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Effect Of The Physico-Chemical State Of The Water Of The Okpara River On The Distribution Of Macroinvertebrates In Northern Bénin

Tayéwo Sylvain Biaou[1], Fadéby Modeste Gouissi[1]*, Hotekpo Hervé Akodogbo[2], Koudjodé Simon Abahi[1], Nonvignon Martial Fassinou[1], Souradjou Orou Goura[1], Wakili Bolatito Yessoufou[1]

[1]Université de Parakou (UP), Faculté d'Agronomie (FA), Laboratoire d'Ecologie, de Santé et de Productions Animales (LESPA), BP 123 Parakou, Bénin

[2]Université d'Abomey-Calavi (UAC). Ecole Polytechnique d'Abomey-Calavi (EPAC). Laboratoire de Recherche en Biologie Appliquée (LARBA). BP 526 Cotonou (Bénin)

*Corresponding Author: Fadéby Modeste Gouissi Téléphone: (229) 97534735 ; E-Mail: gouissi@yahoo.fr

Abstract – The purpose of this work is to study the physico-chemical state of the water of the Okpara river of Bénin on the distribution of macroinvertebrates. Eight sampling stations were retained. The principal components analyses (PCA) of physico-chemical and canonical correspondence analysis (CCA) were used. The results of these analyzes revealed that the temperature, the pH, the depth and the transparency are the parameters which condition more the distribution of the macroinvertebrates. A strong link was observed between polluo-resistant families and temperature. The results from the principal components analysis (PCA) of the physico-chemical parameters showed four groups of stations and highlighted the following assemblages: (i) the group of Tébo, Yéroumarou stations characterized by high temperature values ; (ii) the group of Binassi and Kpassa stations with high pH values; (iii) the group of Wora and Kaboua stations marked by high values of conductivity and TDS and (iv) the group of Gbéré and Igbodja stations with high values of transparency and depth. This characterization of the physico-chemical parameters of the water of the Okapara river is an essential base for the establishment of a lasting management plan of the Okpara River.

Keywords – Physico-chemical parameters, Macroinvertebrate, Bioindicator, PCA, CCA

I. INTRODUCTION

The demographic expansion, the urbanization and agricultural intensification in developing countries like Bénin, is accompanied by a new problem which is the management of solid and liquid wastes. This is because these wastes are discharged without treatment into the waterways (lamizana-diallon, 2008). Thus, these ecosystems are more threatened by the impact of anthropogenic activities (Dudgeon et al., 2006). The OKpara river, one of the important tributaries of the Ouémé river, crosses several communes in the departments of Borgou and the Collines to flow into the Ouémé river in the Okpa village not far from Béteékoukou (Commune of Bassa-Zoumé). Along its route, it receives domestic, agricultural and industrial effluents which constitute a threat to the quality of the water and even to the boidiversity of this river. Thus, the characterization of the physico-chemical parameters of the waters of the Okpara river appear very important for the appreciation of the quality of this river which water constitutes the main source of drinking water for the surrounding populations. Macroinvertebrates are the most widely used organisms in biomonitoring systems in our days (Gnohossou, 2006; Benetti et al., 2012; Moisan et al., 2013). In an ecosystem, habitat characteristics such as the current speed, the nature and heterogeneity of the substrate, and the temperature constitute the main factors that influence the spatial distribution of benthic macroinvertebrates (Hynes, 1970). Thus, the physico-chemical nature of water conditions their development (Tuffery, 1980) and each organism is sensitive to different abiotic factors in its living environment (Gaujous, 1993).

In fact, several studies on the factors influencing the distribution of macroinvertebrates indicate that the macrofauna is affected by water temperature (Tenkiano, 2017), conductivity (Stanert et al., 2008), dissolved oxygen (Kaller and Kelso, 2007), flow velocity and substrates (Beauger, 2008). Similar results are lacking for Bénin's rivers, in particular for the Okpara river which is one of the most important tributaries of the Ouémé river. In addition, a better understanding of macroinvertebrate communities in relation to the environments is of great interest for the management of the rivers (Neff et Jackson, 2011). Thus, the purpose of the current study is to study the relationships between the physico-chemical parameters and the biodeversity of macro invertebrates of the Okpara river.

