0.42) of the waters is due to the presence of large amounts of litter covering the riverbeds, as well as the ferrallitic nature of the soil. According to (34), the pH of surface waters depends on the nature of the terrain, which explains the differences observed between the streams in our study areas. Our results are higher than those obtained by (16) in some streams in the southern region (6.04±0.29 UC).

The waters of the various streams show satisfactory dissolved oxygen saturation levels (73.72±12.48%) in line with the (35) quality grid. This good oxygenation can be attributed to the strong canopy, the natural ventilation of the water, and the presence of riffles, which promote water mixing. These results corroborate the observations of (36) in the Ketsok stream in the Western region (75.64±7.44%) and (37) and (11) (72.43%±2.91%), who emphasize that in forested areas, natural ventilation, riffles, and meanders create conditions of turbulence and water circulation favorable to oxygenation at the water/air interface.

The low nitrite values (0.20±0.02 mg/l) are linked to the saturation of the environment with dissolved oxygen. (38) point out that nitrites are only maintained in running water if the environment is not sufficiently oxidizing. The low levels of nitrates (1.20±1.46 mg/l), ammoniacal nitrogen (0.34±0.51 mg/l) and orthophosphates (0.78±0.34 mg/l) in these waters are linked to their low anthropogenic content. The combination of these different values indicates good ecological water quality, according to (39) grids, with values slightly higher than those obtained by (40).

Regarding heavy metals, the low concentrations of copper (0.29±0.28 mg/l), zinc (0.8±0.54 mg/l), and manganese (0.45±0.27 mg/l) are due to the absence of industry in the study area. (20) note their presence in trace amounts in natural aquatic environments. However, these results are still higher than those obtained by (41) in the Simbi (0.02 mg/l), Kondi (0.01 mg/l), and Logmayangui (0.76 mg/l) streams, respectively, but lower than the (42) standards, which set copper <2 mg/l, zinc <3 mg/l, and manganese <0.4 mg/l for surface waters. These values are higher than those obtained for copper (0.0015±0.00014 mg/l) in the Nsapé stream (43) and those of (16) for manganese in the Nlongo streams in the South region (0.35±0.40 mg/l). The same applies to the low values for cadmium (0.18±0.22 mg/l) and chromium (0.49±0.52 mg/l). (39) assert that metal pollution of surface waters is essentially of anthropogenic origin, with the flow of pollutants increasing with urbanization, industrialization, and population density. Additionally, the relatively high mean value for aluminum (0.81±0.38 mg/l) is thought to be linked to the use of charcoal as fuel during palm oil extraction by local residents, as well as to pesticides and fertilizers used in soil treatment and fertilization or runoff water. These values are still higher than those obtained by (16) in the Myamessamba stream (0.209±0.105 mg/l) and (15) (0.001±0.0009 mg/l) at station ES 4 in brackish waters in the mangrove zone at Mouanko. (44) point out that the use of fertilizers and pesticides are among the anthropogenic sources of heavy metals in the environment. IPO values generally exceeding 3 reflect moderate organic loads in the water, favored by the use of agricultural inputs upstream of the watercourse catchment area and the discharge of various domestic wastes into the watercourses. Similar results were found by (40) in several streams in the southern Cameroon region.

3.2. Benthic Macroinvertebrate of Study area

The taxonomic richness of macroinvertebrates (55 families) observed in all streams is slightly lower than that of (43) in the Mgoua watershed stream (57 families) and (45) in the Essoa stream (69 families) in the same ecological region. This could be explained by the low diversification of ecological niches in the various rivers, influenced by the onset of anthropogenic activities observed at some stations. However, the predominance of the Insect class (8 Orders) and the Atyidae family (54.75% relative abundance) suggests that the watershed has limited anthropogenic impact, resulting in relatively good water quality and enabling organisms to colonize heterogeneous ecological niches. Furthermore, the positive and significant correlations observed between oxygen and Atyidae ($r=0.567$; $p=0.01$), oxygen and Gomphidae ($r=0.549$; $p=0.01$), and Atyidae and Calopterygidae ($r=0.654$; $p=0.01$) reinforce the idea that the waters in the watershed are conducive to the development of pollution-sensitive taxa. Conversely, the negative and significant correlations between oxygen and Chironomidae ($r=-0.641$; $p=0.01$), Calopterygidae and Chironomidae ($r=-0.568$; $p=0.01$), and Atyidae and Chironomidae ($r=-0.613$; $p=0.01$) suggest the opposite. The high values of Sörensen's similarity index observed between different stream stations (N1N2 84.21%, N2N3 83.33%, G1G2 81.36%, and L3N2 73.02%) indicate the faunal similarity underlying most of the stations.

The high values of the Shannon-Weaver diversity index (H') and Piélou equitability index (J) found in the Ndog-Bissolo (H'= 1.83 bits/ind) and Ngwei (J= 0.51) streams could be explained by the diversification of microhabitats at these stations. (46) suggest that the higher the diversity index, the better the environmental conditions for the establishment and maintenance of a balanced, integrated biological community capable of adapting to change. The low values of these indices observed in the Lepp-Nyock stream (H'= 1.70 bits/ind; J= 0.45) reflect the low diversification of ecological niches and fauna, as evidenced by the predominance of the species *Caridina africana*. (47) suggest that the Shannon-Weaver diversity index decreases when a taxon has a very high relative abundance.

The low values of the index at some stations (4.94) appear to be the result of an abundant presence of pollution-sensitive taxa, while the higher values observed (6.38) reflect the presence of pollution-resistant taxa. (29) and (30) point out that this index is lower when the tolerance ratings of the taxa considered are close to 0. Our results are similar to those obtained by (16) in the Nieté (4.26), Nlongo (6.00), and Myamessina (6.61) streams in the southern Cameroon region.

The high values of the EPT, EPTD, EPTC, and EPTH indices found in the various rivers reflect the low anthropogenic impact on the watersheds. This can be explained by the presence of pollution-sensitive taxa such as Decapoda, Coleoptera, and Hemiptera. Our results are consistent with those obtained by (40) in several rivers in the southern region.

4. Conclusion

This study has allowed us to assess the biodiversity and ecological quality of three streams located in a forested area about twenty kilometers from the town of Edéa in the Littoral region. Analysis of the physicochemical parameters shows that the waters are well oxygenated, slightly acidic, with low levels of nitrogenous compounds and heavy metals. The structural study of the benthic fauna reveals a predominance of pollution-sensitive taxa, particularly decapod crustaceans of the Atyidae family (54.75% relative abundance). Analysis of biocenotic indices indicates a poorly diversified, unbalanced population subject to low levels of organic pollution, reflecting the watershed's low level of human activity and the satisfactory ecological quality of the waters in the Lepp-Nyock, Ndog-Bissolo, and Ngwei streams.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this document.

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