International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 9 (2014) pp. 454-468**
http://www.ijcmas.com

Original Research Article

Impacts of climate variability and anthropogenic factors on composition, distribution and abundance of macroinvertebrates along the shores of River Ndongo, Buea south west region Cameroon

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A B S T R A C T

Macroinvertebrates of the shores of the Ndongo River were sampled monthly between January and July 2014 using the Stark *et al*. (2001) method. The distribution of organic matter, substratum texture and other environmental and water parameters accounted for the variations of species composition, taxonomic richness and total abundance at the three study stations. The most dominant taxonomic order was Decapoda represented mostly by *Litopaenaeus vannamei* (Boone 1931), (84.3%) followed by *Johngarthia logostoma* (H. Milne -Edwards, 1837), (10.85%) and *Lymnaea species* (4.85%) in Gastropoda. The abundance of *Litopaenaeus vannamei* is attributed to the fact that they are filter feeders and can filter mud particles. High human activities around station three which released pollutants into the River accounted for the poor species richness. Physicochemical analysis revealed the poor health status of station 3 of the stream with highly polluted water while station 1 has very good water quality. Redundancy Analysis and Monte Carlo tests showed a spatial a spatial distribution of the macroinvertebrate community which is significantly influenced by total dissolved solids, dissolved oxygen, alkalinity, conductivity, turbidity, ammonium, phosphate, nitrate, water depth, water width, biochemical oxygen demand and canopy cover. The study results indicate that poor management municipal wastes and climatic variability contribute to damage the water quality and induce the endangering of macroinvertebrates of the Ndongo River.

Keywords

Climate variability, anthropogenic activities, composition, distribution, abundance, macroinvertebrate, Ndongo River, Cameroon.

Introduction

The composition and structure of macroinvertebrates' communities has been the subject of much research in river systems. Urban water management and the impacts that rapid population growth, anthropogenic activities and climate change are having on it is gaining increasing attention worldwide (Carden and Armitage, 2013). Industrial, agricultural and urban activities produce pollution that exerts considerable pressures on aquatic ecosystems, which result in a deterioration of the water and habitats quality on which the aquatic organisms depend (Wang *et al*., 2012; Morrissey *et al*., 2013). According to Colas *et al*., (2014), aquatic organisms integrate various types and degrees of environmental impacts which occur on a variety of spatial and temporal scales. In most Cameroonian cities, various origins of urban solid wastes are discharged directly in nature without any preliminary treatment (Tening *et al.,* 2013a). In Buea a fast growing city, the problem of aquatic pollution from human activities coupled with climate variability is becoming more acute and complex. In such a situation it is imperative, for any policy of conservation, durable and rational use of the ecosystems, to evaluate the health status of organisms present in the medium (Garcia-Roger *et al*., 2011).

Benefits of such research on macroinvertebrate include the quick assessment of biological resources for conservation purpose and the detection of pollution through the differences between predicted and actual faunal assemblages (Popoola and Otalekor, 2011). Macroinvertebrate are biological quality element required for the classification of biological status of the water bodies (Arimoro and Ikomi 2008). Benthic in-faunal community studies provide the 'golden standard' in terms of determining whether or not alterations in benthic communities are occurring and together with sediment, toxicity and chemistry, whether or not such changes are due to toxic contaminants in the sediments (Okorafor *et al.,* 2012). Studies using macroinvertebrate as bio-indicator of anthropogenic impact on aquatic ecosystem have shown general decrease in macroinvertebrate population and reduction in species diversity and richness Bouchard (2004) and they possess higher ability to tolerate pollution-induced environmental stress than plankton (Ajao, 1990).

Macroinvertebrate are useful bio-indicators providing a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which only gives short term fluctuations (Yakub 2004). In sub-Saharan Africa at large and Cameroon in particular, very few works are devoted to the loss of biodiversity as a response to the deterioration of the medium (Lévèque & Paugy, 1999; N'Zi *et al*., 2008; Camara *et al*., 2009). In Cameroon very few studies have been conducted on impacts of climate change and anthropogenic activities on composition, distribution and abundance of macroinvertebrates in aquatic medium, and a few related works are focused upon the relations existing between the environmental variables and fish fauna (Kamdem Toham and Teugels, 1998) or the dynamics of the benthic invertebrates communities (Foto *et al.,* 2011, 2012 and 2013). Regarding Cameroonian freshwater, macroinvertebrates data on their systematic, biology and ecology are quasi-non-existent (Siméon *et al*., 2014).

