Journal of Applied Biosciences 48: 3306– 3315

ISSN 1997–5902

# Ciliates community distribution and saprobic evaluation of an urban hydrosystem: The Biyeme stream Cameroon (Central Africa)

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Originally Submitted on 22nd September 2011. Published online at www.m.elewa.org on December 29, 2011.

## ABSTRACT

*Objective:* This work aims to evaluate the pollution status of the Biyeme stream using ciliates community, in order to determine the influence of organic pollution on their composition, distribution and their use as water quality indicators.

*Methodology and results:* Thirty-four genera and 49 species were identified using classical methods, among which 14 species are bioindicators of saprobity with 6 (β or β-α mesosaprobic species) having high frequencies at stations Biyeme 1, 2, and 3. The similarity coefficient of Sorensen showed a close resemblance among the ciliates fauna of station Biyeme 1 and 2 (67.69%) with low similarity between stations 1 (36.4%), 2 (44.0%) and 3 (48.8%) with station 4. At stations Biyeme 1, 2, and 3, low values of Shannon and Weaver, Pielou index and dissolved oxygen were observed, while the values of chemical indicators of organic pollution ($PO_4^{3-}$ COD, $BOD_5$, $N0_3^-$) were high. The combination of physico-chemical parameters and ciliates communities have enabled to evaluate the pollution level of an urban hydrosystem in Cameroon. These results show that the Biyeme stream could be classified as alpha to beta-mesosaprobic (stations Biyeme 1, 2 and 3) and oligosaprobic (station Biyeme 4) following the importance of anthropic action exerted along the stream.

*Conclusion and application*: Appropriate disposal of organic waste substances is a primordial sanitary measure to maintain the stream in its natural state therefore rendering it available for human use.

**Keywords:** Ciliates community, organic pollution, constant species, saprobity, Biyeme stream, Cameroon

## INTRODUCTION

Free-living ciliates may be found almost anywhere in which there is liquid water, but species found depend on the type of habitats. Ciliates may consume up to 90% of the production of planktonic bacteria and algae (Arridt, 1993). Large ciliates are common in freshwater environments, in particular those that have been organically enriched (Lobban & Schefter, 2008). The seasonally adapted strategy of infiltration and the extraction of water in and out of the aquifer according to the hydrological properties of the streams, delimits the water protection for purposes of sustainability in most ecological analysis (Balke & Zhu, 2008). By listing and counting the ciliates species in a sample of water, it is possible to estimate quickly how much organic material which could include pollution is present. Studies conducted to evaluate water quality were previously based on physical and chemical characteristics of water (Norris & Thoms, 1999). These parameters not coupled with biotic community do not provide enough evidence to completely evaluate water quality. Physical and chemical parameters combined to biological components have been demonstrated as important tools in the evaluation of water quality in rivers and streams, and have contributed much to determine the level of organic pollutants in urban lotic systems (Madoni & Zangrossi, 2005; Madoni & Braghiroli, 2007), so as to establish sustainable management strategies. The high sensitivity of ciliated protozoa to changes in their environment coupled with their high reproduction rates and variety of trophic niches (bacterivores, algivores, carnivores, omnivores), enable them to respond more quickly to environmental contamination than other organisms, giving them the advantage to be used as bioindicators (Madoni & Zangrossi, 2005). The inflow of organic pollutants to aquatic ecosystems increases the amount of phosphates and other factors altering the bacterial community structure, what could contribute to changes in the community structure of protozoa and algae that, depend on these bacteria directly as food or indirectly for their metabolic products (Madoni & Zangrossi, 2005).Their sensitivity to physical and chemical parameters may be due to the fact that many protozoan have specific demands related to the characteristics of the environment that they live, such as the quantity of organic matter and dissolved oxygen which define the degree of pollution associated to particular species of protozoan indicators (Dias *et al*., 2008). Foissner & Berger (1996) defined four levels of pollution: polysaprobity (very heavily polluted), alpha-mesosaprobity (heavily polluted), beta-mesosaprobity (moderately polluted) and oligosaprobity (clean or slightly polluted). Beside these levels, exist the transitional types such as alpha- Beta mesosaprobity (moderately to heavily polluted), oligo- Beta mesosaprobity (slightly to moderately polluted) and poly-alpha mesosaprobity (heavily to very heavily polluted).

