World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(RESEARCH ARTICLE)

Evaluation by benthic macroinvertebrates of the state of health of some rivers in the south Cameroon region

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World Journal of Biology Pharmacy and Health Sciences, 2023, 14(03), 001–010

Publication history: Received on 20 April 2023; revised on 28 May 2023; accepted on 30 May 2023

Article DOI: https://doi.org/10.30574/wjbphs.2023.14.3.0224

Abstract

Benthic macroinvertebrates are the best indicators of the ecological quality of watercourses because of their specific diversity, their sensitivity, their variable life span and their capacity to adapt to all types of environments. In order to determine the health status of some rivers in the Southern Cameroon Region, a study was conducted in Kribi in the Ocean Department between February 2022 and February 2023. Physicochemical analyses were carried out according to conventional methods. Sampling of benthic macroinvertebrates was done using the multihabitat approach. The results of physicochemical parameters revealed that the water courses were well oxygenated, with a slightly acidic pH with little disturbances from anthropic activities. The abundance of benthic macroinvertebrates showed 17055 individuals collected belonging to 2 phyla, 3 classes, 19 orders, 59 families and 113 genera. The class of Crustacea dominated with 7693 individuals or 45.10% of relative abundance, followed by Gastropods with 5174 individuals or 30.33% of relative abundance and Insects with 4188 individuals or 24.55% of relative abundance. The taxonomic diversity, coupled with the EPT, EPTD, EPTC and EPTH indices, revealed that the water from these water courses is of good ecological quality.

Keywords: Physicochemical parameters; Benthic macroinvertebrates; Water quality; River; Kribi

1. Introduction

Global water use has been increasing over the past 100 years and continues to gradually increase by about 1% per year [29]. Freshwater is a vital resource for all living things. It is food, habitat, means of production, transportation, and a market good [19]. The preservation, rational and efficient management of such a resource is currently a global priority from both a quantitative and qualitative point of view [12,21]. However, the distribution of this resource on a global scale is very heterogeneous. According to the "United Nations Environment Programme" [27], Africa is one of the driest continents in the world with only 9% of freshwater resources. However, anthropogenic activities, marked by the intensification of urbanization, agriculture and industry, are at the origin of a considerable production of solid, liquid and gaseous wastes that degrade water quality. Most of this waste arrives in aquatic ecosystems, which are the terminal receptacle [4].

Indeed, this quality can be established not only by a combination of inorganic and organic substances at various concentrations, but also by the composition and condition of the aquatic organisms living in that environment. Monitoring strategies that take into account aquatic organisms such as benthic macroinvertebrates, because of their taxonomic diversity and functional forms, their variable life span and their wide distribution in flowing waters, are excellent bioindicators of the health of hydrosystems [29].

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In Cameroon, many works have been carried out in lentic and lotic environments, in order to evaluate their health status, notably the Municipal Lake of Yaoundé [30], the Mingoa and Abiergue rivers [1] Lake Obili [14], the Djobo [3], Abouda [7,18], Konglo and Nyong rivers in Bertoua [29], streams. Unfortunately, few data are available on the health status of benthic macroinvertebrates in the southern region. It is to fill this gap that the present study is conducted. More specifically, it was necessary to evaluate the physicochemical parameters of the water, to identify and count the benthic macroinvertebrates and to establish the link between certain biological indices and the quality of the water.

2. Materials and methods

2.1. Geographical framework of the study

Kribi, a city located in the South Cameroon region, is the capital of the Ocean department. The main economic activities are fishing and tourism. The climate is equatorial with four unevenly distributed seasons, including a long dry season from November to March, a short rainy season from April to June, a short dry season in July and a long rainy season in October.