Studies on macro invertebrates of African Lotic waters are generally few in literature and until recently has not received much attention in Cameroon (Tening *et al*., 2013b). However, macroinvertebrates may be present in the majority of Cameroonian rivers and streams and may be good bio-indicators (Foto *et al.,* 2011 and 2013). The structure and macroinvertebrates composition of the Ndongo River is poorly understood. This river has been subjected to domestic, agricultural and industrial activities. The river is the major source of drinking water to the inhabitants of these communities. To our knowledge, little or no study has so far dealt with diversity and ecological requirements of macroinvertebrates in Cameroonian rivers and streams. This study provides a baseline data on the composition, distribution and abundance of macroinvertebrates of the Ndongo River.

Materials and Methods

Study area

The Ndongo river, Buea Fako Division is located between latitudes 04°09.378'N to 04°08.061N and longitudes 009°16.284'E to 009°18.356'E of the equator. It flows at a bearing of 117° northeast from (Bokoko) Lower Bonduma down southeast through Molyko, Mile 17, Bulu, and finally into another stream at Mile 16 (Bolifamba). In the north, the stream is flanked by the Bokoko locality and in the south by Bolifamba.

It has an estimated length of about 46km and is about 2.5m wide at the mouth where it empties into the mangrove creeks of Tiko. Two climatic seasons, wet and dry prevail in the study area. The long wet season which starts from March to November is characterized by high rainfall while the short dry season starting from December to February experiences sunshine with occasional downpours (Suchel, 1972). The shorelines are lined with dark volcanic mud plates usually exposed during the dry season; the water at the shore is rich in macroinvertebrates and debris. The banks are also surrounded by lush evergreen, shrub trees vegetation with different species of grasses.

Three sampling stations were demarcated along the River bank.

Station 1: This station was located at Bokoko (Lower Bonduma), close to the source of the river. The substratum here is covered by mud or clay with an average depth of 0.5m. It is swift-flowing and has a low transparency. The vegetation here includes shrub trees, elephant grasses (The African *Pennisetum purpureum*) and other species of grasses.

Station 2: This station was located at Ndongo Quarter to dirty south near the university of Buea football field; Substratum here is covered with coarse sand and mud with an average depth of 0.3m. It is swift-flowing with medium transparency. Vegetation here is predominantly elephant grasses, (The African *Pennisetum purpureum*), as the river is bordered by farms and houses.

Station 3: This station was located at mile 17 through to the car washing point at mile 16 (Lower Bolifamba), Substratum here is covered with sandy mud with an average depth of 0.26m. It is slow-flowing with low transparency. Vegetation here is made up of patches of elephant grasses (The African *Pennisetum purpureum*), and grasses of different species. There are lots of auto garages located by the river banks, agricultural activities is high and washing of cars and dresses is also carried out on a high scale. Most of the people within this study station use the river as their toilet.

Measurement of environmental variables

At the level of each sampling station, 19 environmental variables were taken into account. Five physical parameters were determined to characterize the habitat. Mean depth and wetted width in meter were quantified on transects with equal distance interval across channel sections (Song *et al*., 2009). Current velocity (m/s) was measured quarterly by timing the front of a neutral non-pollutant dye stuff (ethylene blue) over a known distance along the station. At each sampling site, canopy coverage (%) was estimated visually (Rios and Bailey, 2006). Additionally, types of substrate were characterized by measuring substrate particle size distribution based on methods described by (Plats *et al*., 1983).

