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Water Quality Assessment of Some Forest Streams in the South Region of Cameroon

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Abstract:

The localities of Azem and Mvam Essakoe in Mvila department were chosen to host a study whose goal was to characterize the water of four forest streams. The results showed that water is slightly acidic (5.78 ± 0.91 UC), with a low oxygen saturation rate (58.79 ± 19.10%), and slightly alkaline (2.86 ± 2.08 mg/l) with low nitrateslevel (1.51 ± 0.98 mg/l). The benthic macroinvertebrates showed à high taxonomic richness with 174 taxa; including 3 phyla, 5 classes, 11 orders and more than 62 families. This macrobenthic fauna is dominated by insects (63.67% of relative abundance), followed by crustaceans (33.29% of relative abundance) and at the end came gastropods bivalves and oligochaetes. The diversity index of Shannon & Weaver, the Equitability index of Piélou and the one of Simpson reveal a rich and diversified population.

Keywords **—Forest streams, taxonomic richness, macrobenthic fauna, diversity index**

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I. INTRODUCTION

Since the 19th century, rivers, particularly in industrialized countries and also countries in the process of industrialization, have been seriously affected by different types of pollution (industrial, urban and agricultural) [34]. To assess these major risks that may affect aquatic environments, two tools are often used [4]. The first, which is the oldest and most used till today, is the physicochemical analysis. The second tool, based on an ecosystem approach to disturbance, uses biological organisms [4]. For a better assessment of water quality, new synthetic approach combine both physicochemical and biological components pursue. This method is already used around the world and provide the best information concerning the health status of watercourses.

Thus, monitoring and evaluation programs integrating biological material took place in Europe at the beginning of the 20th century, when ecosystem degradation had become a threat to the health of human populations. Among the biological material used for monitoring aquatic environments, macroinvertebrates are most frequently cited. These organisms have advantages of being mostly

dependent on the environment, responding rapidly to stresses and being one of the first element in the food chain of watershed [35]. Moreover, there is a certain persistence in these organisms which allows them to testify more or less old pollution. Their life cycles are relatively long and can cover more than four years [31]. These specific behavior enable them to become the best bioindicators of the aquatic ecosystems [35].
This study aims to characterize four waterstreams in the Southern region of Cameroon, using benthic macroinvertabrates.

II. MATERIAL AND METHODS

Study area

This study was carried out in South region of Cameroon in Mvila department. Covering a surface of 47 191 km^2. This region is characterized by equatorial climate with four unequal seasons [30] distribuated as follows: a long dry season from mid-November to mid-March, a small rainy season from mid-March to the end of June, a small dry season from July to August and a long rainy season from September to mid-November [30]. The annual precipitation average is approximately 1710 mm and the monthly temperature around 25° ± 0.97°C. The relief is dominated by the southern plate of Cameroon, with altitudes who varying between 0 m and 1000 m. In South region, we have yellow and red ferralitic soil [10]. The vegetation is characterised by the wet dense forest comprising in two variants : the sempervirente forest of Congo or Dja and ombrophilous forest with low altitude of littoral, and the semi-deciduous forest with medium altitude (marshy forest). The hydrographic network is dense and constituted by two important watersheds : the Atlantic and Congo watersheds [10]; [23].

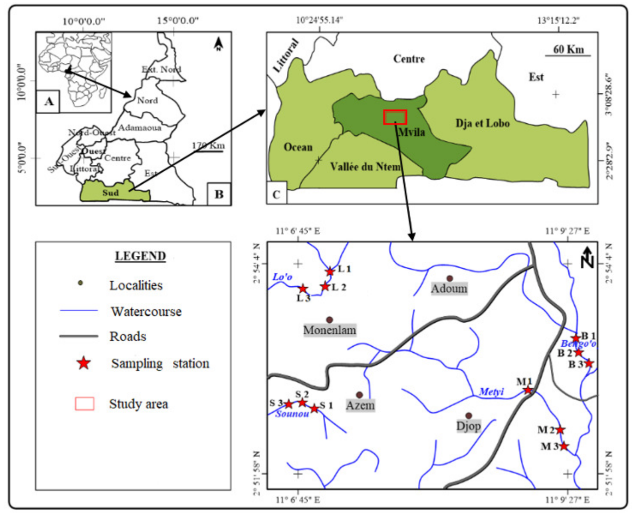

Figure 1: Sampling station in different streams in Mvila department [15], modified.