Many studies have evaluated the composition, distribution and dynamics of ciliates communities in lotic systems (Foto *et al*., 2006; Dias *et al*., 2008; Ajeagah *et al*., 2010), with their value as water quality (Madoni & Zangrossi, 2005; Madoni & Braghiroli, 2007; Dias *et al*., 2008). There is some evidence that ciliates may take part in the transfer and transformation of potential pollutants in most ecosystems (Ajeagah *et al*., 2010).

The present work aims to: (1) Evaluate the pollution status of the Biyeme stream, the major tributaries of the Mfoundi River Basin in Cameroon, by measuring the physico-chemical, and biological variables from upstream to downstream with reference to the anthropogenic and natural pressure exerted in the hydrosystem. (2) Determine the influence of organic pollution on the composition and distribution of ciliates community and their use as water quality indicators.

## MATERIAL AND METHODS

**Description of sampling sites:** The Centre-South forestry region of Cameroon is located between 3°30' - 3°58' of latitude Nord and between 11°20' - 11°40' of longitude East (Santoir, 1995). The average altitude attends 750 m, the relief is globally accidental and the zone extends on many high hills of 25 to 50 m below the plateau.This region is exposed to an equatorial climate of a specific type, known as "the Yaounde Climate", which is characterised by moderate precipitations (1576 mm/year) and a temperature which varies lowly with time (Zebazé Togouet, 2011). Four unequal seasons which vary from one year to another: a long dry season (Mid November to mid March), a small rainy season (Mid March to the end of June), a short dry season (July to Mid August) and a long rainy season (Mid August to mid November) were elucidated (Kuété M, 1987). The length of the Biyeme stream (11.6 km), makes it the most important right tributary of the Mfoundi River Basin. It's river basin ( 22.84 km$^2$), flows through the Mvog-Betsi, Etoug-Ebe, and Biyem Assi quarters to the North, Nsimeyong 1 and 2 to the Centre, Eastern part of Mendong and Simbock, Western part of Nsam, then Ahala 1 and 2 to the South, with the exception of the last quarter of the stream which flows through a semi forestry zone (about 2300 m). After the upper part of the stream, the Biyeme flows through a marshy area that is highly anthropised, in which the river is transformed into a garbage and sewage pipe that constitute a high blockage of the waterway.

Samples were collected in the morning (8 to 10 a.m.) from March to August 2005, once to twice a month in order to respect the same time interval between two consecutive sampling and during 8 campaigns. Four sampling stations were selected namely: stations Biyeme 1 (B 1), Biyeme 2 (B 2), Biyeme 3 (B 3) and Biyeme 4 (B 4) for this hydrobiological and eco-environmental research on the Biyeme stream.

Biyeme 1 (3°50'52.4''N and 11°29'4.0''E) is located at 2.1 km from the source, some 40 m below the bridge linking Biyem-Assi and Etoug-Ebe. There is a metal workshop and a piggery that discharge their liquid and solid waste into the stream. The bottom comprises mud and is 1.5 m wide, with a flow rate of 0.30 m/s. Biyeme 2 (3°50'16.3''N and 11°29'15.4''E) is located at 3,35 km from the source, and some 50 m below the "Niki shop" of Biyem - Assi. An important source of pollution constituted of effluents from the non functional macrophyte station located some 200 m before the sampling point. The bottom is made of mud, and measures 2.5 m wide, with a flow rate that is about 0.35 m/s. Biyeme 3 (3°49'38.5''N and 11°29'5.8''E) is located at Nsimeyong II, and found at some 5.2 km from the source . The right border is being harboured by some houses , whose latrines are directly connected into the stream to release domestic wastewater. The water bed is made of mud, and measures 3,3 m wide, with a flow rate of 0.20 m/s. Biyeme 4 (3°47'40.0''N and 11°29'29.4''E) is situated on the lower course of the stream, at a quarter known as Ahala 2 which is 8.60 km from the source, in a lowly inhabited area, after haven't flown through some semi-forestry zone that is presented on a 2 km distance from the trajectory. Eventhough this station look clearer with respect to the previous stations, this biotope remains under anthropogenic activities. There are numerous washing points that are presented at this part of the stream. The waterbed is muddy, and measures 6.6 m wide, for a flow rate of 0.39 m/s.