II. Material And Methods

2.1. Study environment

The study was carried out along the Okpara river, which is one of the tributaries of the Ouémé River. The Okpara river is located between 8º14'-9º45' north latitude and 2º35'-3º25' east longitude in the Borgou department and originates at an altitude of 450 m in southwest of Nikki to Pèrèrè. The Okpara has an irregular flow varying between 0.0001 and 150 m^3/s. it is approximately 362 km long with a basin of a total area of 10,000 km^2. Its basin largely covers the communes of Pèrèrè in the east, Nikki in the northeast, N'dali in the west, Parakou and Tchaourou in the south and finally a small part of the commune of Bèmbèrèkè in the North. The study area is subject to the influence of the South Sudanese climate, characterized by a long dry season (mid-October to April) followed by a wet period (May to mid-September). The average annual rainfall over the last ten years is 1028.90 mm with maximum rainfall amounts during the months of August and September. The annual average temperature is 27.92ºC. The sunshine is 2314.54 hours per year.

2.2. Sampling stations

In total, 08 stations (Figure 1) were chosen on the Okpara river after study. They were chosen according to the perenity of the water, the altitude, the accessibility in all seasons, the depth and the speed of the current (Abahi et al., 2018).

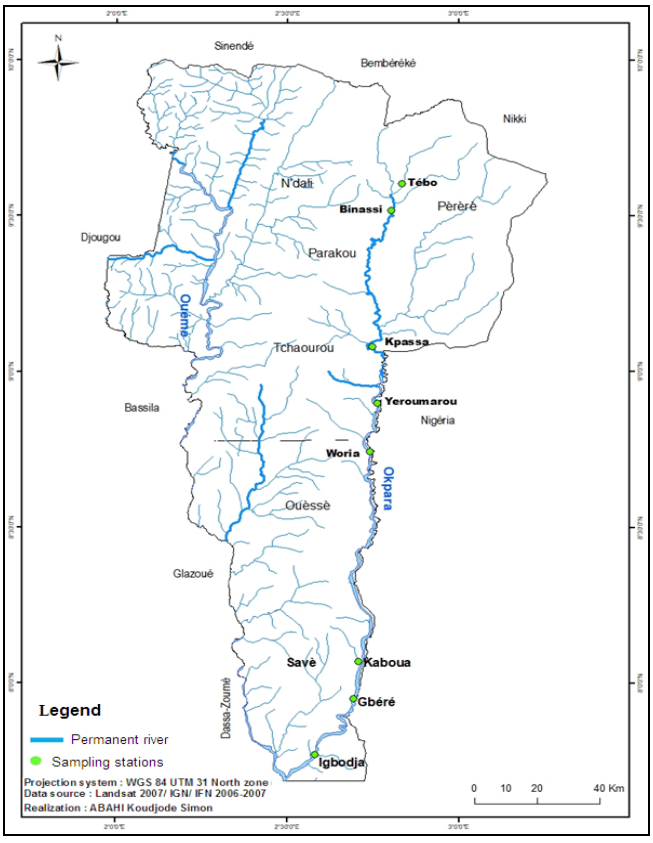

Figure 1: Geographic map of the Okpara river stations

2.3. Measurement of the physico-chemical parameters of water

The measurement of the physico-chemical parameters, namely the temperature, the transparency, the depth, the pH, the total dissolved solids (TDS) and the conductivity were measured in situ at 8 a.m. To 12 p.m. The temperature, the conductivity, and the TDS were measured with a Conductivity Meter HANNA HI 99300. The pH was measured with a pH Meter Hanna HI 98107. As for the transparency and the depth, they were measured with a Secchi disk of local origin. These different measurements were carried out before the sampling the macroinvertebrates to avoid every disturbance of the area of the environment capable of frustrating the results.