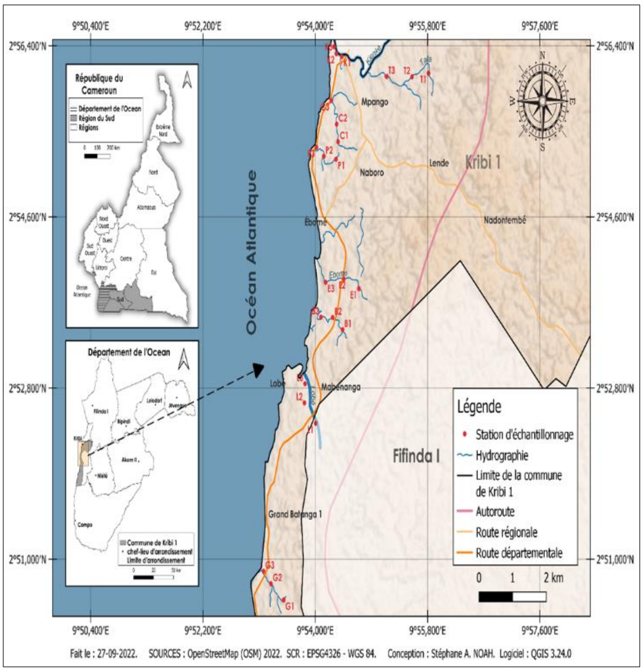

Figure 1 Map showing the geographical locations of sampling stations [20].

Table 1 Geographic coordinates of the different sampling stations

watercourse	Code	Contact detail GPS		Altitude (m)
		Latitude (°N)	Longitude (°E)	
Bwambe	B1	2° 53' 24.829"	9° 54' 26.216"	16
Bwambe	B2	2° 53' 32.497"	9° 54' 16.715"	11
Bwambe	B3	2° 53' 32.696"	9° 54' 5.480"	12
Casino	C1	2° 55' 23.431"	9° 54' 21.945"	4
Casino	C2	2° 55' 34.479"	9° 54' 20.594"	4
Casino	C3	2° 55' 49.461"	9° 54' 15.348"	3
Ebome	E1	2° 53' 50.707"	9° 54' 41.994"	5
Ebome	E2	2° 53' 56.884"	9° 54' 27.559"	5

Ebome	E3	2° 53' 54.741"	9° 54' 9.972"	4
Grand Batanga	G1	2° 50' 34.282"	9° 53' 29.624"	4
Grand Batanga	G2	2° 50' 44.498"	9° 53' 17.399"	11
Grand Batanga	G3	2° 50' 52.361"	9° 53' 10.235"	1
Kienke	K1	2° 56' 16.516"	9° 54' 27.753"	3
Kienke	K2	2° 56' 19.036"	9° 54' 20.281"	2
Kienke	K3	2° 56' 23.290"	9° 54' 18.163"	1
Lobe	L1	2° 52' 25.782"	9° 54' 0.339"	11
Lobe	L2	2° 52' 38.667"	9° 53' 49.570"	1
Lobe	L3	2° 52' 50.747"	9° 53' 50.200"	13
Pangour	P1	2° 55' 12.373"	9° 54' 19.901"	2
Pangour	P2	2° 55' 14.280"	9° 54' 8.236"	4
Pangour	P3	2° 55' 19.907"	9° 54' 1.264"	5
Talla	T1	2° 56' 6.696"	9° 55' 49.032"	6
Talla	T2	2° 56' 4.397"	9° 55' 33.058"	4
Talla	T3	2° 56' 4.606"	9° 55' 8.694"	5

2.2. Physicochemical parameters

Table 2 Class limits of the Organic Pollution Index according [13]

Parameters	**NH_4^+ (mg/l)**	**NO_2^- (µg/l)**	**PO_4^{3-} (µg/l)**
5	< 0,1	≤ 5	≤ 15
4	0,1 - 0,9	6 – 10	16 – 75
3	1 - 2,4	11 – 50	76 – 250
2	2,5 – 6	51 – 150	251-900
1	> 6	> 150	> 900

Table 3 Interpretation of the average class of the Organic Pollution Index according [13]

