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(Research Article)

Physicochemical characterization of the waters of the Lep'oo river in Mbanda (Bot-Makak) and structuring of the benthic macroinvertebrate community

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Abstract

A study on the characterisation of the Lep'oo stream waters in Mbanda (BotMakak) by physicochemical parameters and benthic macroinvertebrates community was conducted from February to July 2016. Physicochemical parameters were measured according to Rodier's recommendations, while benthic macroinvertebrates were collected using the multihabitat approach. The physicochemical analysis showed that the waters of the Lep'oo stream were well oxygenated (71.16%), slightly acidic (6.36 UC), with low values of nitrogen and orthophosphates reflecting litter decomposition. A total of 2019 benthic macroinvertebrates were collected, divided into 4 phyla, 7 classes, 15 orders, 40 families and over 60 genera. The phylum Arthropoda was the most abundant with 98.61% relative abundance, followed by Molluscs (0.99%) and Annelids (0.29%). The greatest number of organisms collected belonged to the class Hexapoda, which represented 56.76% of relative abundance, followed by Malacostraca (41.75%). Within the Hexapoda class, the order Hemiptera predominated with 18.22% relative abundance and in the Malacostraca class, the order Decapoda predominated with 41.75% relative abundance. These two orders were dominated by the families Atyidae, Libellulidae, Gerridae, Leptophlebidae and Hydroptilidea. In the upper part of the Lep'oo stream, the families Libellulidae and Belostomatidae were dominant. The station Lep2 was most colonised by the families Atyidae, Libellulidae, Belostomatidae, Hydrometridae, and Gerridae, while station Lep3 was dominated by the families Atyidae, Hydroptilidae and Leptophlebidae. The Shannon and Weaver (H') and Piélou equitability (J) index showed a greater diversity of taxa downstream of the stream at station Lep3, where conditions seem more favourable to the development of benthic macroinvertebrates as indicated by the physicochemical results. The NGBI index characterized water quality from mediocre to excellent. Finaly, the Lep'oo watercourse had a poor and diversified population of benthic macroinvertebrates, showing a relative good ecological quality of water.

Keywords: Benthic macroinvertebrates; Lep’oo; Forest streams; Djouel River; Mbanda

1. Introduction

Humanitarian water needs are multiple and occur in various sectors (26). However, extensive anthropogenic activities cause considerable production of solid and liquid waste that degrade water quality (39). However, rivers are probably the most vulnerable aquatic ecosystems on the planet due to the multiple threats they face (4).

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In Africa in general and in Cameroon in particular, the increasing of anthropogenic activities and the use of water bodies as a receptacle for waste have deeply disturbed lotic environments. This degradation is more accentuated in urban areas, particularly in the cities of Yaounde and Douala where numerous studies focusing on benthic macroinvertebrates have been carried out (36). It is therefore imperative to direct studies towards forest watercourses with a can be called 'natural' character in order to obtain reference data that will enable us to develop a Cameroonian bioindication matrix.

Among biological communitie, benthic macroinvertebrates are increasingly used to assess the overall health of aquatic ecosystems (18; 5). They are organisms without a bony skeleton, visible to eyes, such as molluscs, crustaceans, insects, and worms that inhabit the bottom of rivers and lakes. They are known to be good indicators of the health of aquatic ecosystems due to their sedentary nature, varieting life cycle, high diversity and variable tolerance to pollution and habitat degradation (25).

In Cameroon, some studies on benthic macroinvertebrates communitie has been carried out on the Mefou (15), the Nga (16), the Tongo'a-Bassa and the Mgoua (36), the Abouda (6). However, very little data is available on forest streams.

In order to contribute to the knowledge of the structure of benthic macroinvertebrates in forest streams, the general objective of this study was to analize the benthic macroinvertebrates population of the Lep'oo stream, a tributary of the Djouel River in Mbanda.

More specifically, the aim was to measure the abiotic parameters of the watercourse, to identifiy and count the various macroinvertebrate taxa in the watercourse, to assess the impact of environmental factors on the dynamics of the macroinvertebrates population and to deduce the state of ecological health of this watercourse.

2. Material and methods

2.1. Sampling period and description of the study site

The first phase, from December 2015 to January 2016, consisted of a survey of the site in order to gain a better understanding of the watershed, and the choice of sampling stations, according, to it accessibility and representativeness. The second phase, carried out from February to July 2016, was devoted to the measurement of abiotic parameters and the sampling of benthic macroinvertebrates at a monthly frequency.