2.4. Statistical analysis of data

The abiotic typology of the eight sampling stations was made using the principal components analysis (PCA) using R3.4.2 software (R Core Team, 2018). Before testing the variability of the parameters with the parametric and non-parametric tests (Student's t test and Kruskal-Wallis test) at the 5% threshold, the normality test was carried out.

The data used are the matrices of the physico-chemical parameters measured and the faunistic lists of the macroinvertebrates. A canonical correspondence analysis of these different data (biotic and abiotic).

III. Results

3.1. Water quality of the Okpara river

The average values of the physico-chemical parameters measured are presented in the Table 1. All the physico-chemical parameters vary significantly between the sites (p values <0.009). For the pH, the highest value was observed at the Binassi station, while the lowest was observed at the Gbéré station. The stations located upstream were globally characterized by the high temperature values. As for the Tébo station (33.48º C), it has recorded the highest average temperature while the Igbodja station (26,67º C) has the lowest average in temperature. The stations located downstream are characterized by the high values of conductivity and TDS. Thus, the highest conductivity and TDS values were observed at Kaboua station while the weakest correspond to the Tébo station. The depth and the transparency have evolved in the same direction. The highest transparency and the depth were recorded at the Igbodja station downstream while the lowest values are observed at the Binassi station upstream.

Table 1: Physico-chemical characteristics of the water of Okpara river

Stations	Temperature	Conductivity	TDS	Transparency	pH	Depth
Tebo	33,48	34,67	17,33	16,00	7,24	18,67
Binassi	29,78	54,00	27,00	12,33	8,40	12,33
Kpassa	30,27	62,33	30,83	16,73	6,98	17,70
Yeroumarou	32,10	36,00	18,00	17,42	7,40	20,33
Woria	28,23	72,00	36,00	17,33	7,40	18,33
Kaboua	27,33	100,58	51,08	14,00	7,21	14,00
Gbere	28,97	76,00	38,00	31,67	7,18	29,67
Igbodja	26,87	65,33	31,67	42,00	7,34	56,33

3.2. Typology of stations

The principal component analysis (PCA) indicates that the information contained in the variables are explained at 82.06% by the first two axis (1 and 2) (Figure 2). The temperature, the conductivity and the TDS contribute more to the formation of the first axis while the temperature and the depth contribute more to the formation of the second axis.

The correlation circle (Figure 2) indicates that the conductivity ($r = 0.87$; $p = 0.004$), TDS ($r = 0.85$; $p = 0.006$) and temperature ($r = -0, 92$; $p = 0.017$), the significantly correlated with axis 1 while transparency ($r = 0.79$; $p = 0.017$), depth ($r = 0.84$; $p = 0.008$) are strongly and significantly correlated with axis 2.