Class averages classes	**Organic pollution level**
5,0 – 4,6	Nil
4,5 – 4,0	Low
3,9 – 3,0	Moderate
2,9 – 2,0	Strong
1,9 – 1,0	Very high

Physicochemical parameters were measured (February 2022 to February 2023) both in the field and in the laboratory following the recommendations [2,22]. Temperature, dissolved oxygen, and electrical conductivity were measured in situ using a HANNA HI 98130 thermometer and multimeter, respectively. In the hydrobiology and environment laboratory of the Faculty of Sciences of the University of Yaoundé 1, orthophosphate ions and nitrogen forms were measured with a WAHTECH spectrophotometer and oxidizability was measured by volumetry from water samples taken in the field using 1000 mL double-stoppered polyethylene vials The organic pollution index (OPI) was calculated according to the recommendations [13].

2.3. Sampling of benthic macroinvertebrates

Benthic macroinvertebrates at these study stations were collected using a 30 cm x 30 cm dip net with a 400 µm mesh size and a depth of 0.5 m. At each study station, about twenty dip net strokes were made. The organisms collected were fixed in 10% formalin in glass pillboxes. In the laboratory, the specimens were washed with running water and then preserved in 70° alcohol before identification and counting. All benthic macroinvertebrates were determined under a Wild M5 binocular loupe up to the rank of genus or species, using the identification keys proposed by [6,23,16]. The data obtained were translated into simple variables (Kruskal-Wallis and Mann-Whitney U test and EPT, EPTD, EPTC, EPTH and EPT density/chironomid density indices).

3. Results

3.1. Physicochemical parameters

3.1.1. Temperature

The temperature of the different streams varied from one station to another. The maximum value (31.3 °C) was recorded in April at the Pangour 3 station and the minimum value (20.3 °C) at the same station in February, for an average of 26.26 ± 1.47 °C (Figure 2). Spatially, the Kruskall-Wallis test revealed no significant difference (p<0.005) (Figure 2).

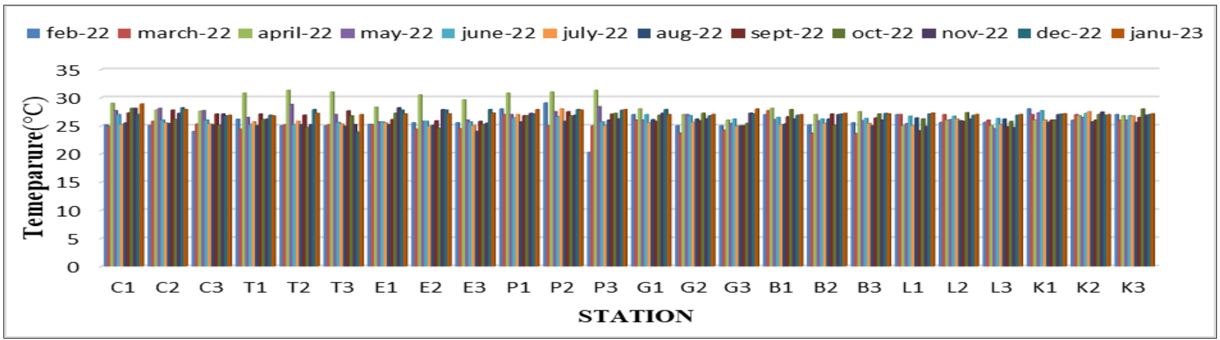

Figure 2 Spatial and temporal variation of temperature during the study period

3.1.2. pH

The hydrogen potential varied from station to station. The maximum value (9.8 CU) was recorded in June at the Casino 1 station and the minimum value (5.76 CU) in February at the Lobe 1 station (Figure 3). Spatially, the Kruskall-Wallis test revealed no significant difference (p<0.005) (Figure 3).