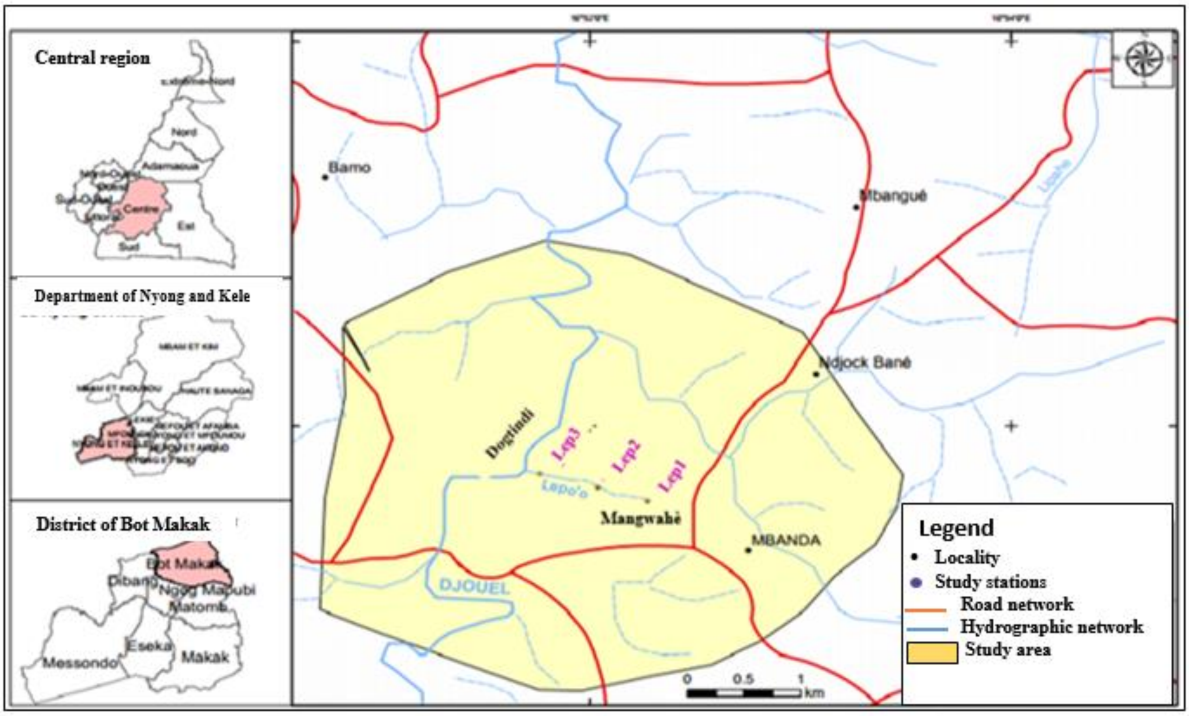


Figure 1 Hydrographic map of the Lep'oo catchment area (Source: INC, from the Ndikinimeki 1/200000 topographic base; 2017, modified)

The Lep'oo stream is about 5.5 km length and starts its spring in the village of Mangwahè, crosses the village of Mbanda before flowing into the Djouel river in the village of Dogtindi, before flowing in the Sanaga river. Its spring is limnocrene. Three sampling stations (Lep1, Lep2 and Lep3) were chosen in this watercourse (Figure 1).

The station Lep1 (Figure 2A) has the geographical coordinates 04°01'.557'' N and 010°51'.361'' E and is located at an altitude of 364 m and approximately 100 m from the spring. The riparian vegetation consists of ferns (*Filicophyta*), cocoa trees (*Theobroma cacao*) and large trees forming a canopy and preventing light penetration in the water.

The station Lep2 (Figure 2B), with geographical coordinates 04°01'.602'' N and 010°51'.213'' E and an altitude of 355 m, is located about 2.5 km from the spring, a short distance from the bridge in the village of Logsen, close to houses and fields. The banks are littered with oil palm (*Elaeis guineensis*) and banana (Musa) trees. Downstream of this station, some anthropic activities are carried out by the riparian population such as washing clothes, dishes and bathing.

The station Lep3 (Figure 2C) is located about 5 km from the spring and 400 m from the confluence with the Djouel River in the village of Dog-tindi. Its geographical coordinates are 04°01′.600′′ N, and 010°51′.747′′ E and it is 338 m above sea level. The width of the bed varies in places. The flow is quite high and has weirs and wets. The banks are dotted with trees uprooted by the winds and the force of the water is made more aggressive by the input of the Djouel stream (backwater).

Figure 2 Partial view of the sampling stations on the Lep'oo stream A(Lep1), B(Lep2), C(Lep3) Scale: 1/12

3. Measurement of hydrological and physicochemical parameters

For the hydrological parameters, the velocity was measured in the field using the indirect polystyrene method and the flow rate was calculated using the formula:

$$Q = VS \text{ with } Q \text{ in } m^3/s; V \text{ in } m/s \text{ and } S \text{ in } m^2.$$

Physicochemical analysis was carried out both in the field and in the laboratory of Hydrobiology and Environment following the recommendations of (3) and (31).

Water temperature, hydrogen potential and dissolved oxygen were respectively measured using a HANNA multimeter model HI 991301 and a HANNA oxymeter model HI 9829.

Nitrates, nitrites, Ammoniacal Nitrogen and phosphates were measured in the laboratory by colorimetry with a HACH DR/3900 spectrophotometer.

4. Collection and identification of benthic macroinvertebrates

The benthic macroinvertebrates were collected using a 30 cm square net with a conical net of 400 µm mesh opening and 50 cm depth. Sampling was carried out following the multihabitat approach proposed by (34). At each station, about 20 haul outs were carried out in different microhabitats for an area of about 3 m^2. The organisms retained by the net were then collected with a pair of fine tweezers, fixed in 10% formalin and preserved in pillboxes. On return to the laboratory, the samples were rinsed with running water, preserved in 70° alcohol and identified using the identification keys of Levêque and Durand (10)*.* Tachet *et al.* (35), Stals and de Moor (33).