Sampling and analysis physicochemical variables

The evaluation of physicochemical parameters was done following the recommendations of [2] ; [25]. Thus, temperature (°C). dissolved oxygen (%) and pH(UC) were measured *in situ* using a portable multimeter HANNA HI 991301.
In the laboratory, orthophosphates, mineral form of nitrogen, suspended solids, color and turbidity were determined by colorimetry using the Hydrotest photometer HT1000, and the alkalinity by volumetry. The results were given in mg/l and NTU. Oxidability was also measured volumetrically. In a 500 ml Erlenmeyer flask, 200 ml of raw water sample was introduced, followed by 2 ml of monosodium carbonate, and the whole was brought to the boil. Immediately after boiling, 20 ml of $KMnO_4$ N/80 was added. Ten (10) minutes after boiling started, the Erlenmeyer flask was cooled with running water, then 5 ml of 25 % H_2SO4 and 20 ml of Mohr's salt were added. The decolored sample was then titrated with $KMnO_4$ N/80 to pink. The oxidability expressed in mg/l of O_2 is obtained by the formula:

$$\text{Oxidability (mg/L of } O_2\text{)} = \frac{q-qo}{2} \times 3.95$$

q = burette run of the sample and q_0 = burette run of the control.

Sampling of Benthic Macroinvertebrates

The collection of benthic macroinvertebrates was done monthly from December 2018 to May 2019, according to multi-habitat approach [28], using a kick-net (30 cm x30 cm side, 400µm mesh size).Thus, in each station, 20 drags of kick-net were done in different microhabitats, corresponding to a surface of 3 m^2. The contents of each sample were introduced into polyethylene vials containing 10% formalin. In the laboratory. samples were rinsed with tap water and organisms were identified under a binocular stereomicroscope WILD M3B, using appropriate identification keys of [9] ; [32] ; [13] ; [6] ; [7] ; [27] ; [19].

Data analysis

The normality of the distribution was used to Shapiro test, while those of Kruskal-Wallis and Mann-Whitney were chosen to significance test ($p < 0.05$) sustained by the XLSTAT version 2007. The Principal Component Analysis (PCA) established the relationship between environmental variables and abundance of benthic macroinvertebrates. Some ecological index as Shannon and Weaver, Simpson and Piélou equitability index were used to determine the structure of the population. Also, Organic Pollution Index (OPI) and Normalised Global Biological Index (NGBI) was done.

III. RESULTS AND DISCUSSION

Results

Temperature

In Metyi stream, temperature values ranged from 22.30° C (M3, February) to 25.40° C (M2, October), oscillating around an average of 24.11 ± 0.77 ° ($p > 0.05$). In Bengo'o stream, the temperature varied from 23.40° C (B3, February) to 25.80) C (B3, October). The mean value is 24.52 ± 0.58° C (Table I) ($p < 0.05$). In Sounou stream, temperature values varied between 21.80° C (S2, July) and 25.20° C (S2 and S3, March). with overall average temperature of 23.52 ± 0.88° C ($p < 0.05$). In Lo'o Stream, temperatures is located between 22.10° C (L2, July) and 25.10° C (L2, March) with an overall average of 23.48 ± 0.76° C ($p < 0.05$).

Hydrogen potential (pH)

In Metyi watercourse, pH ranged from 4.30 CU (M3, April) to 7.51 CU (M1, November). The average pH value is 5.87 ± 0.76 CU. ($p<0.05$). In Bengo'o stream, the pH varied from 5.08 CU (B2, February) to 8.11 CU (B1, November) with an average of 6.34 ± 0.68 CU ($P<0.05$). In Sounou stream, pH was located between 2.29 CU (S3, December 2019) and 7.66 CU (S3, November) with an average of 5.30 ± 0.1 CU ($p<0.05$). In Lo'o watercourse, pH values fluctuated between 4.55 CU (L3, October) and 8.31 CU (L1, November). With an average of 5.63 ± 0.89 CU ($p<0.05$).