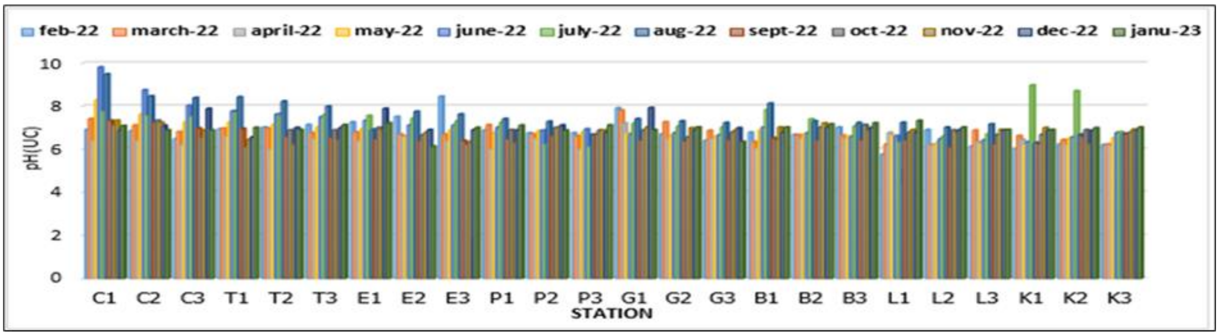

Figure 3 Spatio-temporal variation of Ph during the study period

3.1.3. Dissolved oxygen

Dissolved oxygen levels varied from station to station. The maximum value (94.5%) was recorded in April at the Casino 1 station and the minimum value (10.9%) in February at the Ebome 2 station (Figure 4). Spatially, the Kruskall-Wallis test showed no significant difference ($p<0.005$) (Figure 4).

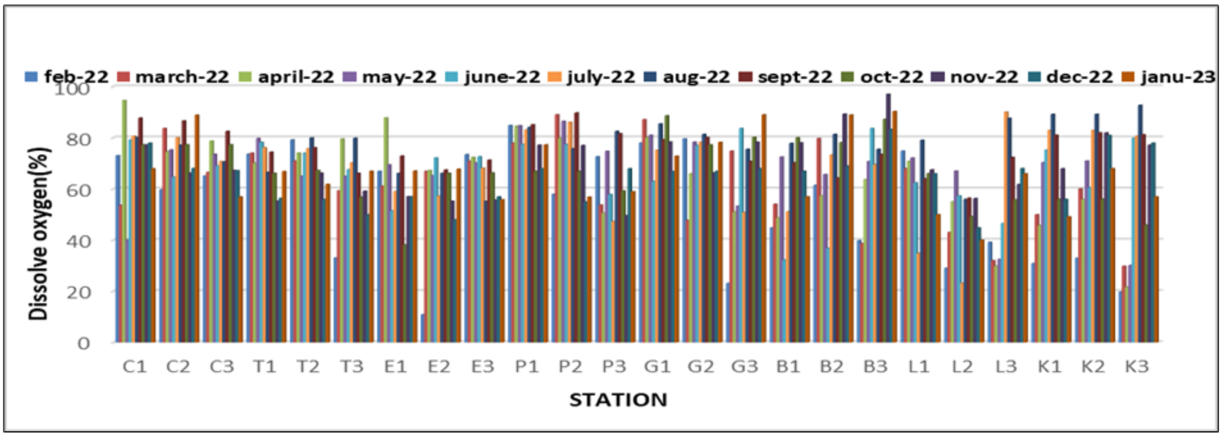

Figure 4 Spatial and temporal variation of dissolved oxygen during the study period

3.1.4. Nitrates

Nitrate levels varied from station to station. The maximum value (0.99 mg/L) was recorded in September at the Lobe 1 station and the minimum values (0 mg/L) in May, June and July at the Casino 3, Talla1 1, Grand Batanga 2 and Bwambé2 stations (Figure 5). Temporally, the Kruskal-Wallis test showed a significant difference ($p < 0.05$) between June and September (Figure 5).