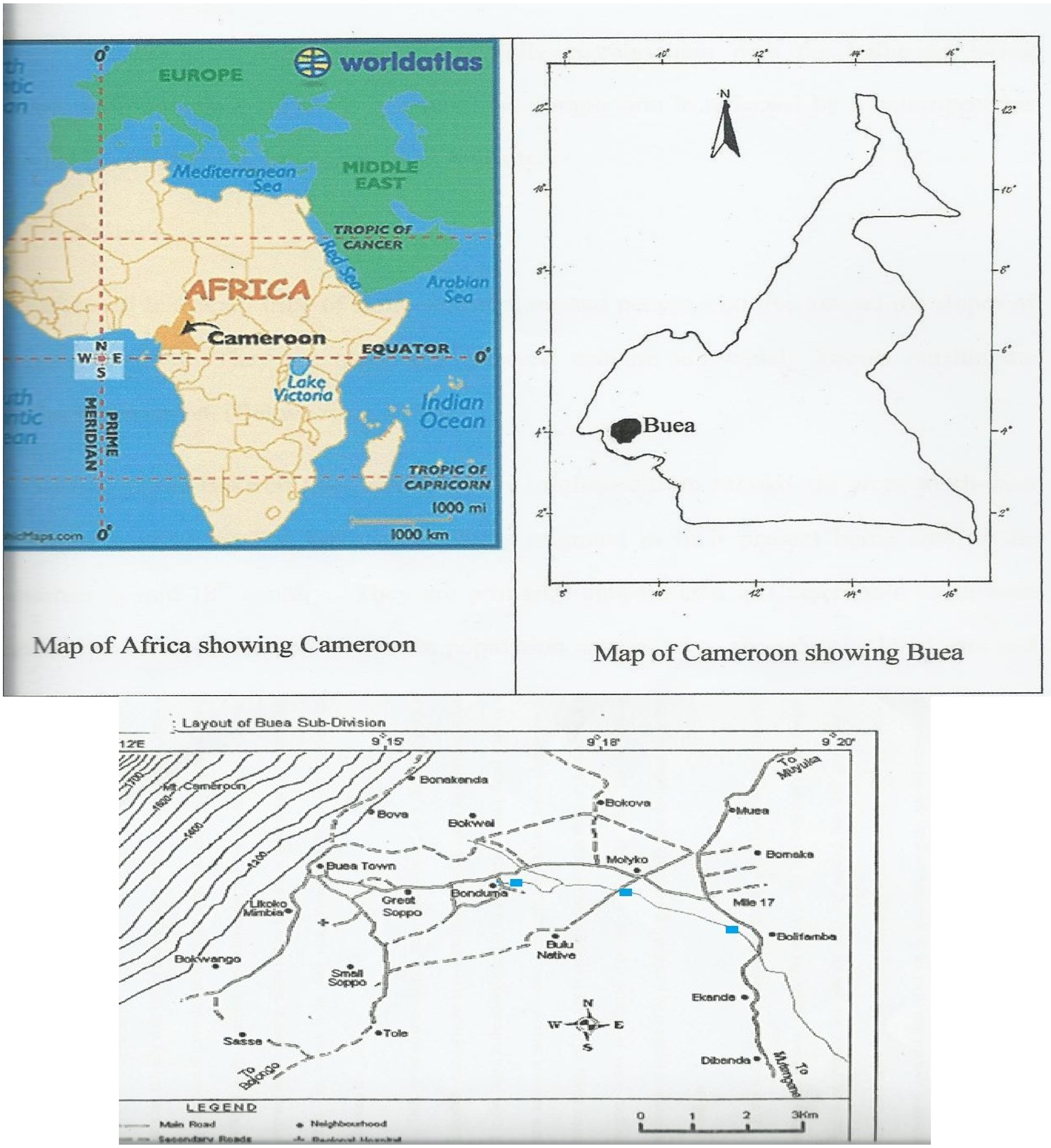

Figure.1 Detail map of Buea adapted from BRC 2010; showing sampling stations in blue

Measurements of physicochemical parameters of water at the different sampling stations were done according to APHA (1998) and Rodier *et al.*, (2009) standards. Whereby, water temperature (^oC), pH (CU) and Dissolved Oxygen (DO) rate (%) were measured in situ respectively using an alcohol thermometer, a HACH HQ11d pH-meter and a HACH HQ14d oxymeter. Likewise, salinity (‰), electric conductivity (EC) (µS/cm) and Total Dissolved Solids (TDS) (mg/L) were measured in situ using a HACH HQ 14d TDS-conductimeter. Turbidity (NTU) was measured in the laboratory with the help of a HI 93702 HANNA instruments. Suspended Solids (SS), ammonium, nitrates and Phosphates were also determined in the laboratory using HACH DR/2800 spectrophotometer. Alkalinity and oxydability were dosed by complexometry, whereas the Biochemical Oxygen Demand (BOD) was measured using a LIBHERR BOD analyzer. The sediments collected were poured into polythene bags and taken to the IRAD Ekona Soil laboratory for analysis. The sediments were passed through 3 sieves of 2mm, 1mm and 0.5mm mesh sizes to collect the benthos.