5. Statistical analysis and biocenotics index

The Kruskal-Wallis test allowed us to see if the results obtained vary significantly along the river and from one month to another and the Mann Whitney U test the stations two by two. These two tests were carried out using PAST 3.14 software as well as Spearman's rank correlation coefficient, relating physicochemical variables to each other and then to physicochemical and biological variables.

Principal Component Analysis (PCA) was used to establish the links between physicochemical and biological variables, and Sörensen's similarity coefficient to establish the degree of similarity or dissimilarity of MIB populations between the different stations.

The Shannon-Weaver index (17) was used to characterise the equilibrium of the population and the Piélou equitability index to assess the equi-repartition of taxa independently of the specific richness.

The Ephemeroptera, Plecoptera and Trichoptera (EPT) index was used to measure the taxonomic richness of organisms sensitive to pollution (30) and to habitat modification (24). The ratio of EPT density to Chironomid density establishes abundance relationships between the two groups.

6. Results

6.1. Physicochemical parameters

6.1.1. Temperature

During the study period, water temperature varied from 23.2 °C (July, Lep2) to 27.7 °C (March, Lep2) (Figure 3A), with a thermal amplitude of 4.5. The Kruskal-Wallis test revealed significant variations in temperature between months ($p < 0.05$).

6.1.2. pH

The pH values varied between 5.02 CU (April, Lep1) and 8.34 CU (February, Lep3). A relatively decreasing progression from the source to the outlet can be seen (Figure 3B). The Kruskal-Wallis test showed no significant difference between stations and months ($p > 0.05$).

6.1.3. Dissolved Oxygen and Oxidability

The maximum dissolved oxygen saturation (Figure 3C) was obtained in March (96%) at Lep2 and Lep3, and the minimum in May (54%) at Lep1. The percentage of oxygen saturation fluctuated around an average value of 71.76%, indicating fairly good oxygenation of the water. The maximum value of oxidizability (Figure 3D) was obtained in the month of February for a value of 2.17 mg/L at station Lep1 and the minimum value in July with 0.03 mg/L at station Lep3. However, no significant difference was observed for these two parameters during the study period ($p>0.05$).

6.1.4. Nitrates, Nitrites, Ammoniacal Nitrogen and Orthophosphates

The maximum levels of Nitrates and Nitrites (Figure 3E and 3F) were respectively 12.2 mg/L and 4.2 mg/L in the month of April at the station Lep3, the minimum values being respectively 0.02 mg/L in the month of March at the stations Lep2 and Lep3 and 0 mg/L in the month of July at the stations Lep1 and Lep2.

The maximum Orthophosphate content (Figure 3G) was 3.6 mg/L in April at the station Lep3 and the minimum value is 0.01 mg/L in June at the station Lep3.

The maximum value of ammoniacal nitrogen (Figure 3H) was 2.85 mg/L in April at station Lep3, and the minimum value of 0 mg/L in July at the stations Lep1 and Lep2.

Nitrate, Nitrite and Orthophosphate levels do not vary significantly along the river ($p> 0.05$), but rather from month to month ($p< 0.05$). For Ammoniacal Nitrogen, the levels show no significant difference between stations and months ($p> 0.05$)