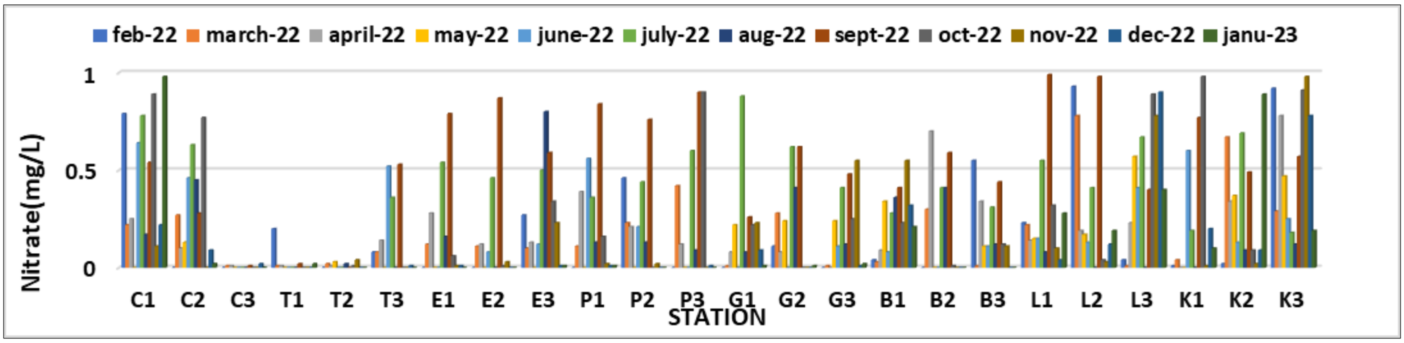

Figure 5 Spatial and temporal variation of Nitrate levels during the study period

3.1.5. Nitrites

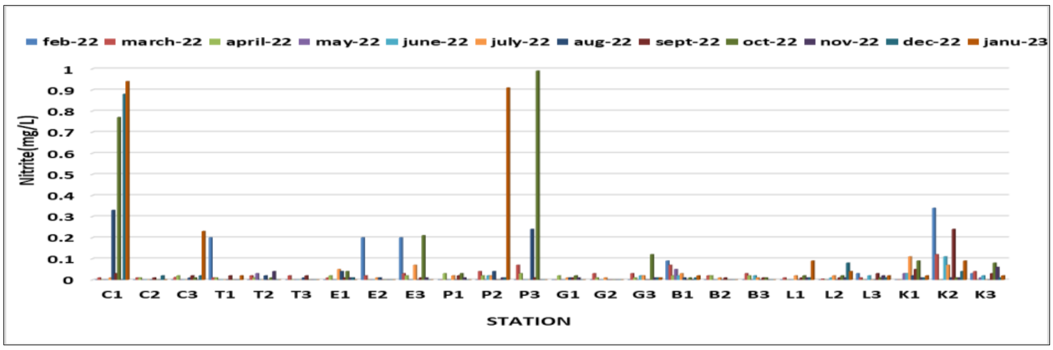

Figure 6 Spatial and temporal variation of Nitrite levels during the study period

Nitrite levels varied from station to station. The maximum value (0.94 mg/L) was recorded in January at the Casino 1 station and the minimum values (0 mg/L) in May, June and July at the Casino 2, Casino 3 and Ebome 2 stations (Figure 6). Temporally, the Kruskal-Wallis test showed a significant difference ($p < 0.05$) between January and June (Figure 6).

3.2. Benthic macroinvertebrates

3.2.1. Taxonomic richness and relative abundance

In all the 24 stations studied, 17055 individuals were collected belonging to 2 phyla, 3 classes, 19 orders, 59 families and 113 genera. The Arthropods phylum revealed 4188 individuals or 24.55 % of relative abundance and the Molluscs with 12867 individuals or 75.44 % of relative abundance. The class Crustacea dominated with 7693 individuals or 45.10% relative abundance, distributed in 1 order, 11 families and 29 genera, followed by Gastropoda with 5174 individuals or 30.33% relative abundance, distributed in 10 orders, 19 families and 48 genera and Insects with 4188 individuals or 24.55% relative abundance, distributed in 8 orders, 29 families and 37 genera (Figure 7).