Sampling and identification of freshwater macroinvertebrates

In order to determine macroinvertebrate diversity and to assess the impact of anthropogenic activities and climate change on their distribution, 3 sites were monitored; at the river Ndongo.

Sampling of macroinvertebrate was conducted fortnightly for seven (7) months at monthly intervals between January and July 2014. During this period, sampling was done between 07:30 and 12:30 hours on each sampling day.

Macroinvertebrate were collected using a long-handled kick net (25 x 25cm side, 500 µm mesh size). Samples were collected in a 150m stretch for each of the three stations, following Protocols described by (Stark *et al*., 2001). Materials collected in the sampling net were rinsed through a 500 µm sieve and all macroinvertebrate individuals were sorted and placed in plastic sampling bottles with 70% ethanol. In the laboratory, all the different macroinvertebrate were handpicked using a fine dissection forcep and sorted into Petri dishes. All specimens caught were identified under a compound microscope using taxonomic keys (Powell, 1980; Day *et al*., 2001) and counted.

Data analyses

Macroinvertebrate richness, abundances and frequency of occurrence (FO) were used to classify species according to (Dajoz, 2000). Before performing the comparison test, the normality of data was checked using the Kolmogorov-Smirnov test. The Kruskal-Wallis H-test followed by a test of multiple comparisons of rank was performed to compare physicochemical variables and macroinvertebrate abundances between sampling sites using PAST 3.0 software package. A significance level of $p < 0.05$ was considered. Hierarchical Ascending Classification (AHC) base on Euclidean distance and Ward's algorithm was performed to cluster sampling stations according to their physicochemical water quality status. Correlation between environmental variables and taxonomic richness of macroinvertebrate was determined by Spearman correlation test. In order to study relationships between environmental variables and the distribution and dynamic of the macroinvertebrate communities, Canonical Redundancy Analysis (RDA) was performed based on the data matrix of macroinvertebrate abundances. RDA is a constrained ordination method, efficient in directly revealing relationships between the spatial structure of communities and environmental factors that might be responsible for that structure (Legndre *et al*., 2011). Environmental variables and macroinvertebrate data were log10(x + 1) transformed prior to analysis. Monte Carlo permutations (499) were done so as to identify a subset of measured environmental variables, which exerted significant and independent influences on macroinvertebrate distribution at $p < 0.05$. RDA was performed using CANOCO for Windows 4.5 software (Ter Braak and Smilauer, 2002).

Results and Discussion

Environmental variables

The mean and ranges values of environmental variables are shown in (Table 1). Water temperature varied from 25 ^{o}C (S1) through 26 °C (S2) to 26.7 ^{o}C. The pH values varied between 7.2 (S1) 6.7 (S2) and 6.9 (S3). Dissolved oxygen was overall high in the catchment area of the Ndongo River 91.4% (S1) then decreased to 58% (S2) with some human activities while at (S3) situated at mile 17 through to mile 16 where cars, dresses and carpets are washed, with a lot of petroleum products washed into the stream by runoff from auto-garages the value was 0.9% (S3). Electric conductivity ranged between 8 µS/cm (S1) and 1671 µS/cm (S2). Similar variation trend was observed for TDS, with low (2.9 µS/cm) and high (973µS/cm) values registered at stations (S2 and S3) respectively. Salinity was nil at station (S1), while the highest value (1.12 ‰) was recorded at station 3. Turbidity and suspended solids were virtually very low in all the stations with values ranging from 2 to 46 NTU and from 0.4 to 12 mg/L for stations (S2 and S3) respectively. Alkalinity varied between 0 mg/L (S1), 672 mg/L (S2) and 1050 mg/L (S3). The lowest values (0 mg/L) of nitrates, ammonium and phosphates were recorded in station (S1 and S2), whereas the highest were registered at the station (S3), (6.2 mg/L) S1, (10.5 mg/L) (S2) and (20.4 mg/L), (S3) respectively. As for oxydability and BOD, lowest value (1.6 and 4 mg/L) respectively were observed in (S1 and S2), while the highest values (122 mg/L) was obtained at station (S3). Mean values of water's depth and wetted width fluctuated between 0.13 m (S1); 0.56 m (S2); and 1.9 m (S3) respectively. The lowest mean value (0.42 m/s) of current velocity was recorded at the station (S3), whiles the highest (0.89 m/s) was obtained in station (S1). At the level of the entire stations canopy was secondary with mostly grasses. Two types of substrates were characterized for the whole study sites: Sandy mud (S1 and S2) and very sandy mud (S3).