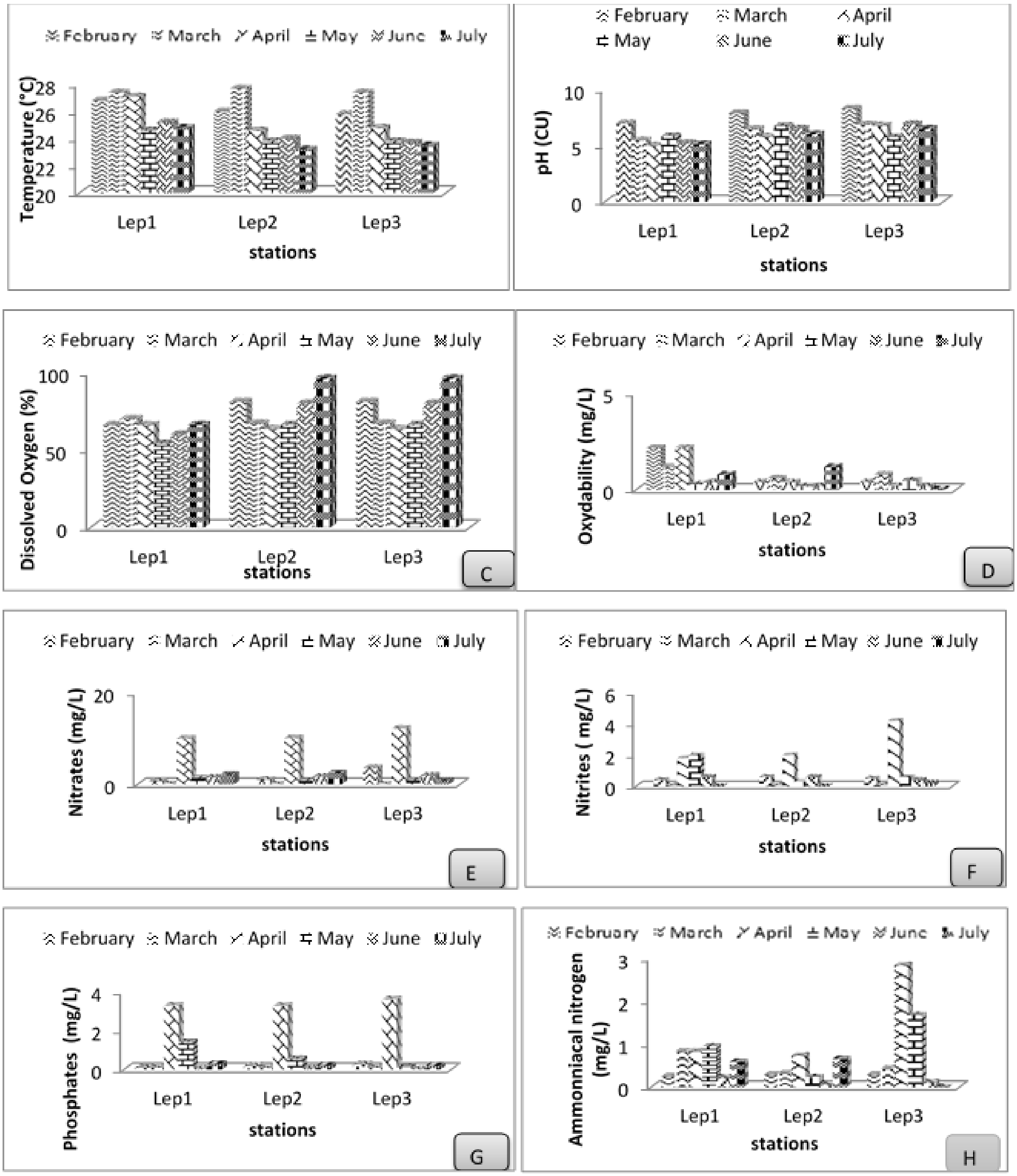


Figure 3 Spatial and temporal variation of Temperature (A), pH (B), Dissolved Oxygen (C), Oxidizability (D), Nitrates (E), Nitrites (F), Orthophosphates (G) and Ammoniacal Nitrogen (H) in the Lep'oo stream during the study period.

6.2. Abundance and taxonomic richness

A total of 2019 individuals, 4 phyla, 7 classes, 15 orders and 40 families were counted, the phylum Arthropoda (98.612%) being the most represented, followed by Molluscs (0.992%) and Nemathelminthes (0.099%).

Of the 40 families identified, 7 belonged to the order of Hemiptera, 7 to the order of Odonata, 5 to the order of Coleoptera, 4 to the order of Ephemeroptera, 3 to the order of Trichoptera, 3 to the order of Decapoda, 2 in the order of Diptera and Haplotoxidea and the remaining 7 orders (Gordiaceae, Rhynchobdellidae, Basommatophores, Eulamellibranchs, Dictyoptera, Lepidoptera and Plecoptera) represented by only one family (Figure 5).

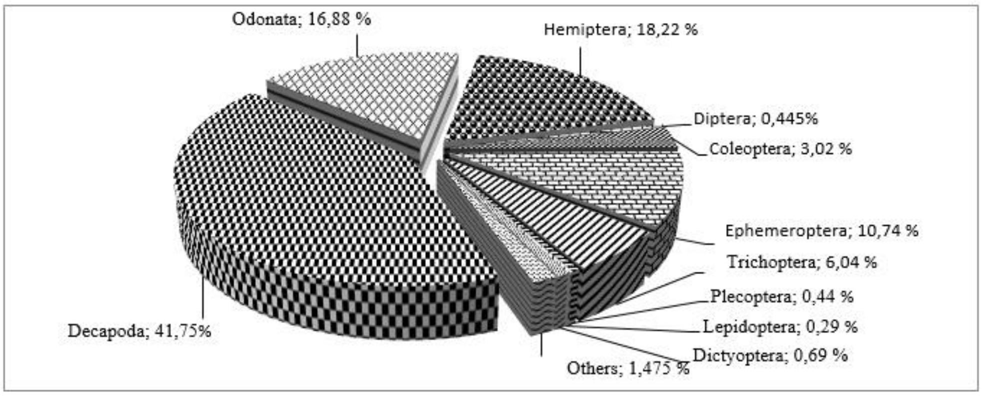


Figure 4 Relative abundance of MIB orders in the river Lep'oo during the study period