The 19 oeders arranged in descending order were as follows (Figure 7), Decapods with 7693 individuals (45.10%), Hemiptera with 2973 individuals (17.43%), Mesogasteroptera with 2246 individuals (13.16%), Basommatophores with 1811 individuals with (10, 61%), Odonata with 596 individuals (3.49%), Coenogasteropoda with 382 individuals (2.23%), Neogasteropoda with 283 individuals (1.65%), Coleoptera with 247 individuals (1.44%), Diptera with 184 individuals (1, 07%), Neotaenioglosaa with 131 individuals (0.76%), Phaladomyoides with 114 individuals (0.66%), Littoriminophes with 83 individuals (0.48%), Trichoptera with 79 individuals (0.46%), Aricides with 66 individuals (0.38%), Ephemeroptera with 52 individuals (0.30%), Plecoptera with 33 individuals (0.19%), Myoides with 41 individuals (0.24%), Dictyoptera with 24 individuals (0.14%) and Trochida with 17 individuals (0.09%) (Figure 8).

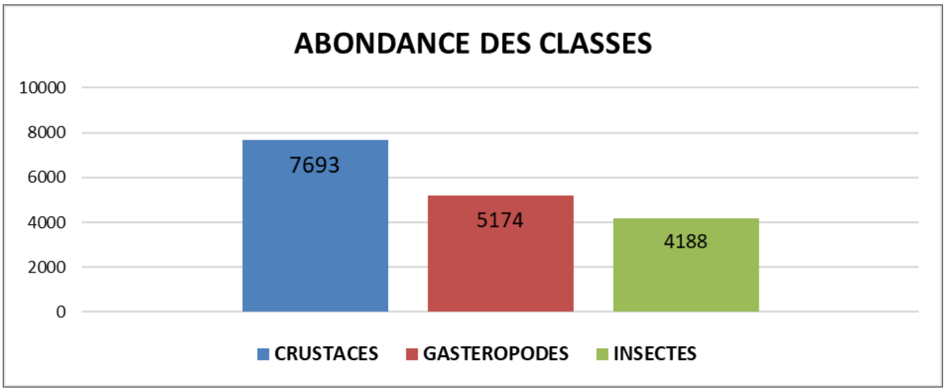

Figure 7 Abundance of benthic macroinvertebrate classes during the study period

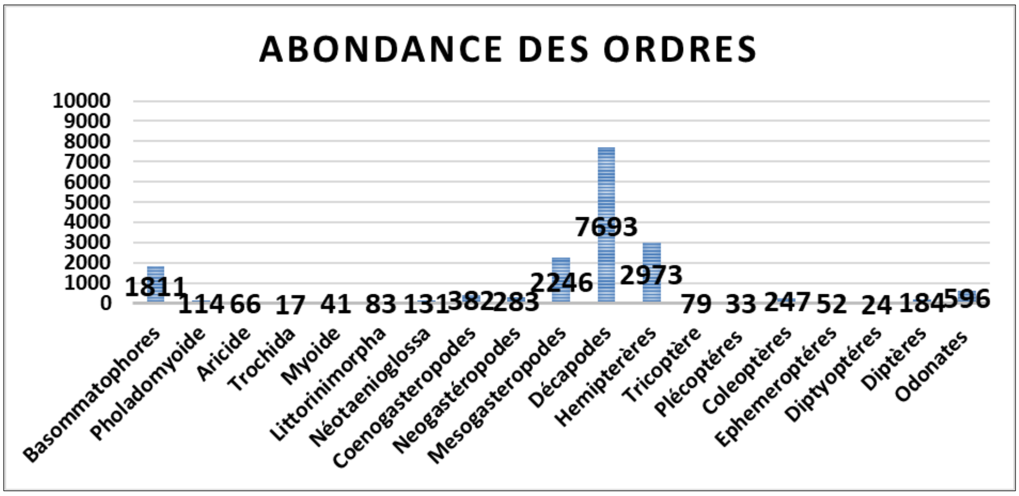

Figure 8 Abundance of benthic macroinvertebrate orders during the study period

3.3. Organic Pollution Index (OPI)

The results of the Organic Pollution Index (OPI) calculation are shown in Figure 9, with values ranging from 2 for high pollution (Kienke 2) to 3.33 for moderate to low pollution at most stations (Grand Batanga 1, 2 and Casino 2).