Dissolved oxygen

In Metyi stream, dissolved oxygen ranged from 8% (M2, October) to 85% (M3, February) of 53.14 ± 22.53% ($p<0.05$). In the Bengo'o stream, dissolved oxygen rates ranged from 38% (B2, November) to 90% (B1, January), with an average of 63.79 ± 14.20 % ($p<0.05$). In Sounou stream, dissolved oxygen ranged from 11% (S2, July) to 89.30% (S1, December 2018) with an average of 57.13 ± 20.74% ($p<0.05$). In Lo'o stream, the values of dissolved oxygen were situated between 15% (L3, July) to 88.90% (L1, December 2018) with an average of 61.09 ± 16.77% ($p<0.05$).

Alkalinity

In Metyi stream, alkalinity varied from 1mg/l (M1, M2, M3 in June, August, November and December 2019) to 4mg/l (M2, March and M1, October) with an average of 1.95 ± 0.84 mg/l ($p<0.05$). In Bengo stream, alkalinity values oscillated between 2 mg/l (B2 and B3, December 2018; B1, January and B1, September) and 18 mg/l (B3, April) with an average of 4.51 ± 2.63 mg/l ($p>0.05$). In Sounou stream, alkalinity data fluctuated between 1 mg/l (S1, S2, S3 August and December 2019; S1, November) to 10 mg/l (S3 April). In Lo'o stream. alkalinity oscillated between 1 mg/l (L1, August and November; L2, L3 in December 2019) and 12 mg/l (L3, April) with an average of 2.71 ± 1.89 mg/l ($p<0.05$).

Nitrates

In Metyi stream nitrates varied from 0.35 mg/L (M1, December 2019) and 4.90 mg/l (L3, February) with an average of 1.64 ± 1.05 mg/l ($p<0.05$). In Bengo stream, nitrates data fluctuated between 0.2 mg/l (B2, June) and 5 mg/l (B1, March) with a mean value of 1.55 ± 1.02 mg/l ($p<0.05$). In Sounou stream nitrate values fluctuated from 0.45 mg/l (S1, November) and 4.43 mg/l (S3, October) with a mean of 1.51 ± 098 mg/l ($p<0.05$). In Lo'o stream, nitrate values oscillated from 0.39 mg/l (L2, December) to 4.00 mg/l (L1, February) with an average of 1.34 ± 0.84 mg/l ($p<0.05$).

Oxidability

In Metyi stream, oxidiability values ranged from 0.2 mg/l (M1, M2 July; M1 August and October) to 6.6 mg/l (M3 December 2018), with an average of 1.51 ± 1.47 mg/l. ($p<0,05$). In Bengo stream, oxidiability values fluctuated from 0.0 mg/l (B1, October) to 4.15 mg/l (B2, April) with a mean of 1.1 ± 1.08 mg/l, ($p<0.05$). In Sounou stream, oxidability data ranged from 0.0 mg/l (S3, September) to 4.54 mg/l (S3, June) with an average of 1.36 ± 1.06 mg/l, ($p<0.05$). In Lo'o stream, oxidability values fluctuated from 0.0 mg/l (L1, L3 August; L1, September; L2, L3, October) to 2.37mg/l (L3, March) with a mean of 0.9 ± 0.7 mg/l. ($p<0,05$).

Table I : Minimum (Min), Maximum (Max), Mean value and Standard deviation of some environmental parameters in different streams during the study period