**Physico-chemical parameters:** Measuring of physical and chemical parameters of water at the different sampling points was done according to Rodier (1996) and APHA (1998). The parameters recorded were temperature, pH, conductivity, organic mater ($BOD_5$ and COD), percentage of oxygen saturation, phosphates, and nitrates.

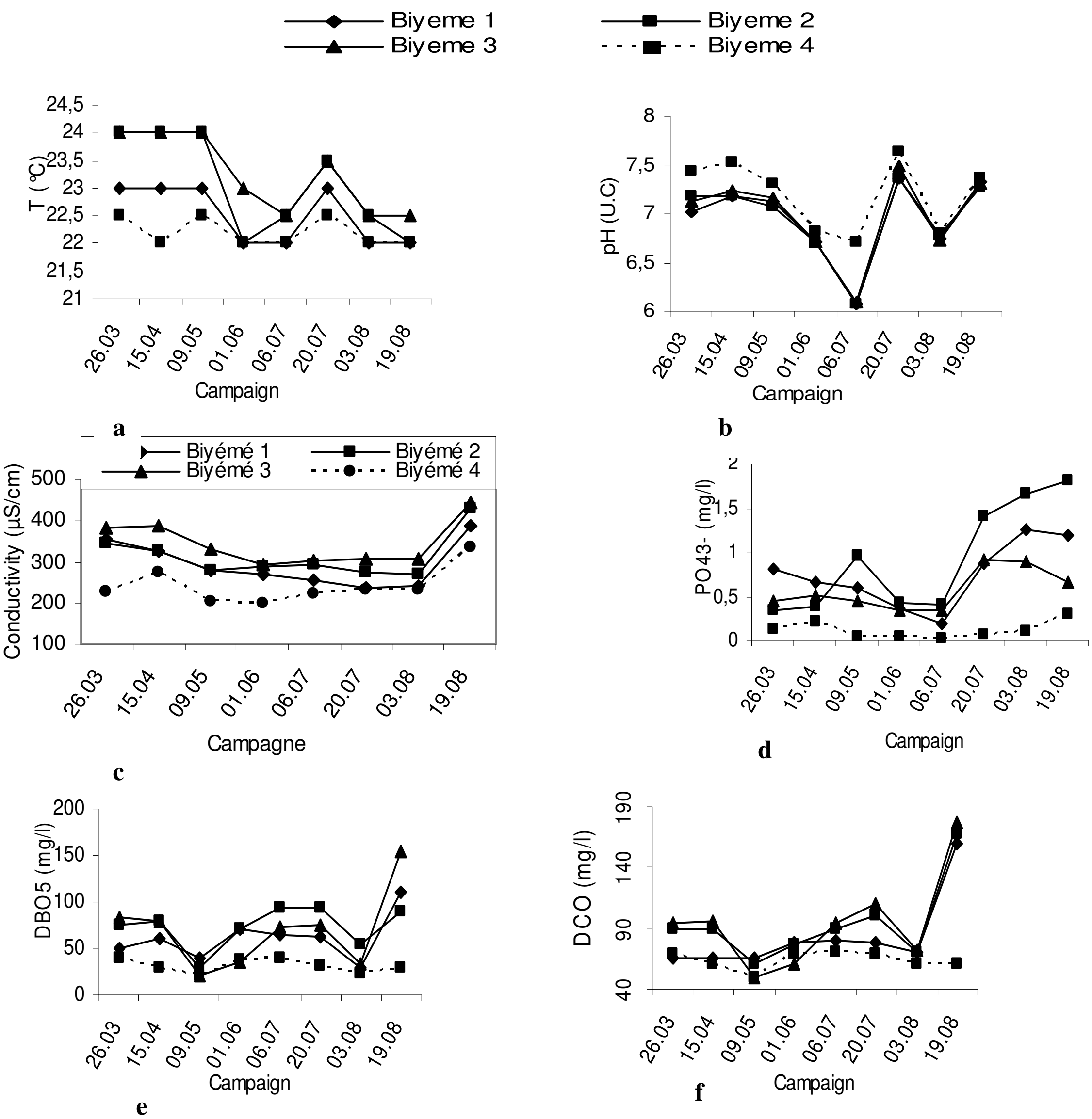
**Biological parameter:** Ciliates were collected using direct method (Sime-Ngando *et a*l., 1990). Samples were examined in the laboratory within 4 hours so as to reduce predation of some ciliates on others and identification and counting of ciliates species in each sample were made *in vivo* under a stereoscopic microscope Wild M 5. Impregnation was done when necessary following Fernandez-Galiano (1976) to reveal infraciliature of the ciliates. The identification keys of Dragesco & Njiné (1971), Dragesco & Dragesco-Kerneis (1986) were used.