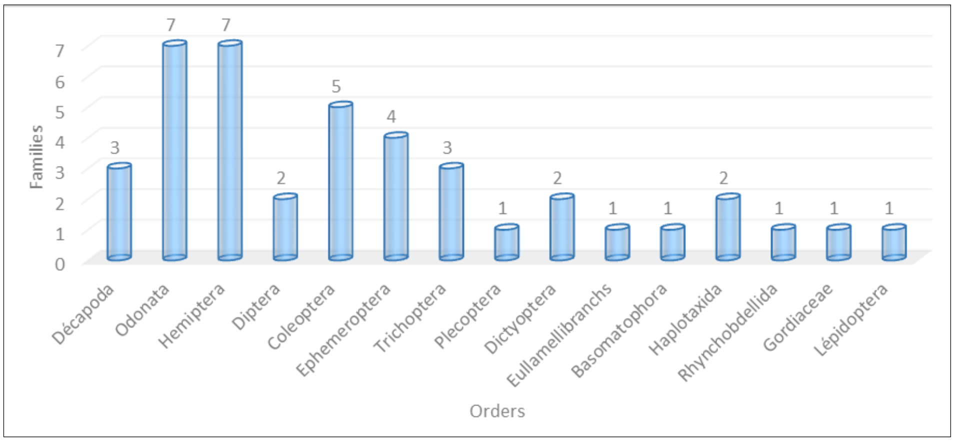


Figure 5 Order richness of MIBs in the river Lep'oo during the study period

6.3. Spatial and temporal variation in the abundance of benthic macroinvertebrates

The profile of the total abundance of benthic macroinvertebrates collected in the Lep'oo watercourse during the study period showed the respective values of 293 organisms in the up stream (Crenon) (Lep1) for a relative abundance of 14.51%, 550 organisms in the midle stream (Rhithron) (Lep2) for a relative abundance of 27.24% and 1176 organisms in the down stream (Potamon) (Lep3) for a relative abundance of 58.24% (Figure 6A).

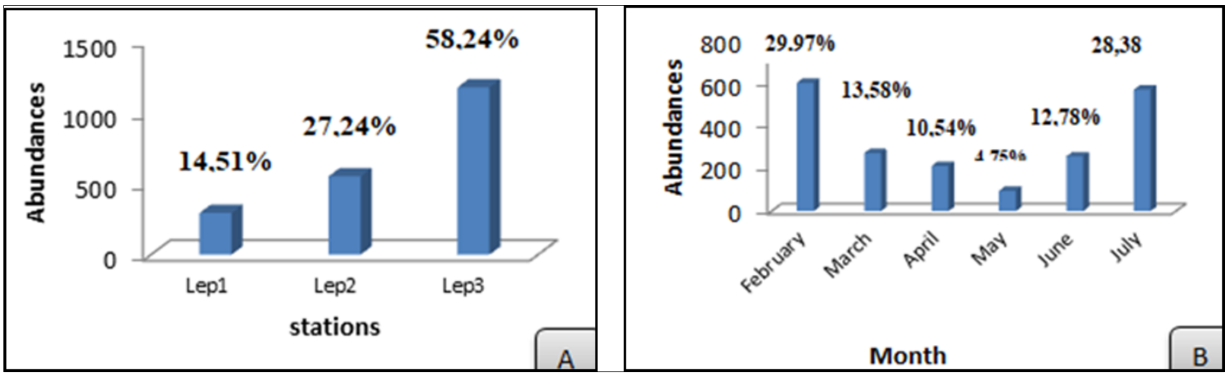


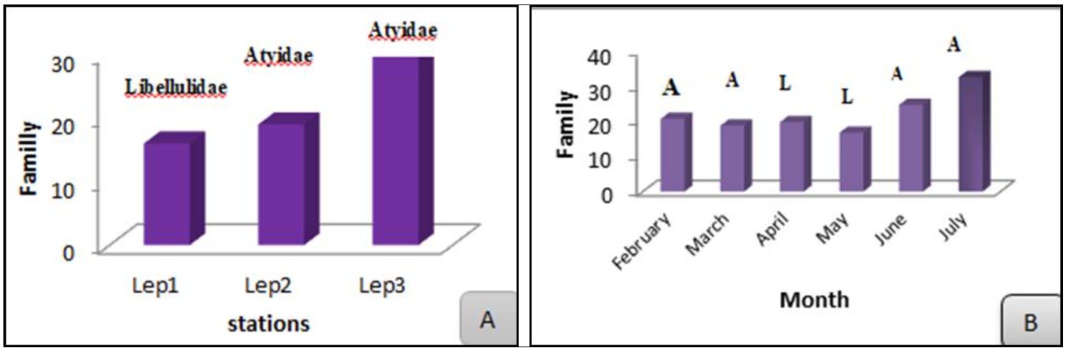
Figure 6 Spatial (A) and temporal (B) variations in total and relative abundance of MIBs in the river Lep'oo during the study period

Temporally, the abundances of benthic macroinvertebrates show an irregular evolution with a maximum of 605 organisms, i.e. 29.97% relative abundance, and 573 organisms, i.e. 28.38% relative abundance, in February and July respectively, and a minimum of 96 organisms, i.e. 4.75% relative abundance, in May, with an average of 336.5 ± 83.90 organisms (Figure 6B). However, no significant difference was observed between values along the river and between months ($p > 0.05$).

6.4. Spatial and temporal variation in taxonomic richness

Of the 40 macroinvertebrate families counted, 11 were common to all the three stations (Figure 7A). The number of families varied from 16 at station Lep1, to 19 and 30 respectively at stations Lep2 and Lep3, with relative abundances of 40%, 47.5% and 75% respectively. The family of Atyidae predominates with a relative abundance of 40.71%, followed by the family of Libellulidae (11.78%), and the family of Gerridae (8.37%). The family of Tipulidae is reduced to a relative abundance of 0.049 % represented by a single organism.