		Métyi	Bengo	Sounou	Lo'o	Global
Temperature (°C)	Min	22.30	23.40	21.80	22.10	21.80
	Max	25.40	25.80	25.20	25.10	25.80
	Mean	24.11	24.52	23.52	23.48	23.90
	Stand. dev.	0.77	0.58	0.89	0.76	0.87
pH (UC)	Min	4.30	5.08	2.29	4.55	2.29
	Max	7.51	8.11	7.66	8.31	8.31
	Mean	5.87	6.34	5.30	5.63	5.78
	Stand. dev.	0.76	0.68	0.99	0.89	0.91
Dissolved oxygen(%)	Min	8.00	38.00	0.00	15.00	8.00
	Max	85.00	90.00	89.30	88.90	90.00
	Mean	53.14	63.79	55.82	61.09	58.79
	Stand. dev.	22.53	14.20	22.65	16.77	19.10
TDS (mg/l)	Min	10.00	20.00	10.00	10.00	10.00
	Max	30.00	90.00	30.00	20.00	90.00
	Mean	12.18	63.85	11.28	12.56	24.97
	Stand. dev.	5.71	14.44	4.09	4.42	23.99
Alkalinity (mg/l)	Min	1.00	2.00	1.00	1.00	1.00
	Max	4.00	18.00	10.00	12.00	18.00
	Mean	1.96	4.51	2.26	2.72	2.86
	Stand. dev.	0.84	2.63	1.55	1.89	2.08
Nitrates (mg/l)	Min	0.35	0.20	0.45	0.39	0.20
	Max	4.90	5.00	4.43	4.00	5.00
	Mean	1.65	1.55	1.51	1.35	1.51
	Stand. dev.	1.05	1.02	0.99	0.85	0.98
Oxydability (mg/l)	Min	0.20	0.00	0.00	0.03	0.00
	Max	6.60	4.15	4.54	19.00	6.60
	Mean	1.52	1.11	1.37	1.71	1.23
	Stand. dev.	1.48	1.08	1.07	3.93	1.13

Organic Pollution Index (OPI)

In Metyi stream, the Organic Pollution Index varied from 2.33 (March) to 4.00 (May) for an average of 3.41 ± 0.48, ($p>0.05$). In Bengo stream, the OPI varied from 2.33 (March) to 4.33 (May) with a mean of 3.64 ± 0.6, ($p>0.05$). In Sounou stream, the IPO values ranged from 2.33 (February) to 4.00 (September) for an average of 3.46 ± 0.50, ($p>0.05$). Finally, in Lo'o stream, the OPI varied from 2.33 (February) to 4.67 (July) with a mean of 3.77 ± 0.62, ($p>0.05$). (Figure 2).

In general, the Organic Pollution Index during the whole study period varied from 2.33 to 4.67, which indicates a moderate to weak level of environmental alteration.

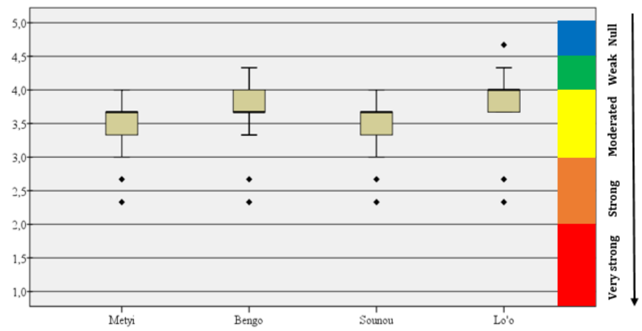

Figure 2: Spatial variation of Organic Pollution Index

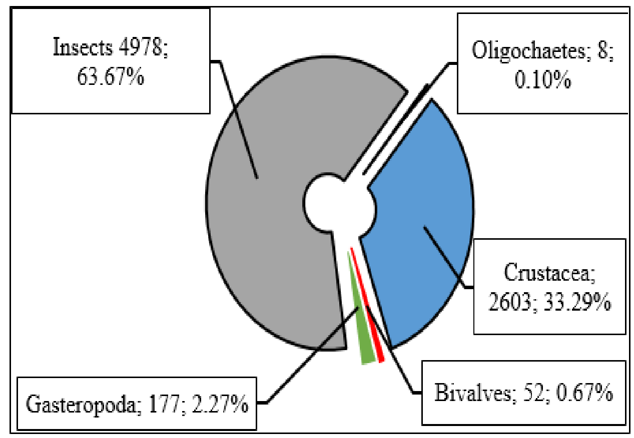

Figure 3 : Relative abundance of different class of benthic macroinvertebrates during the study period**.**

Biological variables

Global taxonomic composition

A total of 174 taxa were identified, divided into 3 phyla (Arthropods, Molluscs and Annelids), 5 classes (Crustacea, Insects, Gastropods, Bivalves and Oligochaetes), 11 orders and 62 families.