**Statistical treatment:** Species constance which corresponds to the ratio of number of samples containing the species studied on the total number of samples collected was used to characterised each station (Dajoz, 1982). Three categories of species were defined: constant species (frequency more than 50%), accessory species (frequency between 25% and 50%) and accidental species (frequency less than 25%).

The parametric and non parametric analysis of variance tests (One way ANOVA and Kruskal-Wallis) were used to compare the values of the physical and chemical parameters among the different stations. The level of statistical significance was at least 5% ($P \leq 0.05$).The degree of similarity among the ciliate community between the different stations was determined using the qualitative similarity index of Sorensen (Magurran, 1988). The index of Shannon and weaver which permit to study the regularity of species distribution and Pielou which gives the quality of species organisation.

## RESULTS AND DISCUSSION

**Physico-chemical results:** Temperature varied between 22°C and 24°C along the Biyeme stream with higher values (24°C) recorded at midstream in the months of March, Apiril and May (Biyeme 2) and lower values (22.0°C) at downstream in the months of April, June, July and August (Biyeme 4) (Figure 1 a). There was a significant difference between the stations Biyeme 1 and 3 ($P = 0.03$), 2 and 4 ($P = 0.04$) and 3 and 4 ($P = 0.003$). The pH values varied between 6.07 and 7.6 with no significant difference observed between the stations (Figure 1b). High values of conductivity were recorded at the stations Biyeme 1, 2 and 3 in the months of March, April and August (station Biyeme 1) (Figure 1c). A significant difference was observed between the station Biyeme 1 and 4 ( $P = 0.05$), 2 and 4 ($P = 0.01$) and 3 and 4 ($P = 0.001$). High values of phosphates were obtained upstream in the month of August (1.8 mg/L at station Biyeme 2) compared to downstream (0.3 mg/L at station Biyeme 4) (Figure d). This variation showed a significant difference between the stations Biyeme 1 and 4 (P = 0.0004), 2 and 4 (P = 0.001) and 3 and 4 (P = 0.0001). The rates of biochemical oxygen demand ($BOD_5$) and chemical oxygen demand (COD) showed a progressive increase from the month of June in stations Biyeme 2 and 3 despite the sharp decrease observed during the month of August (Figure 1e and f). These values were significant for $BOD_5$ between the station Biyeme 1 and 4 (P = 0.01) and 2 and 4 (P = 0.004), and for COD between the stations Biyeme 1 and 4 (P = 0.04), 2 and 4 (P = 0.01) and 3 and 4 (P = 0.04). Apart from the station Biyeme 2, where the values of nitrates reached 0.3 mg/L, the other stations were characterised by low values (Figure 1g), with the difference observed between the different stations being not significant. Variation of dissolved oxygen showed that water was more oxygenated at the stations Biyeme 1 and 4 compared to stations Biyeme 2 and 3 (Figure 1h). Globally, the rate of dissolved oxygen decreased in the month of July when the lowest values were recorded at the stations Biyeme 2 and 3 (42.34%). This variation showed a significant difference between the stations Biyeme 1 and 3 (P = 0.002), 2 and 4 (P =0.03) and 3 and 4 (P = 0.002).



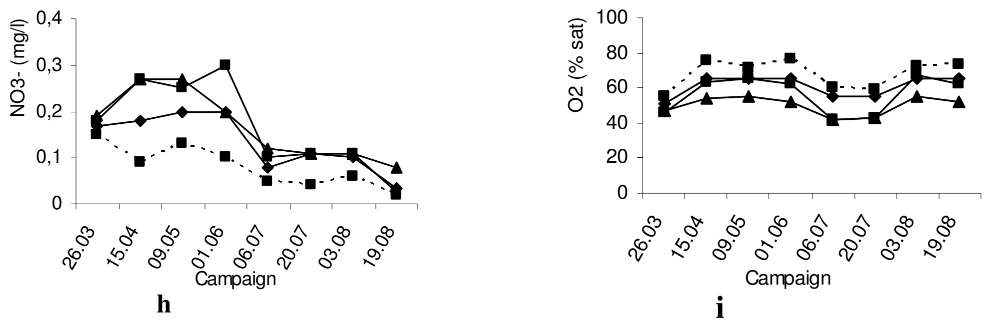



**Figure 1:** Variation of physicochemical parameters during the study period ( a: Temperature; b: pH; c: Conductivity; d: Phosphates; e: Chemical oxygen demand: f: Biochemical oxygen demand; g: Nitrates; h: Dissolved oxygen).