Temporally, the number of families fluctuated from 17 in May with a relative abundance of 42.5% to 33 in July with a relative abundance of 82.5% (Figure 7B). However, no significant differences were noted along the river and during the study period ($p>0.05$).



A = Atyidae L = Libellulidae

Figure 7 Spatial (A) and temporal (B) variation of number of families in Lep'oo stream during the study period

6.5. Shannon and Weaver index and Piélou equitability

The variation of the Shannon and Weaver diversity index spatially showed that the diversity of the benthic macroinvertebrates was relatively high along the Lep'oo river, with values of 2.22 bits/inds, 2.78 bits/inds, and 3.12 bits/inds respectively at stations Lep1, Lep2, and Lep3 (Figure 8A). Temporally, this index showed that the months of April, May, June, and July had similar high diversity, with values of 3.67 bits/inds, 3.38 bits/inds, 3.6 bits/inds, and 3.78 bits/inds respectively.

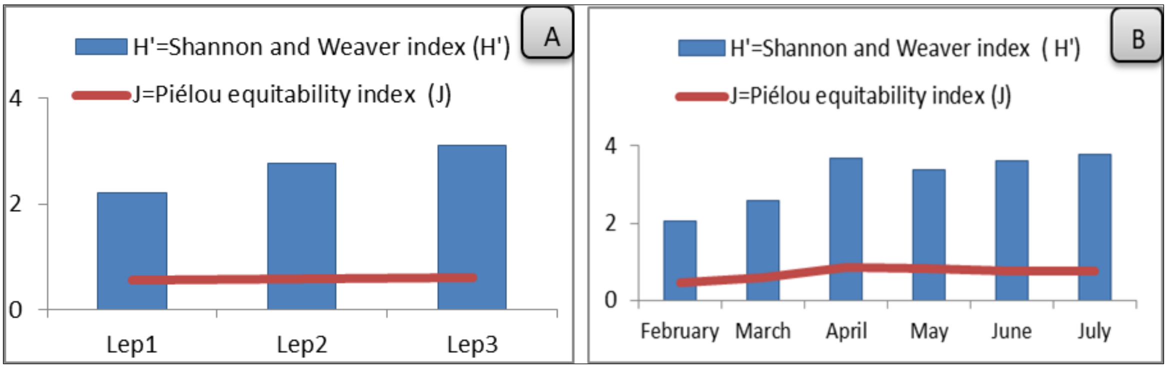


Figure 8 Spatial (A) and temporal (B) variations of the Shannon and Weaver index and the Piélou equitability index

Spatially, the Piélou equitability index varied between 0.55 (Lep1) and 0.6 (Lep3), reflecting an equi-partition of individuals within the different families (Figure 8A). On the other hand, this index varied between 0.46 (February) and 0.84 (April), reflecting a poor distribution of families during the study period (Figure 8B).

6.6. Sörensen similarity index

The determination of Sörensen's similarity index showed a high faunal similarity between stations Lep2 and Lep3 (68.85%) compared to 61.90% between stations Lep1 and Lep2, and 58.82% between stations Lep1 and Lep3 (Table 1).

Table 1 Sörensen's similarity index values between the different stations in the river Lep'oo

Stations	Lep1 et Lep2	Lep1 et Lep3	Lep2 et Lep3
Sörensen's similarity index (%)	61.90	58.82	68.85

6.7. Normalized Global Biological Index (NGBI)

The calculation of the Normalized Global Biological Index at the stations Lep1, Lep2 and Lep3 gave respectively the values 6, 7 and 17 revealing the poor quality of waters at the stations Lep1 and Lep2, compared to the excellent quality of waters (station Lep3) (Table 2).

Table 2 NGBI values and interpretation

Stations	Lep1	Lep2	Lep3
Diversity	16	19	30
Group indicator	2	2	9
IBGN Value	6	7	17
Water quality	mediocre	mediocre	Excellent

The determination of the EPT index at the different stations gives values of 0 at station Lep1, 2 for Lep2 at 8 for Lep3 for an overall average of 3.33 ± 2.40. The EPTD index, applied to the different stations, reveals a variation of 0 for Lep1, 4 for Lep2 and 11 for Lep3. Overall, it could be seen that this index increases from upstream to downstream of the watercourse.