A Hierarchical ascending classification performed to cluster sampling stations according to their physicochemical water quality status, distinguished 3 groups of stations. Group I made up of stations S1 sheltered with secondary vegetation of shrub trees and grasses and free of anthropogenic or agricultural activity. Group II is constituted by (S2) situated in a highly populated area of Buea (Molyko) where many people dump household refuse, wash dresses, plates. Herbicides, fertilizers and pesticides are also washed from nearby farms into the river. Group III is constituted by station (S3) located in an area with high anthropogenic activities (Auto garages, washing of cars directly in the river, a lot of farms by the river banks discharging pesticides, herbicides and fertilizers into the stream and most people use the river as toilet). The test of Kruskal-Wallis realized from the matrix of physicochemical variables, showed significant differences ($P<0.05$) between the groups I, II and III Composition and distribution of macroinvertebrate species.

Relationships between environmental variables and macroinvertebrate community

The analysis of the Spearman correlations (Table 2) indicated positive and very significant ($p<0.01$) correlations between the 8 species of macroinvertebrate and dissolved oxygen, canopy coverage and water depth. Contrariwise, it appeared that all the macroinvertebrate species were not negatively and significantly influenced by values of temperature, but negatively and significantly influenced by conductivity, TDS, salinity, turbidity, suspended solids, alkalinity, nitrates, ammonium, phosphates and BOD. Moreover, *Belostoma species*, *Lymnaea species*, *Leutra species*, *Chironomus larva and Callinetctes sapidus* were found to be negatively and very significantly influenced by pH and oxydability. Except suspended solids ($P=0.037$), *Litopenaeus vannamei* ($P=0.028$) and *Johngarthia logostoma* ($P=0.002$), the Mann- Whitney U-test showed no significant difference ($P>0.05$) between stations (S1 and S2) regarding environmental variables and macroinvertebrate diversity and distribution. Four (4) orders were identified belonging to two phyla from a total of 235 individuals collected from all the three stations. The Bokoko station accounted for the highest abundance (40.4%) by number while the Mile 17 through to Mile 16 car washing station accounted for the lowest abundance (24.8%) by number. The highest number of taxa (5) was recorded in both stations. Arthropods had the highest percentage composition (97.8%) by number while Mollusca were the least (2.2%) by number. All the stations were dominated by Crustaceans, represented mostly by Litopenaeus vannamei (91.7%) followed by Johngarthia logostoma (7.0%) and Lymnaea species (1.3%) in gastropoda. Though percentage abundance of Insecta was low (0.91-2.73%) Chironomus larvae, Leutra species and Belostoma species were encountered during the study period.

Diversity and dominance indices calculated for the three stations are shown in (Table 5). Taxa richness calculated as Margalef's index (d) was least in (Mile 17 to Mile 16 car washing point) station (0.610) while (Ndongo quarter to dirty south) station accounted for the highest diversity (1.045). Taxa evenness and species abundance calculated as Shannon diversity index (H) was least in (Mile 17 to Mile 16 car washing point) station (0.295) while Bokoko station accounted for the highest diversity (0.732). Equitability was least in (Mile 17 to Mile 16 car washing point) station (0.057) and highest in Bokoko station (0.251). Stations (S1 and S2) had more or less equal dominance and diversity levels with insignificantly different indices values.

Macroinvertebrates population was generally low at the shores of River Ndongo because of some imbalance in some important ecological factors arising from alterations of some important factors governing the abundance and distribution of macroinvertebrate communities. Such factors include water quality, substrate for habitat and availability of food. According to Brinkhurst (1970) cited by (Yakub and Ugwumba (2009) the bigger the size of a lotic water body, the poorer the macroinvertebrate richness. In addition, high human activities around the sampling stations which releases wastes into the river can be a possible reason for the low abundance of macroinvertebrate assemblages. Ogbeibu and Egborrge (1995) reported that high biodiversity is expected in aquatic ecosystems devoid of significant anthropogenic impacts.