**Biological results:** A total of 34 genera and 54 species were identified during the study period. Among these, 17 species and 5 genera were identified for the first time. The number of species, density and specific richness reduced progressively from upstream to downstream (Table1 and figure 2a). In Biyeme 1, 35 species of ciliated protozoa were identified among which 5 were constant species *(Euplotes amieti*, *E. patella*, *Paramecium africanum, P. aurelia* and *Urocentrum turbo)*, 12 accessory and 18 accidental. In Biyeme 2, out of the 28 species identified, 4 were constant *(E. amieti, E. patella, P. africanum,* and *P. aurelia*), 14 accessory and 11 accidental. Out of the 20 species identified in Biyeme 3, 4 were constant species (*E. amieti, E. patella, P. africanum and P. Aurelia),* 7 accessory and 9 accidental. The station Biyeme 4 was characterised by the absence of constant species, 4 accessory and 15 accidental species (Table 1 and 2). Six species (*Euplotes amieti*, *Euplotes charon*, *Euplotes patella*, *Glaucoma scintillans*, *Paramecium aurelia* and *Urocentrum turbo*) occurred at all the sampling stations. A total of 24 species occurred only at one station at very low values of both frequency and abundance: *Caenomorpha medusula*, *Carchesium polypinum, Didinium nasutum, Hemiophrys meleagri*, *Paraglaucoma sp., Porodon africanus, Spathidium muscicola, Spathidium spathula*, *Stentor coeroleus*, *Stentor gallinulus* and *Vorticella sp.* (Station Biyeme 1); *Metopus spiralis* and *Pleurotricha lanceolata* (Station Biyeme 2); *Amphileptus pleurosiga*, *Colpoda cucullus, Frontonia vesiculosa*, *Frontonia atra*, *Metopus sp* and *Stentor niger* (Station Biyeme 3); *Amphileptus claparedei, Colpidium campylum, Dileptus tenius, Lembadion lucens* and *Metopus mirabilis* (Station Biyeme 4) (Table 1).

Among the species identified, 14 are bioindicators of saprobity: *E. patella, F. leucas*, *U. turbo* and *V. campanula* (β- mesosaprobic), *E. charon* and *P. aurelia* (β- α mesosaprobic*), C. hirtus*, *S. minus* (α -β mesosaprobic), *C. medusula, M. spiralis, Metopus sp.,* and *P. caudatum* (polysaprobic), *Stentor coeroleus* (α-mesosaprobic), and *H. grandinella* (α- oligo-mesosaprobic). The degree of similarity among ciliates fauna at the four sampling stations showed a close similarity between station Biyeme 1 and 2, while a low resemblance is observed between stations Biyeme 1 (36.4%), 2 (44.0%) and 3 (48.8%) compared with station Biyeme 4, and between station Biyeme 2 and 3 (43.13%) (Table 3). Relatively low values of Shannon and Weaver, and Pielou index were observed at stations Biyeme 1, 2, and 3 compared to station Biyeme 4 (Figure 2a).

**Table 1:** List of ciliate species and number sampled at each stations (B1, B2, B3, B4) with their occurrence frequency given in bracket

| Ciliates species | B1 | B2 | B3 | B4 |
|---|---|---|---|---|
| *Amphileptus claparedei* * | - | - | 20(1) | - |
| *Amphileptus pleurosiga* * | - | 12(1) | - | - |
| *Caenomorpha medusula* | 48(1) | - | - | - |
| *Campanella umbellaria* * | 23(2) | 15(2) | - | - |
| *Carchesium polypinum* * | 45(1) | - | - | - |
| *Chilodonella uncinata* | 12(1) | 12(1) | - | - |
| *Coleps hirtus* | 12(1) | - | - | 9(1) |