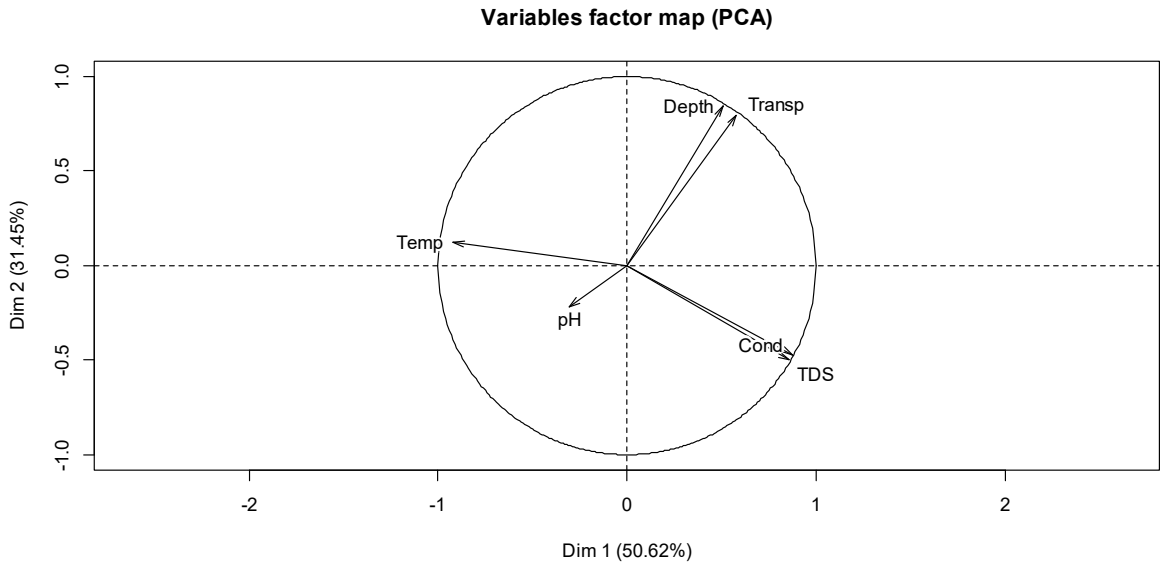

Figure 2: Circle of correlation of parameters on in the axis

The factorial map (Figure 3) shows the distribution of the eight sampling stations according to their physico-chemical characteristics. It made it possible to form four groups and to highlight the following assemblages: (i) the group of Tébo, Yéroumarou stations characterized by high values of temperature; (ii) the group of Binassi and Kpassa stations marked by high values of pH; (iii) the group of Wora and Kaboua stations marked by high values of conductivity and TDS and (iv) the group of Gbéré and Igbodja stations with high values of transparency and depth. In addition, the axis opposes the stations upstream to stations downstream.