Results from the present study showed that the most abundant macroinvertebrate species in River Ndongo is *Litopenaeus vannamei*. This could be attributed to the fact that these crustaceans are filter feeders. They extract indiscriminately from the mud particles. Gastropods recorded during this study could have been transported by water current and were tolerant to the prevalent water conditions. The low species diversity generally observed in this study could partly be due to some physicochemical conditions like fast flow of water in some areas, turbidity and low dissolved oxygen probably resulting in disruption of reproductive cycle and food chain.

This assessment study also revealed a significance difference between river water source and midstream water quality and ecology. The relative stable temperature values observed in both stations S1, S2 and S3 could reflect the character of forest streams little exposed to the solar rays thanks to the important canopy coverage as reported by (Yakub and Ugwumba, 2009). In line with Akindele and Adeniyi (2013), the high percentage of oxygen saturation (>70 %) in station 1 is an index of very good water quality. Indeed, in forest zone high photosynthetic activities of river basin, natural ventilation and the presence of rapid flow rate and curved flow of water which lead to disturbance and recirculation of water, favor its reoxygenation at the water/air interface. Furthermore, the low acidity of water, the low mean values of conductivity, TDS, salinity, turbidity, suspended solids, alkalinity, diverse ions (NO_3^-, NH_4^+, PO_4^{3-}), oxydability and BOD recorded throughout the study period in station 3 could indicate on one hand, low mineralization of water, and on the other hand, a low organic matter loads, thus indicating good water quality of the mount Cameroon watershed basin. These results are in accordance with those obtained by Foto *et al*. (2013) in a suburban forest stream of the Yaoundé city. Similar observations were documented by Wang *et al*. (2012) in the tributaries of Qiangtang River (China).

Contrariwise, the slightly higher temperature values registered in station 3 located around miles 17 through to mile 16 car washing point can be attributed to anthropogenic activities. According to Porse (2013) anarchic land used, overpopulation, domestic and industrial activities are factors that interfered to increase air temperature. Also, hypoxic condition of water, very high values of conductivity, TDS, salinity, turbidity, suspended solids, alkalinity, diverse ions (NO_3^-, NH_4^+, and $PO4^{3-}$), oxydability and BOD obtained at station 3, testified the highly polluted state of the section of this urban stream due to, domestic, agricultural and industrial wastes. These results corroborate those of Tening *et al.* (2013a) conducted in Douala-Edea mangrove ecosystem. Similar results were published by Kaonga *et al.* (2013) in Malawi and Dhillon *et al*. (2013) in India. Moreover as specified by clustering classification station S3 appears to be the most polluted point, followed by station S2 situated downstream of the outlet of domestic wastes dumps into the river. This clearly highlights the contribution of domestic wastes in water quality damaging. Similar observations were documented in India by Jain (2012) and Bhat *et al*. (2013) and in China by Wang *et al*. (2012) and Hanting and Lili (2013).

This study achieved in river Ndongo permitted to us to identify 8 freshwater invertebrate species. This taxonomic richness is greater than that recorded by Foto *et al*. (2013) in a suburban forest stream of the Yaoundé city where just 2 species were identified. This difference is probably due to the geographical situation of these regions.

Table.1 Mean and ranges values of environmental parameters evaluated at each sampling station during the study period

Variable	Study stations			
		S1	**S2**	**S3**
Temperature (^oC)	Mean Ranges	25.5 24-27	25.5 24-27	25.8 24-27.6
pH (UC)	Mean Ranges	7.4 6.8-7.9	7.05 6.8-7.3	6.8 6.6-6.9
Dissolved Oxygen (%)	Mean Ranges	70.9 62.7-79.1	62.85 54.1-71.6	26.4 20-32.7
Conductivity (µs/cm)	Mean Ranges	20 8-32	19.6 8-31.2	315 133-497
TDS (mg/L)	Mean Ranges	8.9 3.8-14	12.8 3.7-9.1	156.5 71-242
Salinity ($^o/_{oo}$)	Mean Ranges	0.001 0-0.003	0.001 0-0.003	0.01 0-0.02
Turbidity (NTU)	Mean Ranges	20 3-37	36.5 2-71	214 30-398
Suspended solids (mg/L)	Mean Ranges	6 0-12	9 1-17	176 13-339
Alkalinity (mg/L) $CaCO_3$	Mean Ranges	8 0-16	19 2-36	130 44-216
Nitrates (mg/L) NO_3^-	Mean Ranges	0.2 0-0.4	0.24 0-0.47	3.7 0.8-6.6
Ammonium (mg/L) NH_4^+	Mean Ranges	0.2 0-0.4	0.2 0-0.4	5.1 1.3-8.9
Phosphates (mg/L) PO_4^{3-}	Mean Ranges	0.15 0-0.3	0.3 0-0.6	0.65 0 -1.3
Oxydability(mg/L)	Mean Ranges	6.2 1.2-11.2	8.25 1.4-15.1	24 10-38
BOD (mg/L)	Mean Ranges	15.5 5-26	19.5 5-34	105.5 29-182