6.8. Principal Component Analysis (PCA)

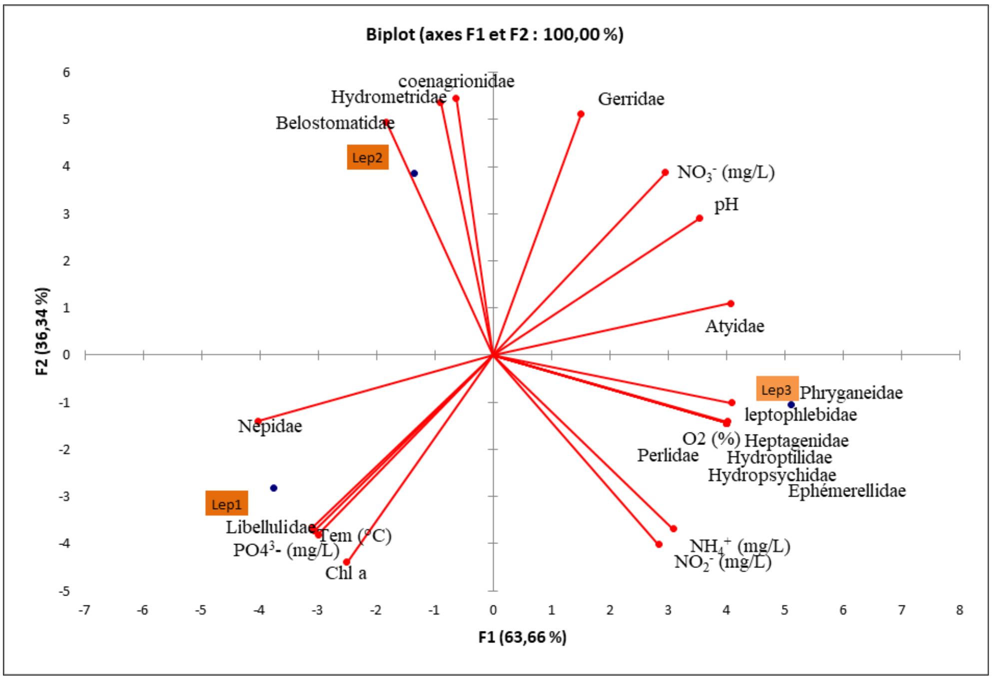


Figure 9 PCA values grouping affinities between benthic macroinvertebrates families and physicochemical parameters

The principal correspondence analysis (Figure 12) showed three affinity nuclei.

Core 1, which was organized around the Lep1 station, grouped together the Libellulidae and Nepidae, which prefer calm waters with relatively high temperatures.

Core 2, which was formed around station Lep2, with a strong affinity between the Belostomatidae, Hydrometridae and Coenagrionidae that characterise this station.

Finally, at the Lep3 station, there was a predominance of pollutant-sensitive taxa (Atyidae, Ephemerellidae, Hydropsychidae, Hydroptilidae, Leptophlebidae, and Perlidae). The high oxygenation that characterises the very little anthtropised level of this station thus favours the good development of polluosensitive organisms.

7. Discussion

7.1. Physicochemical parameters

The variation of the water temperature of the Lep'oo stream is closely related to the variation of the ambient temperature. The low temperature variation is due to the large trees forming a canopy that limits the penetration of solar radiation and keeps the water temperature almost constant (29). Furthermore, the small fluctuations in water temperature in Lep'oo are similar to the results obtained in the Nga (16) on and Djobo (23).

The waters of the Lep'oo stream are slightly acidic, this acidity may be due to the nature of the substrate as according to Segalen (33), the ferralitic soils of the Central region are acidic. However, the slight increase in pH could be explained by high mineralising activity.

The waters of the Lep'oo stream show satisfactory oxygenation according to the water quality assessment grid proposed by Nisbet and Verneaux (27). The good oxygenation of the water can be explained by the presence of tree trunks that litter the bed of the watercourse, forming obstacles that favour mixing and consequently the enrichment of the water in oxygen. These results corroborate the assertions of Devidal *et al.* (9) that in forested areas, natural ventilation, presence of riffles and meanders create conditions of turbulence and mechanical mixing favourable to natural water aeration. However, the drop in values in May observed at the Lep1 station could be explained by the significant mineralising activity of the microorganisms.

The high value of oxidability at station Lep1 could be the result of the strong decomposition of dead leaves and allochthonous inputs. Indeed, this station is located near the spring where the populations get their water. According to Power and Dietrich (28), forest streams are dependent on regular allochthonous inputs containing largely leaf litter from riparian vegetation, increasing the organic matter and consequently the oxidability.

The relatively high concentrations of ammoniacal nitrogen could be the result of incomplete degradation of the abundant organic matter on the stream bed. This result is similar to that obtained in the Konglo station by Dzavi (11) and in the Mbeme station at Mbalmayo by Tchouapi (37).

The low level of nitrates is explained by the fact that organic matter accumulates on the bed of the watercourse and degrades very little. The low level of orthophosphates is due to the low anthropogenic character of the Lep'oo watercourse. The maximum values of nitrates (April, Lep1, Lep2, Lep3) and orthophosphates (April, Lep1 and Lep3 and March, Lep2) could be attributable to runoffs. Indeed, in unpolluted natural water, nitrate levels are highly variable depending on the season and the origin of the water, these results are similar to that obtained by Mbohou (23) in the Djobo stream.

The low nitrite values (0-0.8 mg/L) result from incomplete oxidation of ammoniacal nitrogen, or partial denitrification of nitrates (22), high oxygen saturation of the water as nitrites are only maintained in flowing water if the environment is not sufficiently oxygenated (20). Moreover, the increase in levels from upstream to downstream is the result of the mineralisation of litter (branches, dead leaves) which accumulates progressively and therefore great time the residence downstream (19).

The low nitrate levels can be explained by the low degradation of the organic matter in the water. The low levels of orthophosphates would depend on the low anthropogenic character of the water.

The relatively high levels of ammoniacal nitrogen could be the result of incomplete degradation of organic matter. This result is similar to that obtained by Dzavi (11) in the Konglo stream at Mbalmayo. In this regard, Afonso (2) points out that the high ammoniacal nitrogen content is linked to a large organic load whose degradation generates nitrogen compounds.