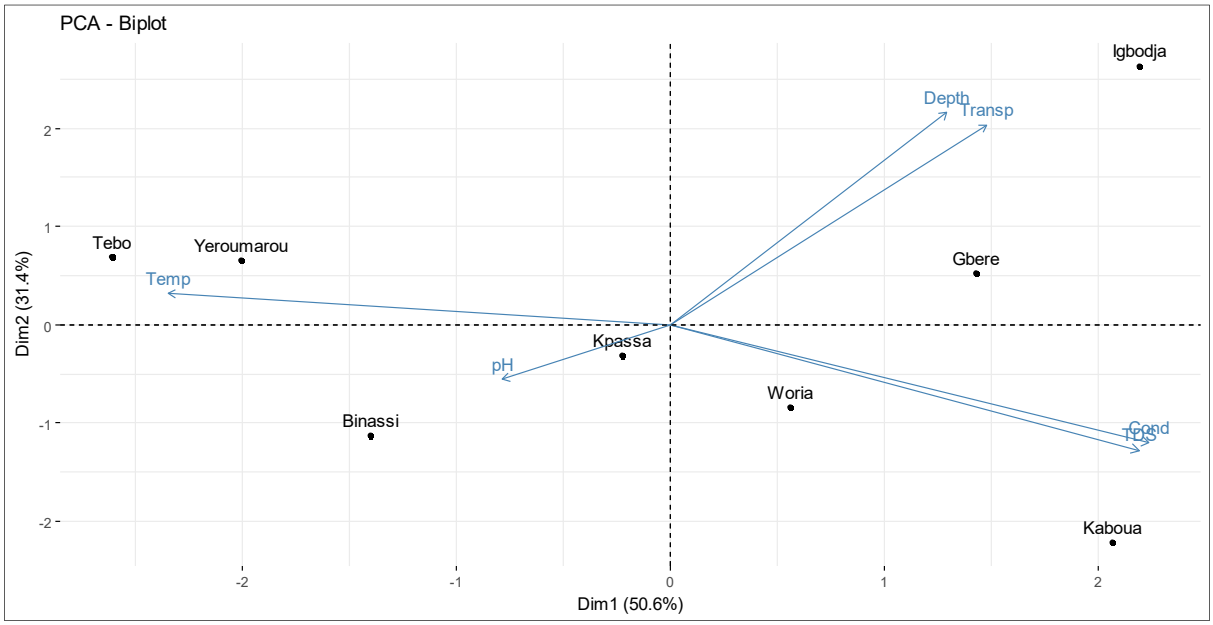

Figure 3: Distribution of physico-chemical parameters and stations

3.3. Relationship between macroinvertebrates and water quality

The canonical correspondence analysis (ACC) carried out between the physic-chemical parameters and the densities of the macroinvertebrates indicates that the information contained in the variables is explained at 72.48% by the system of axes 1 and 2.

The temperature, the pH, the depth and the transparency are the factors that most influence the distribution of macroinvertebrates. The two axis oppose the temperature to the physic-chemical parameters.

The first axis positively and strongly correlates with Limnaeidae, Hydracarids, Elimidae, to the transparency and the depth while it is strongly and negatively related to Glossiphoniidae, Perlodidae, Sphaeriidae, Hydrobiidae, Culicidae, Pyralidae, Baetidae, Lumbriculidae, Philopotamidae, Dytiscidae, Nemathelminthes, Hydrophilidae, Caenidae and temperature. The second axis is positively and strongly related to Elmidae, Perlidae, Dytiscidae, Caenidae, Sphaeriidae, Gloosiphoniidae and to temperature while it is strongly and Negatively associated with Libelludiae, Hydrophilidae, Philopotamidae, pyralidae, Potamanthidea and with pH.

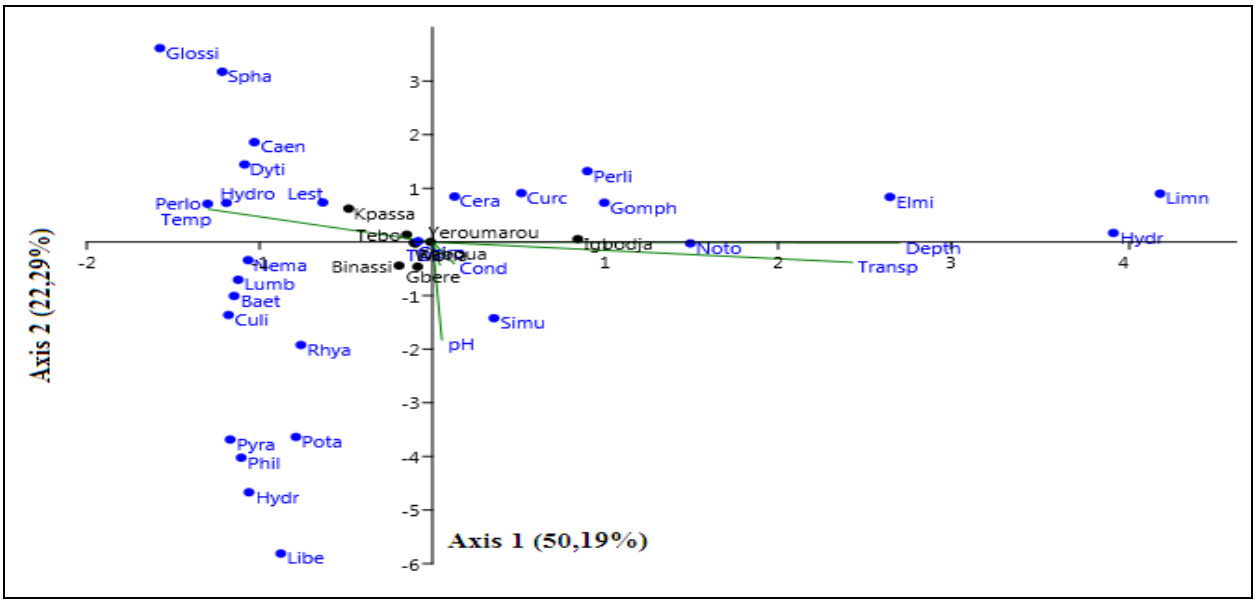

Figure 4: Canonical analysis of the correspondence of macroinvertebras and physico-chemical variables