| | | | | |
|---|---|---|---|---|
| *Colpoda cucullus* | - | 7(1) | - | - |
| *Colpidium campylum* | - | - | - | 9(1) |
| *Colpidium colpoda* | 192(1) | 7393(2) | 155(2) | - |
| *Didinium nasutum* | 71(3) | - | - | - |
| *Dileptus tenius* * | - | - | - | 96(1) |
| *Euplotes amieti* | 477(5) | 1392(8) | 1532(5) | 76(2) |
| *Euplotes charon* | 369(3) | 464(4) | 378(4) | 18(1) |
| *Euplotes patella* | 3041(7) | 3808(8) | 3003(7) | 100(3) |
| *Frontonia atra* | - | - | 64(2) | - |
| *Frontonia leucas* | 48(1) | 37(1) | - | - |
| *Frontonia vesiculosa* | - | - | 20(1) | - |
| *Glaucoma scintillans* | 212(4) | 43(2) | 235(2) | 209(3) |
| *Halteria grandinella* | 155(3) | 19(2) | - | - |
| *Hemiophrys meleagri* * | 11(1) | - | - | - |
| *Hemiophrys pleurosigma* * | - | - | 162(1) | 41(1) |
| *Histriculus histriculus* | 45(1) | 47(1) | - | - |
| *Holosticha camerounensis* | 24(1) | 56(2) | - | - |
| *Keronopsis longissima* | - | - | 55(1) | 40(1) |
| *Lembadion lucens* | - | - | - | 32(1) |
| *Litonotus quadrinucleatus* | 48(1) | 12(1) | - | - |
| *Metopus mirabilis* * | - | - | - | 40(1) |
| *Metopus sp* | - | - | 105(2) | - |
| *Metopus spiralis* * | - | 47(1) | - | - |
| *Paraglaucoma sp* * | 58(2) | - | - | - |
| *Paramecium africanum* | 1565(7) | 3409(5) | 1647(7) | - |
| *Paramecium aurelia* | 3211(7) | 4973(7) | 3563(7) | 55(2) |
| *Paramecium caudatum* | 198(4) | 760(2) | - | 40(1) |
| *Paramecium jankowski* | 189(2) | 7(1) | 650(2) | - |
| *Paramecium trichium* * | 404(3) | 777(2) | - | - |
| *Pleurotricha lanceolata* | - | 12(1) | - | - |
| *Prorodon africanus* | 48(1) | - | - | - |
| *Prorodon armatus* * | 23(2) | 12(1) | - | 15(1) |
| *Prorodon ovalis* | 144(1) | 49(2) | - | - |
| *Pseudoglaucoma sp* * | 144(2) | - | 54(1) | - |
| *Spathidium muscicola* | 48(1) | - | - | - |
| *Spathidium spathula* | 12(1) | - | - | - |
| *Spirostomum minus* | - | 158(3) | 162(1) | 32(1) |
| *Stentor caudatus* | - | 54(2) | 54(1) | - |
| *Stentor coeroleus* | 11(1) | - | - | - |
| *Stentor gallinulus* * | 34(1) | - | - | - |
| *Stentor niger* | - | - | 20(1) | - |
| *Tachysoma sp* * | 48(1) | - | - | 32(1) |
| *Urocentrum turbo* | 348(5) | 92(2) | 520(4) | 80(1) |
| *Uronema sp* * | - | 20(1) | - | 63(1) |
| *Urosoma acuminata* | - | - | 41(1) | 144(1) |
| *Vorticella campanula* | 127(4) | 69(3) | - | - |
| *Vorticella sp* * | 34(1) | - | - | - |
| **Total** | 35 | 28 | 20 | 19 |

*: species identified for the first time

**Table 2:** List of constant species sampled at each station and their saprobity levels (S)

| Species | Stations | | | | S |
|---|---|---|---|---|---|
| | B1 | B2 | B3 | B4 | |
| *Euplotes amieti* | + | + | + | - | - |
| *Euplotes patella* | + | + | + | - | β |
| *Paramecium africanum* | + | + | + | - | - |
| *Paramecium aurelia* | + | + | + | - | β - α |
| *Urocentrum turbo* | + | - | - | - | β |