7.2. Benthic macroinvertebrates

Concerning the abundance of the different orders, our results are similar to those obtained by Tombou (38) in Matouou stream in Makak. The taxonomic richness observed in the Lep'oo stream shows the predominance of Insects (56.71%), which would reflect little anthropized and good quality of the water. According to Tachet *et al.* (35) and Moisan, and Pelletier (24), most aquatic insects are very sensitive to pollution and/or habitat modification and are therefore the first to disappear in a disturbed environment.

Furthermore, the very low abundance of Molluscs and Annelids (1.04%) would indicate the beginning of pollution of the aqueous support, due to the presence of tree branches and decomposing leaves. Indeed, Tachet *et al.* (35) and Moisson and Pelletier (24) emphasise that in polluted hydrosystems, the benthic macrofauna is largely dominated by saprophilic and saprobiontic taxa such as Chironomids, Hydrobiids, Physids and Tubificids. Moreover, the predominance of Atyidae decapods is attributed to the very good oxygenation of the waters of Lep'oo, because according to FOGEM (13). Tachet *et al.* (35), freshwater decapod crustaceans proliferate in well-oxygenated environments and are very sensitive to a drop in dissolved oxygen content in the water. These results corroborate those observed by Foto *et al.* (16) in the Nga stream and by Mbohou (23) on the Djobo stream. Furthermore, the total absence of Decapods at the Lep1 station would be due to the low dissolved oxygen levels, coupled by the high organic matter loads illustrated by the high oxidability values. Similarly, Ephemeroptera, which are the faunal group most sensitive to pollution (24), are also well represented, particularly at the Lep2 and Lep3 stations, confirming the good ecological quality of the water at these stations as well as the low anthropogenic character of the Lep'oo catchment. In addition, the high abondance of Plecoptera and Trichoptera, which are known to be pollutant-sensitive, downstream at station Lep3, coupled with the remarkable development of Decapoda Atyidae and Dictyoptera Blaberidae, attests very good ecological quality of the waters at this station and at the same time confers on Decapoda Atyidae and Dictyoptera Blaberidae the status of pollutant-sensitive taxa. Spatially, the abundance of benthic macroinvertebrates is increasing. The highest abundance was found at the third station (1176 ind.) due to its multihabitat character (sand, clay, boulders). The lowest abundance was recorded at the first station (293 ind.) where the low flow velocity of the water does not favour its enrichment in oxygen, a phenomenon aggravated by the presence of a muddy substrate rich in litter. These factors favour unstable conditions for the development of certain benthic macroinvertebrate taxa.

In terms of time, the greatest number of families was observed in July (33), characterised by persistent rainfall. In this respect Foto Menbohan *et al.* (14) point out that rainy months are generally favourable to a greater diversity of benthic macroinvertebrates taxa due to the availability of a diversity of microhabitats.

7.3. Biocenotic index

The Shannon & Weaver diversity index (H') and Piélou equitability index (J) data show lower values at station Lep1. This could be due to the high abundance of Odonata (Libellula and Ortherum) which account for more than half of the individuals at this station (293), either 56.31% of relative abundance. These results corroborate those of Fisher *et al.,* (12) and Levêque and Balian (21), according to which the Shannon & Weaver diversity index decreases when a taxon has a very high relative abundance. Stations Lep2 and Lep3, on the other hand, show higher diversity index values, supported by Sörensen's Similarity Index, which shows a high degree of similarity between the taxa of these two stations (68.85%). Moreover, these high values illustrate the perfect integrity of these hydrosystems. To this end, Fisher *et al*., (12) and Dajoz (7) state that the diversity index is all higher when the environmental conditions favour the installation and maintenance of a balanced, integrated biological community capable of adapting to changes. The high values of the NBI at station Lep3 can be explained by the diversification of the microhabitats that are called upon to accommodate a large number of taxa (1).

The analysis of the PCA shows a predominance of polluosensitive taxa (Ephemerellidae, Hydropsychidae, Hydroptilidae, leptophlebidae, Perlidae and Atyidae) at station Lep3 would be linked to the high oxygenation, which would reflect the low level of pollution at this station, thus favouring the good development of polluosensitive organisms.

In summary, the Lep'oo watercourse hosts a large number of organisms sensitive to pollution, which need certain favourable conditions for their installation. This is the case of groups such as Crustaceans, which like well oxygenated water with little organic matter. These results are similar to those obtained by Tombou (38) in the Matouou stream at

Makak where the abundance of Atyidae reached 1038 ind. against 826 ind. in Lep'oo. Their predominance in this river underlines the good ecological health of the waters.

8. Conclusion

Physicochemical variables such as temperature, dissolved oxygen and nitrogenous forms influence the settlement of the benthic macrofauna associated with the ecosystem. Good oxygenation of the water, low concentrations of nitrogenous, phosphate forms and oxidability are ecological factors favourable to the distribution of benthic macroinvertebrates. The high taxonomic diversity recorded in forest streams (Lep'oo) is attributable to the diversity of microhabitats. The high abundance of Atyidae and other organisms such as Ephemeroptera, Trichoptera and Plecoptera observed in this stream would reflect the good ecological quality of the water that can be easily used by the populations for their activities.

Compliance with ethical standards

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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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