The Arthropods phylum is the most represented with 2 classes (Crustacea and Insects), 8 orders (Decapoda, Heteroptera, Coleoptera, Ephemeroptera, Plecoptera, Trichoptera, Odonata and Diptera), 55 families and 163 genera / species, followed by Molluscs with 2 classes (Gastropods and Bivalves), 2 orders (Mesogasteropods and Eulamellibranchs), 5 families and 5 genera / species and Annelids with 1 class (Oligochaete), 1 order and 2 families.

The class of Insects counts 4978 individuals (63.67% of relative abundance) and is divided into 7 orders (Heteroptera. Coleoptera. Ephemeroptera, Plecoptera, Trichoptera, Odonata and Diptera), 52 families and 159 genera / species. It is followed by the class of Crustacea with a total of 2603 individuals representing 33.29% of relative abundance. This class included 1 order (Decapoda), 3 families and 4 genera / species and in followed by the class of Gastropods with 177 individuals representing 2.26 % of relative abundance divided into 1 order (the Mesogasteropods), 3 families and 3 genera / species and the class of Bivalves and Oligochaetes with respectively 52 individuals (0.67 % of relative abundance) and 8 individuals (0.10 % of relative abundance) divided into 2 orders and 2 families. (Figure 3).

Absolute and relative abundance

Of the 7828 benthic macroinvertebrates collected throughout this study, 1313 individuals were recorded in Metyi stream corresponding to relative abundance of 16.77%, 1657 individuals in Bengo stream representating a relative abundance of 21.17%, 3185 individuals in Sounou stream equivalent to a relative abundance of 40.69% and 1673 in Lo'o stream corresponding to relative abundance of 21.37% of relative abundance (Figure 4).

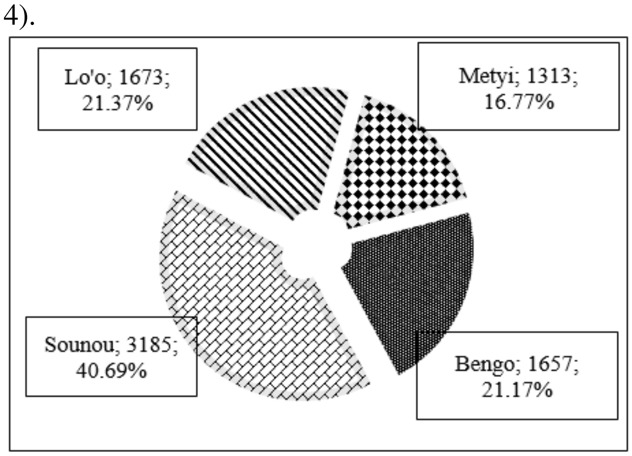

Figure 4: Relative abundance of benthic macroinvertebrates collected at each stream during study period

Temporally, February appeared as the month of higher absolute abundance of 1358 individuals representing 17.35% of relative abundance, followed by the month of July with an absolute abundance of 889 individuals corresponding to a relative abundance of 11.36 %, the months of January with an absolute abundance of 853 individuals equivalent to a relative abundance of 10.90%, December with an absolute abundance of 749 individuals representing 9.57% of relative abundance, June with an absolute abundance of 889 individuals corresponding to relative abundance of 7.45%, august with 571 individuals (7.29% of relative abundance), May with 557 individuals (7.12% of relative abundance, October with 459 individuals (5.86% of relative abundance), November with 409 individuals (5.22% of relative abundance). The months of March, April and September were characterized by the least absolute and relative abundance (Table II).

Table II : Relative abundance of benthic macroinvertebrates collected at each month during study period**.**

Month	Absolute abundance	Relative abundance (%)
December-18	444	5.67
January	853	10.90
February	1358	17.35
March	351	4.48
April	348	4.45
May	557	7.12
June	583	7.45
July	889	11.36
August	571	7.29
September	257	3.28
October	459	5.86
November	409	5.22
December-19	749	9.57
Total	7828	100.00

Principal Component Analysis (PCA)

The Principal Component Analysis (PCA) carried out on the constant, regular and ubiquitous taxa presents a factorial map with information presented on the first two dimensions (45.4%). Dimension 1 contained 28.5% information while dimension 2 contained 16.9% information. The factorial map allowed the different stations to be grouped into three large groups (I, II and III). Group I, located in the negative part of dimension 1 and the positive part of dimension 2, consisted of stations M1 and M2 of Metyi stream. Group II is located in the negative parts of dimensions 1 and 2, and consisted of stations B1, B2, B3, M3 and L3 of Bengo, Métyi and Lo'o stream respectively. Group III is located in the positive part of dimension 1 as well as in the negative and positive parts of dimension 2, and comprises stations S1, S2, S3, L1 and L2 of Sounou and Lo'o stream respectively (Figure 5).