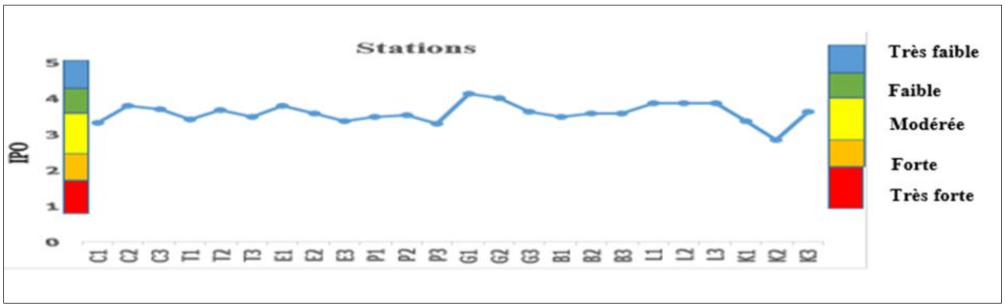

Figure 9 Spatial and temporal variation of the SOP over the study period

3.4. EPT, EPTC, EPTH and EPTD indices

The species richness of Ephemeroptera (E), Plecoptera (P), Trichoptera (T), Coleoptera (C), Hemiptera (H) and Decapoda (D) was determined in order to assess the spatial distribution of the descriptor groups (EPT, EPTC, EPTH and EPTD) (Table 4 and 5). Taxa of the EPTD group were encountered in all stations, while EPT were encountered exclusively in stations Casino1, Talla1, 2, Ebome2, 3, Grand batanga 1,2 and Lobe1,2. Taxa of the EPTC group are present in all stations except Kienke (1,2,3).

Table 4 Spatial variation in taxonomic richness of different descriptor groups during the study period

Descriptors (indices)	C1	C2	C3	T1	T2	T3	E1	E2	E3	P1	P2	P3
EFA	11	0	0	2	4	0	0	1	1	0	0	0
TCPS	11	1	1	3	5	0	2	2	2	0	0	0
EPTH	16	6	6	7	9	4	5	5	5	2	3	2
EPTD	17	14	14	14	14	9	12	9	15	4	9	8
EFA density (ind./m2)	0,27	0	0	0,06	0,10	0	0	0,05	0,034	0	0	0
Chironomid density (ind./m2)	2	6	43	12	0	0	34	0	0	0	32	0
EFA density/ Chironomid density	0,135	-	-	0,005	-	-	-	-	-	-	-	-

Table 5 Spatial variation in taxonomic richness of different descriptor groups during the study period

Descriptors (indices)	G1	G2	G3	W1	W2	W3	L1	L2	L3	K1	K2	K3
EFA	1	1	0	1	0	0	1	2	0	0	0	0
TCPS	1	1	1	3	1	1	5	1	0	0	0	0
EPTH	4	1	6	5	1	2	2	2	0	0	0	0
EPTD	6	6	7	5	3	4	3	3	1	6	7	6
EFA density (ind./m2)	0,07	0,14	0	0,71	0	0	0,09	0,09	0	0	0	0
Chironomid density (ind./m2)	22	0	2	0	0	0	9	0	0	0	2	0
EFA density/ Chironomid density	0,003	-	-	-	-	-	0,01	-	-	-	-	-

E= Ephemeroptera, P = Plecoptera, T = Trichoptera, D = Decapoda, C = Coleoptera and H = Hemiptera; Stations: C1, C2, C3 (Casino), T1,T2,T3 (Talla), E1,E2,E3 (Ebome), P1,P2,P3 (Pangour), G1,G2,G3 (Grand Batanga), W1,W2,W3 (Wbambe), L1,L2,L3 (Lobe) and K1,K2,K3 (Kienke).