Perlidae = Perli ; Perlodidae = Perlo ; Phil = Philopotamidae ; Rhya = Rhyacophilidae ; Caen = Caenidae ; Baet = Baetidae ; Pota = Potamanthidae ; Noto = Notonectidae ; Curc = Curculionidae ; Dyti = Dytiscidaet ; Hydr = Hydrophilidae ; Cera = Ceratopogonidae; Chao = Chaoboridae; Chiro = Chironomidae ; Culi = Culicidae ; Calo = Calopterygidae ; Libe = Libelludiae ; Gamm = Gammaridae, Spha = Sphaeriidae; Hydro = Hydrobiidae; Limn = Limnaeidae ; Lumb = Lumbriculidae ; Nema = Nematodes ; Hydr = Hydracariens; Temp = Temperature ; Transp = Transparence ; Depth = Depth ; Cond = Conductivity ; TDS = Total Dissolved Solids.

IV. DISCUSSION

The values of temperature observed vary between 33.48 and 26º c and are slightly higher than those recorded by Kra et al.. (2018) and koundenoukpo at al., (2017a). These high temperature values observed especially at the Tébo, Kpassa and Yéroumarou stations are due to the fact that they are deprived of canopy and therefore exposed to sunshine. As for the pH, it presents values between 6.98 and 8.40. These values are characteristic of surface waters where life can develop optimally manner (IBGE, 2005). The depth and the transparency varying in relation to the sampling point but globally are very high at downstream stations. The strong depth values recorded are justified by the deepening of the stations downstream due to the confluence. The conductivity and the TDS values recorded in this study are similar to those reported in Cote d'Ivoire (Kra et al., 2018), in Burkina-Faso (Lamizana-Diallo, 2008) and in Bénin (Lawani et al., 2017). The average values obtained in this study are within the range of the IBGE standard (50 and 1500 uS/cm), which characterizes natural waters (IBGE, 2005). The distribution of macroinvertebrates is function of environmental variables. Indeed, the water temperature (Tenkiano, 2017; Hynes, 1970), the transparency and the depth (Abahi et al., 2018) and the pH (Kra et al., 2018) are the main factors that influence the spatial distribution of benthic macroinvertebrates. The observations of the various authors are confirmed by the results obtained in this study. The strong link between the families: Glossiphoniidae, Sphaeriidae, Hydrobiidae, Culicidae, Pyralidae, Lumbriculidae, Dytiscidae, Hemathelminthes, Hydropohilidae and the temperature would be due to the fact that these families are polluo-resistant families. In fact, these families can live in poorly oxygenated water with a good quantity of pollutant at a higher temperature (Touzin et Roy, 2008).

V. CONCLUSION

The protection of ecosystems is now emerging as a necessity for the conservation of the biodiversity of aquatic ecosystems. The spatial study of the water quality of the Okpara river shows that the values of the parameter studied are within the tolerable limits which characterize the waters where life develops in optimal manner. The physic-chemical parameters such as the temperature, the pH, the depth and the transparency are the factors which influence more the distribution of the macroinvertebrates. Thus a strong correlation was established between the polluo-resistant families and the temperature. Nevertheless, an in-depth study based on monitoring parameters such as: nitrates, nitrites, ammonium, phosphate, biochemical oxygen demand, and chemical oxygen demand and total nitrogen must be conducted to assess the physico-chemical quality of the water of the Okpara river.

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