The factorial weights of the biological variables taken into account in the assemblage defined by the PCA reveal that more than half of the organisms were correlated to the first two dimensions (1 and 2). Thus, group I, consisting of stations M1 and M2, is characterised by organisms correlated negatively on dimension 1 and positively on dimension 2. These organisms have high affinities with the predominant chemical variables in these stations. The organisms that characterising this group were : *Derallus sp., Cylindrostethus quadrivittatus, Somatochlora metallica, Sympetrum flaveolum, Sympetrum meridionale, Laccophilus sp., Naucoris sp., Gerrisella setembrinoi, Gerris sp.* (Figure 5).

Group II consisted of stations B1, B2, B3, M3 and L3, included organisms that were negatively correlated on dimensions 1 and 2. These organisms had favourables conditions for their development. The characteristic organisms of this group are : *Orectogyrys sp, Hydrometra carayoni, Hynesionnella omer-cooperi.*

Group III consisted of stations S1, S2, S3, L1 and L2 and included organisms that are positively correlated on both dimensions (1 and 2) with the exception of 3 organisms that are positively correlated on dimension 1 but negatively correlated on dimension 2. The organisms that thrive in the conditions offered by the stations of this group III were *Sympetrum depressiusculum, Tenagogonus* *albovittatus, Adenophlebia sp., Macromia splendens, Calopteryx splendens, Calopteryx haemorrhoidalis, Thraulus bellus, Orthetrum brunneum, Sudanaute aubryi, Sudanaute africanus, Caridina africana, Macrobrachium sp., Rhagovelia sp., Liebellula quadrimaculata* (Figure 5).

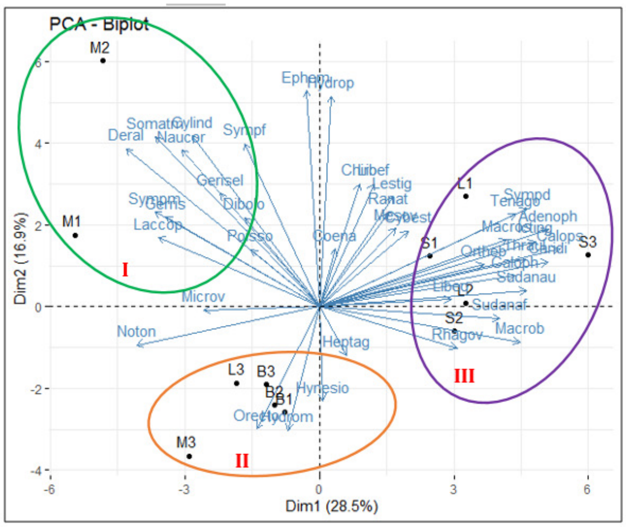

Figure 5: Principal Components Analysis (PCA) of physicochemical parameters during the study period

Biocenotic index

The values of Shannon & Weaver index vary from 3.29 bits/ind in Sounou stream to 4.48 bits/ind in Lo'o stream with an average of 4.12 ± 0.56 bits/ind. Metyi and Bengo streams have Shannon & Weaver Index values of 4.24 bits/ind and 4.47 bits/ind respectively. The Kruskal Wallis test shows no significant difference between these values ($p = 0.39$).

The equitability of Piélou has values varying from 0.50 bits/ind in Sounou stream to 0.68 bits/ind in Metyi and Bengo streams, with an average of 0.63 ± 0.08 bits/ind. The Kruskal Wallis test shows no significant difference between the values of Piélou ($p = 0.39$).