β: beta-mesosaprobity; β -α: beta-apha mesosaprobity, S: saprobity level; +: present; -: absent

**Table 3:** Sorensen's similarity index (%) among stations applied to ciliates communities

| **Stations** | **B1** | **B2** | **B3** | **B4** |
|---|---|---|---|---|
| B1 | - | 67.69 | 40.0 | 36.4 |
| B2 | | - | 43.13 | 44.0 |
| B3 | | | - | 48.8 |
| B4 | | | | - |

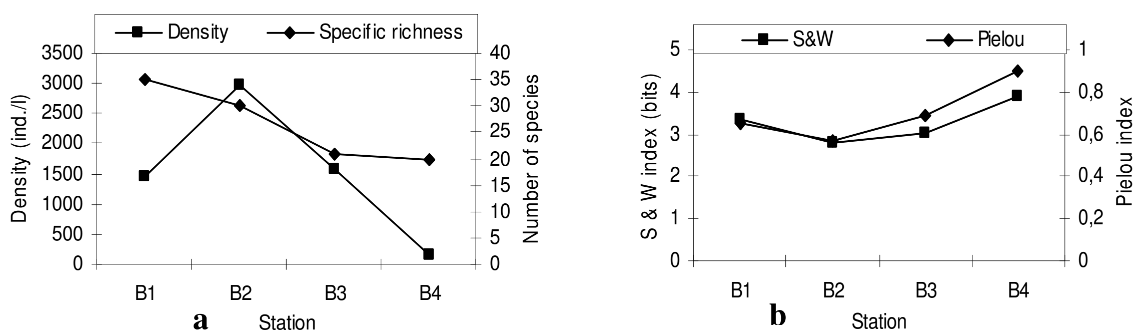



**Figure 2:** Spatial evolution of the specific richness and population densities of ciliates (a) and variation of Shannon and Weaver, and Pielou index (b) at the four sampled stations.