Table.2 Summary of spearman correlation between invertebrates' abundance and environmental variables

Parameters	Litopenaeus vannamei	Johngarthia Logostoma	Chironomus Larva	L eutra species	Belostoma species	Lymnaea species	Viviparous species
Variables							
Temperature (^{o}C)	-0.302**	-0.441**	-0.341**	-0.212**	-0.267**	-0.425**	-0.163*
pH (UC)	-0.225**	-0.361**	-0.2*	-0.044^{ns}	-0.076^{ns}	-0.169*	-0.083^{ns}
Dissolved Oxygen (%)	0.337**	0.482**	0.501**	0.227**	0.266**	0.31**	0.159*
Conductivity (µS/cm)	-0.349**	-0.496**	-0.379**	-0.224**	-0.248**	-0.268**	-0.175*
TDS (mg/L)	-0.349**	-0.496**	-0.378**	-0.224**	-0.246**	-0.269**	-0.178*
Salinity ($^{o}/_{oo}$)	-0.337**	-475**	-0.378**	-0.218**	-0.249**	-0.296**	-0.169*
Turbidity (NTU)	-0.358**	-0.559**	-0.5**	-0.218**	-0.249**	-0.283**	-0.14*
Suspended Solids (mg/L)	-0.354**	-0.567**	-0.458**	-0.219**	-0.26**	-0.26**	-0.157^{ns}
Alkalinity (mg/L $CaCO_3$)	-0.353**	-0.571**	-0.472**	-0.219**	-0.258**	-0.299**	-0.17*
Nitrate (mg/L NO_3^-)	-0.344**	-0.558**	-0.469**	-0.24**	-0.248**	-0.268**	-0.16*
Ammonium (mg/L NH_4^+	-0.366**	-0.581**	-0.464**	-0.217**	-0.259**	-0.292**	-0.167*
Oxydability (mg/L)	-0.34**	-0.554**	-0.458**	-0.241**	-0.26**	-0.5**	-0.16^{ns}
Current Velocity (m/s)	0.063^{ns}	0.115^{ns}	0.069^{ns}	0.03^{ns}	0.035^{ns}	0.036^{ns}	0.019^{ns}
Phosphates (mg/L PO_4^{3-}	-0.361**	-0.544**	-0.46**	-0.243**	-0.257**	-0.255**	-0.16**
BOD (mg/L)	-0.367**	-0.581**	-0.464**	-0.222**	-0.249**	-0.298**	-0.163*
Water Depth (m)	0.3**	0.411**	0.418**	0.159**	0.209**	0.282**	0.17*
Canopy Coverage (%)	0.649**	0.763**	0.768**	0.352**	0.41**	0.472**	0.271*
Water Width (m)	0.029^{ns}	0.026^{ns}	0.073^{ns}	0.017^{ns}	0.005^{ns}	0.077^{ns}	0.07^{ns}

*or ** correlation is significant at the level P≤ 0.05 or 0.01 respectively.
ns: non-significant correlation

Table.3 Macroinvertebrate taxa

Taxa					
Class	Order	species	S1	S2	S3
Insecta	Diptera	Chironomus larva	2[a]	1[a]	1[a]
	Plecoptera	Leutra species	3[a]	1[a]	1[a]
	Hemiptera	Belostoma species	1[a]	2[a]	-
Crustacea	Decapoda	Callinectes sapidus	1[a]	-	-
		Litopenaeus vannamei	84[a]	63[a]	52[a]
		Johngarthia logostoma	6[a]	6[a]	3[a]
Gastropoda	Family(Lymnaeidae)	Lymnaea species	2[a]	1[a]	-
		(Viviparous) species	1[a]	3[a]	1[a]