The values of Simpson's dominance index, fluctuate from 0.73 bits/ind in Sounou stream to 0.90 bits/ind in Bengo and Lo'o streams with an average of 0.85 ± 0.08 bits/ind. The Kruskal Wallis test shows no significant difference between the Simpson index values ($p = 0.39$).

The specific richness ranges from 74 taxa in Metyi stream to 107 taxa in Lo'o stream, for a mean of 93.0 ± 13.83 taxa (Table III).

Table III : Some biocenotic index evaluated in different streams during the study period.

	Shannon et Weaver (H')	Piélou (J)	Simpson	Log2 (S)	Abundance	specific Richness (S)
Métyi (M)	4.24	0.68	0.88	6.21	1313	74
Bengo (B)	4.47	0.68	0.90	6.55	1657	94
Sounou (S)	3.29	0.50	0.73	6.60	3185	97
Lo'o (L)	4.48	0.66	0.90	6.74	1673	107

Normalised Global Biological Index (NGBI)

The Normalised Global Biological Index has very high values in the studied rivers. The results of the calculations are shown in the table below. In general, the IBGN shows a very good water quality in the different studied stream (Table IV).

Table IV: Normalised Global Biological Index values in different streams during study period

Streams	Metyi	Bengo	Sounou	Lo'o	Global
Variety class	14	14	14	14	14
Indicator group (GI)	5	7	7	7	7
IBGN	18	20	20	20	20
Quality	Very good	Very good	Very good	Very good	Very good

Discussion

Physicochemical parameters

The temperature of the streams varies very little overall (21.80°C - 25.8°C). The low values recorded in the different streams could be explained by the vegetation cover of the different sampling stations. This temperature is similar to the one of the forest streams of Mabounié basin (20°C- 27°C) in Gabon [18]the Abouda, Nga, Fam and Nkoumou streams (20.2°C- 23.9°C) [3], the Ndog Bissolo stream (24°C - 26.3°C) [21] and the Mbeme stream (20.5°C - 24°C) [33]. The significance of the Kruskal Wallis test ($p<0.05$) would be due to the time of sampling that was spread over the whole day. In this sense. [16]revealed that there is a linear relationship between water temperature and air

temperature. [29] conformed that the main source of heat in a forest stream is solar energy.
The slightly acidic average pH (5.78 ± 0.91 CU) of the waters in this region is close to the pH of the forest streams in Mabounié basin (6.25 ± 0.62 CU) in Gabon [18] and Nga, Abouda, Fam. and Nkoumou streams (5.37UC- 7.72 CU) [3]. This slight acidity of the waters would be due to humic acids in the absence of anthropic activities in the basin [18].
For the oxygen saturation rate the waters in this basin are less well oxygenated overall (58.79 ± 19.10%). This low oxygenation of the waters could be explained by the low speed of the water, but also by the fishing activities carried out by the populations in the different rivers, by creating fishing weirs along the watercourse which modify strongly the speed as well as the flow of the water, being able to entail their stagnation. The low oxygenation of the waters in this basin contrasts with the oxygen saturation values of Mabounié basin (80.44±10.01%) in Gabon [18].
The low alkalinity values (2.86 ± 2.08 mg/l) of the different streams are attributable to the low mineralization and low acidity of the water. These values are closed to those obtained in the Nga, Abouda, Fam and Nkoumou stream (2 - 24.1mg/l) [3]. [17] ;[25] noted that variations in water alkalinity are closely related to the degree of mineralization and oxidation of organic compounds.
The low nitrate values (1.5 ± 0.98) recorded in the different streams of the Mvila department would be related to the low mineralization of the organic matter present.