## DISCUSSION

Temperature values recorded along the Biyeme stream (between 22°C and 24°C) indicates that its water is relatively hot, according to Foto Menbohan *et al.* (2006) who showed that water with temperature variation situated between 22.4°C and 26.5°C are considered to be relatively hot. The significant difference in temperature observed between the stations Biyeme 1, 2 and 3 and Biyeme 4 could reflect the impact of the forest which is situated immediately before the station Biyeme 4, which serve as a canopy, preventing solar rays from reaching the water. The pH values situated between 6.7 and 7.6 indicate the neutral status of the water of the Biyeme stream, implying that the soil that stream crosses is homogeneous. This result is different from that obtained in the upstream station of Ake stream and the downstream of Abiergue where acid and basic pH was obtained respectively (Foto *et al.*, 2006). This reflects the observation of Nola *et al.* (1999) who showed that the pH of water depends on the type and nature of the soil that water crosses. Dissolved oxygen and conductivity are important variables in characterising water bodies and detecting sources of pollution (Von Sperling, 1996). The results of the physical and chemical characteristics such as low levels of dissolved oxygen, high values of conductivity and high values of chemical indicators of organic pollution ($PO_4^{3-}$, COD, $BOD_5$, $N0_3^-$) recorded at stations Biyeme 1, 2 and 3 as well as the high similarity among the ciliates fauna at station 1 and 2, and low similarity at the other stations (Table 3), implies that these stations are highly degraded. Also, the low values of Shannon and Weaver reflecting low species diversity, and Pielou index which reflect disequilibrium in the distribution of species, observed at stations Biyeme 1, 2, and 3 show that these stations are more subjected to stress. These observations are in line with the results obtained in an urban stream in Brazil (Dias *et al*. 2008). Among the 54 species identified during the study period, 17 species and 5 genera are cited for the first time in Cameroon. This seem to confirm the suggestion of Segers (1994) and Zebazé *et al*. (2006) who showed that the biodiversity of an area depends on sampling periodicity. The species *P. aurelia, E. patella* and *U. turbo* have been shown to develop in medium polluted by organic matter (Foissner, 1996; Dias *et al*., 2008). The presence of constant ciliates species (*P. aurelia, P. africanum, E. patella, E. amieti* et *U. turbo)* which could be considered as being characteristic of the stations Biyeme 1, 2 and 3 could reflect the fact that, these stations subjected to anthropic action, constitute favourable environment for their development, as observed in other studies (Bruno *et al*., 2005), following the presence of organic matters that lead to multiplication of bacteria, which are essential food sources of ciliates (Mazei & Burkovsky, 2006 ; Dias *et al*., 2008). The availability of food is an important biotic factor that controls the distribution of ciliated protozoan populations in the various ecosystems (Madoni & Zangrossi, 2005; Madoni & Braghiroli, 2007). The absence of constant species in the station Biyeme 4 as well as the low number of species, density and specific richness of ciliates fauna may be due to shortage of nutritive substances in this medium following low values of Nitrates, phosphates and organic matter (COD and $BOD_5$) (Dufour & Berland, 1999; Dias *et al*., 2008), reflecting results obtained in other zooplanctonic groups (Bouzidi *et al*., 2010). This lack of nutrients can cause ecological equilibrium disturbance of the medium, leading to a reduction of zooplankton community (Dufour & Berland, 1999; Dias *et al*., 2008). The remarkable frequency of ciliates population observed in the stations Biyeme 1, 2, and 3 has equally been observed in other highly degraded streams of the Mfoundi river basin (Foto *et al*., 2006). The occurrence of *U. turbo* in all stations of the Biyeme stream could reflect a high ecological valence characterising this species, what has equally been reported along rivers with different saprobic levels, (Madoni & Bassanini, 1999; Dias *et al*., 2008). This affirmation is contrary to that of Foissner & Berger (1996) who showed that this species develops only in less polluted medium. The species that occurred at all stations (Table 1) could be considered as true cosmopolitan or ubiquitous species. Among the species that occur in all the collection stations, *P. aurelia* is exclusively bacterivorous, *G. scintillans* is algivorous while *E. patella, E. amieti, E. charon* and *U. turbo* are omnivorous. The omnivorous feeding habits of some ciliates species can permit them to develop in diversify ecosystem (hard waters and polluted streams), as has been the case in studies carried out in other areas (Dias *et al*., 2008). Some of the species that occurred only at one station were anaerobic ciliates such as *M. spiralis* and *Metopus sp*. which have the capacity of developing in polluted water (Madoni & Zangrossi, 2005). The number of *Vorticella sp* individuals (34) and low frequency (1) recorded during this study is quite low compared to that obtained by Foto *et al*. (2006), where relatively high abundance and density were obtained. This difference may indicate the high level of stress that the Biyeme stream has been subjected to during the past years. Studies on hydrosystems subjected to anthropic impacts have showed the presence of β-α - mesosaprobic and polysaprobic species (Madoni & Zangrossi, 2005; Madoni & Braghiroli, 2007; Dias *et al.,* 2008). This could explain the increasing proportion of *P. aurelia* (β-α mesosaprobic species) at stations Biyeme 1, 2 and 3, *Metopus sp*. at station Biyeme 3 and *P. caudatum* at station Biyeme 1 and 2 (polysaprobic species). Studies related to freshwater protozoa (Patterson, 1996) classified species of the genera *Metopus, Caenomorpha* and *Spirostomum* as anoxic benthonic ciliates in a community called "Metopetum" (Foissner & Berger, 1996), which is composed mainly of strictly anaerobic organisms, deprived of mitochondria and present sulphurous bacteria as symbionts, being infallible indicators of the presence of sulphurated hydrogen in the water, indicating highly polluted medium. However, the presence of *Spirostomum sp.* at the station Biyeme 4 at a relatively low frequency may simply be accidental following punctual pollution.

The combination of physical parameter and ciliates communities have enabled the characterisation of the Biyeme stream. The high number of species recorded at upstream and midstream (Stations Biyeme 1, 2 and 3), same as the presence of characteristics species observed reflect the high organic loads at these stations due to anthropic action, compared to downstream (station Biyeme 4). These results show that the Biyeme stream could be classified as alpha to beta-mesosaprobic (stations Biyeme 1, 2 and 3) and oligosaprobic (station Biyeme 4). Proper disposal of organic waste substances is therefore a primordial sanitory measures to combat the prevailing disposal of garbage and sewage in urban aquatic ecosystem, what will permit to reduce pollution of water systems and develop strategies for their exploitation for human needs.

**ACKNOWLEDGEMENT**

The authors would like to thank Dr. Nkengazong Lucia for her valuable assistance in building up the manuscript.

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