4. Discussion

During the study period, the pH values indicated that the stream waters are acidic with a slight tendency to neutrality (5.7-9.8UC). These are due to the absence of anthropogenic activities in the basin. Similar results were obtained by [15] in the coastal waters of Cameroon and [17] in the waters of southern Cameroon.

The slightly elevated temperatures (20.3 to 31.3 °C) observed at the Pangour 3 station could be due to the climate, its proximity to the Atlantic Ocean and solar radiation. The high temperature values are characteristic of warmer coastal marine and mangrove waters [26] and are similar to those obtained by Ghali Fatiha and Hammou Fatiha (2017) in the Salamander, Sablette, and Sidi Medjdoub streams in Algeria.

The high values of the percentage of dissolved oxygen saturation (94.5%) at the Casino 1 station showed a good saturation of the waters that could be attributable to the low heating of the waters, coupled with the high photosynthetic activity, the natural ventilation and the presence of riffles and meanders that create conditions of turbulence and recirculation of the waters, as well as reoxygenation at the water/air interface. These values could be attributed on the one hand, to the flow velocity of the water generating turbulence phenomena, resulting in the reoxygenation of the water, and on the other hand to the presence of riffles and meanders [5]. These results are similar to those of [24,8,9,10] where average rates higher than 75% were recorded in some forest streams.

Nitrogenous mineral elements (NO2- and NO3-) showed or shows low values in all watersheds, reflecting the low level of mineralization of the waters, their good oxygenation and the low anthropization of the watersheds. These results are similar to those of [10] and [24] obtained in a few forested streams.

Overall, the Crustacea class predominates with 6696 individuals or, 39.26% relative abundance, followed by Insects with 5373 individuals, or 31.50% relative abundance and finally Gastropods with 4986 individuals, or 29.23% relative abundance. This abundance of crustacean classes would be linked on the one hand to the proximity of these stations to the Atlantic Ocean and on the other hand, by the great rainy season. Indeed, [25] emphasizes that the rainy months are globally in favor of a greater diversity of benthic macroinvertebrate taxa due to the availability of a diversity of microhabitats

The analysis of the Organic Pollution Index values shows that the level of pollution in the stream is moderate, which is reflected in the low organic matter loads and the low anthropogenic character of these watersheds. These results are similar to those obtained by [17] in the waters of southern Cameroon.

The values of the EPT, EPTD, EPTC and EPTH indices obtained in the different sampling stations showed or shows that the watershed is little anthropized and that its waters are of good ecological quality, with the exception of the Kienke. these results would reflect the sensitivity of Decapod, Coleoptera and Hemiptera taxa.

5. Conclusion

This work allowed us to evaluate the health of some rivers in the Southern Cameroon Region using benthic macroinvertebrates. The physico-chemical quality reveals waters of moderate quality, as they are little disturbances by anthropic activities. The 17055 organisms collected belong to 2 phyla, 3 classes, 19 orders, 59 families and 114 genera. The class of Crustacea predominates with 6696 individuals or 39.26% of relative abundance, followed by Insects with (5373 individuals, or 31.50% of relative abundance) and Gastropods (4986 individuals, or 29.23% of relative abundance). The taxonomic diversity, coupled with the EPT, EPTD, EPTC and EPTH indices, reveals an environment little affected by anthropic activities and consequently, waters of good ecological quality.

Compliance with ethical standards

Acknowledgments

I would like to express my sincere thanks to my supervisors prof Foto Menbohan Samuel and Ajeagah Aghaindum Gideon their contributions to writing of this article, not forgetting my fellow laboratory students.

Disclosure of conflicts of interest

All authors declare that they have no conflicts of interest.

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