Biological parameters

The qualitative analysis of the biological data of the streams shows a high taxonomic richness defined by 174 taxa divided into 3 phyla. 5 classes. 11 orders and 62 families. This taxonomic richness is nevertheless low compared to the taxonomic richness collected in Mabounié basin (202 taxa) in Gabon by [18] it is closed to that observed by [12] (197 taxa) in some peri-urban streams of the city of Yaoundé, but higher than that obtained in Nguitto and Pala streams (114 taxa) in Central African Republic [22]. The taxonomic richness obtained in different streams could be explained by the nature of the substrate and the low water flow velocity. In fact, the high flow velocity can cause the drift on benthic macoinvertebrates. Whereas the low velocity hinder renewal of oxygen in the water and therefore the installation of certain polluo-sensitive groups. These observations were also made by [11], who emphasized that local factors (flow rate, bed width, water flow velocity, etc.) would be related to the assembly of fluvial forms in the channel, which also influences the macroinvertebrate community.
The high abundance of the class of insect with 63.67% recorded in this sudy is comparable to those collected in Kalengo River in DRC with 62.5% insects [20] and Agneby in Ivory Coast with 68% [8]. This predominance of insects could be explained by their genetic plasticity, cosmopolitanism and ability to colonize diverse ecological niches and translate the low degradation of study milieu [5] ; [14] and [24]. The high proportions of crustaceans (33.29%) in the streams is close to those observed in Ndog Bissono stream (55.60%) by [21]. This high relative abundance of crustaceans is linked to satisfactory oxygenation and abundance of litter that serves as refuge [32].
The benthic macroinvertebrates are most abundant in Sounou stream (40.69%), followed by Lo'o stream (21.37%) Bengo stream (21.17%) and Metyi stream (16.77%). The predominance of decapod crsutaceans in Sounou stream cab explained by the low water column coupled with a very abundant litter, that favour their multiplication.
However, the high diversity of macroinvertebrates recorded in Lo'o stream (107 taxa) reflects an environment that has been little disturbed by human activity. These remarks had already been made by [1] who noted that a less altered environment or one with little anthropic pressure favours the installation of benthic macrofauna.

Biocenotic Index

The values of the Shannon & Weaver index (3.29 bit/ind) and the Piélou equitability (0.50 bit/ind) recorded in Sounou stream reflect a low diversity of macroinvertebrates with a weak predominance of one group (Decapods). This leads to an imbalance in the macroinvertebrate population. In contrast, Metyi, Bengo and Lo'o streams. which have Shannon & Weaver index values much closer to Log2(S) values. show sufficiently high diversity and equitable distribution of organisms. Similar observations allowed Fisher et al. 1982 to emphasize that an high index of diversity creates the conditions of the environment that allow the installation and the maintenance of a balanced biological community, integrated and capable of adapting.

The organic pollution index shows that the watercourses studied as a whole were only slightly affected by human activities and were therefore of good ecological quality.

The Principal Component Analysis divided the benthic macroinvertebrates into three groups according to their affinities and their sensitivity to environmental components. To this end, the species of group III (*Sympetrum depressiusculum, Tenagogonus albovittatus, Adenophlebia sp., Macromia splendens, Calopteryx splendens, Calopteryx haemorrhoidalis, Thraulus bellus, Orthetrum brunneum, Sudanaute aubryi, Sudanaute africanus, Caridina africana, Macrobrachium sp., Rhagovelia sp., Liebellula quadrimaculata*), which included stations B1, B2, B3, L3,M3 ; S1, S2, S3, L1, L2, respectively whose waters are only slightly affected, could be considered as indicator taxa of good ecological quality of the watercourse. In the same way, the taxa in group II (*Orectogyrys sp, Hydrometra carayoni, Hynesionnella omer-cooperi.*) could be considered as indicators of good ecological quality of the watercourse. Furthermore, the species as group II and III could integrate polluosensitive taxa.

IV. CONCLUSION

At the end of this work, a characterization of the waters of some forest streams in Mvila department was established. Thus, it emerges that in this locality, the waters are low temperatures due to the canopy, slightly acidic overall with a slightly low oxygen saturation due to fishing activities. The organic matter is weakly mineralized as reflected in the low values of nitrates and alkalinity. Biologically, the taxonomic richness has been evaluated at 174 taxa divided into 3 phyla, 5 classes, 11 orders and more than 62 families. The organisms thus collected are dominated by insects which represent 63.67% of relative abundance, followed by crustaceans with 33.29% of relative abundance. The diversity index of Shannon & Weaver, the Equitability index of Piélou and the index of Simpson show a diversity of macroinvertebrates with a tendency to equipartition of the individuals in the most studied stream. At the end of these study, we can say that forest stream of the South region notably the department of Mvila, are of good ecological quality.

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