In the same row abundance is of macroinvertebrates species followed by different letters are significantly different at P≤0.05. (-) absence

Table.4 Composition and Relative Abundance of Macroinvertebrate in the Ndongo River

composition	Stations							
	S1		S2		S3		Total	
TAXA	No	%	No	%	No	%	No	%
MOLLUSCA								
Gastropoda								
Lymnaea species	2	1.82	1	0.91	-		7	13.32
Vivparous species	1	0.91	3	4.12	1	0.92	5	7.95
ARTHROPODA								
INSECTA								
Hemiptera								
Belostoma species	1		2		-		3	1.12
Plecoptera								
Leutra species	1	0.91	3	2.73	1		4	1.68
Chironomus larva	-		2	2.62	1	0.91	3	1.12
CRUSTECEAN								
Decapoda								
Litopenaeus vannamei	84	76.4	63	62.9	52	58.5	199	75.8
Johngarthia logostoma	6	6	8	7.4	3	3.91	17	9.8
Callinetctes sapidus	-		1	1.22	-		1	0.52
Total Number of Taxa	**4**		**4**		**4**		**12**	
Total Number of Individual	**95 40.4**		**82 34.8**		**58 24.8**		**235 100**	

Station 1: Bokoko Station 2: Ndongo quarter to dirty south and Station 3: Mile 17 to Mile 17 car washing point

Table.5 Diversity Indices of Macroinvertebrate of River Ndongo

Stations	Station 1	Station 2	Station 3	Total
Margalef's diversity (d)	0.979	1.045	0.610	2.634
Shannon weiner (H)	0.732	0.457	0.295	1.848
Equitability (E)	0.251	0.191	0.057	0.499

In fact, Buea is closer to the sea compared to Yaoundé and it is known that many crustacean species have their larval stages in brackish or marine water (N'Zi *et al*., 2008). Our species richness is greater than that obtained by Camara *et al*. (2009) in Banco River (3 species) and slightly lower than that recorded by N'Zi *et al*., (2008) in Boubo river where 9 species were identified in 19 sampling sites.

The low abundance and distribution of macroinvertebrate in station 3 can be explained by the very poor water quality of this section of the Ndongo stream due to uncontrolled discharge of domestic, urban and industrial wastes and sewages in the rivers.

Spearman correlation and redundancy analysis which showed negative influence of polluted water on macroinvertebrate distribution confirm this hypothesis. This observation corroborated the results of N'Zi *et al.* (2008) which showed the decrease of macroinvertebrate species richness downstream of the outlet of the effluents of a palm oil industry in the river Boubo. The results obtained from this study are also in accordance with those of Foto *et al.* (2011 and 2013) which showed that in Yaoundé, macroinvertebrate were absent in urban streams of the Mfoundi river basin and present in suburban streams of the same ecological region. Several studies have shown that species richness, abundance and distribution of benthic macroinvertebrate assemblages are generally extremely influence by physicochemical water quality (Nicola *et al*., 2010; Wang *et al*., 2012; Morrissey *et al*., 2013; Colas *et al*., 2014). Among macroinvertebrate species caught, Litopenaeus vannamei was the most frequent and abundant. This specie is positively influenced by the fact that it is filter feeder and can tolerate low dissolved oxygen content of water. This observation confirms that of Foto *et al*. (2013) who also found positive correlation between *Litopenaeus vannamei* and dissolved oxygen concentration. Similarly, N'Zi *et al.* (2008) documented that the distribution of this specie was influenced by canopy coverage. It was follow by Johngarthia logostoma which also requires good water quality. In the midst of Palaemonidae, *Callinetctes sapidus* a large- egged species which was first said to be endemic to Ivory Coast (Powell, 1980; Camara *et al*., 2009), appear to be a first record for Cameroon.

This testified that in Cameroun, biodiversity of freshwater macroinvertebrates is yet entirely to be investigated. Indeed, Ndongo is a small head watershed river with just 46 km length and 2.5 m mean width. Callinetctes sapidus a very rare and small size crustacean was present only in station S2 with very low occurrence and abundance. The rarity of this crustacean even in brackish water has already been documented (Anker, 2001).

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