Article N°3

Titre de l'article*:* Comparative characterization of some physico - chemical and hydromorphological parameters from three rivers of Gabon: Rembo Bongo, Ogooué and Nyanga

Auteurs *Jean Félicien Liwouwou, **Delphine Adandédjan**, Jean Daniel Mbega, Philippe Lalèyè*

Année: 2018

Références: International Journal of Advanced Research in Biological Sciences (Int. J. Adv. Res. Biol. Sci.) (2018) 5 (4): 186-201.

Type de revue: Revue indexée et abstractée avec facteur d'impact FI: 6, 433

à Google Scholar, Indian Science, Prizmshare, Yahoo Search, ACS Chemistry for life, Actseek, Altavista, Academic.edu, SJIFV, Academic Resources Advanced Science Index, FWS, World Cat, OAJI, ICI, UIF Base, GIF, JIF, ROAD, SRJIF, etc. et ICV : 83.8 (2016).

ISSN de la revue: 2348-8069

DOI : http://dx.doi.org/10.22192/ijarbs.2018.05.04.019

Site web: www.ijarbs.com

Langue de la publication: Anglais

Mots clés *:* Physico-chemical and hydromorphological parameters, three Rivers, Gabon

Date de publication: 20 Mai 2018.

IJARBS

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN BIOLOGICAL SCIENCES

(ISSN: 2348-8069)

IMPACT FACTOR: 6.433, ICV: 57.38

Volume.5 Issue.4 (2018)

www.ijarbs.com

E-mail: editorijarbs@gmail.com/submitijarbs@gmail.com

PUBLISHED BY:

DARSHAN PUBLISHERS

International Journal of Advanced Research in Biological Sciences

ISSN: 2348-8069

www.ijarbs.com

VOLUME: 5, ISSUE: 4 (APRIL - 2018)

CONTENTS

International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG(USA) Volume 5, Issue 4 - 2018

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2018.05.04.019

Comparative characterization of some physicochemical and hydromorphological parameters from three rivers of Gabon: Rembo Bongo, Ogooué and Nyanga

Jean Félicien Liwouwou[1,2], Delphine Adandedjan[1], Jean Daniel Mbega [2], Philippe Lalèyè [1]

[1] Laboratory of Hydrobiology and Aquaculture, University of Abomey - Calavi, 01BP 526, Calavi, Benin
[2] Laboratory of Hydrobiology and Ichthyology, National Center for Scientific and Technological Research, PO Box 2246, Libreville, Gabon.
*Corresponding author: *jean_feli@yahoo.fr*

Abstract

A comparative study on the characterization of the physicochemical and hydrodromorphological parameters of the rivers Ogooué, Rembo Bongo and Nyanga in Gabon was carried out in order to understand the structure of their operation on the one hand and to assess their ecological status on the other hand. The study showed that the Ogooué River is very different from the other two by its depth, the speed of its current, its total hardness and the structure of its sediments. The Rembo Bongo River and the Nyanga River contain over 55% sand. But the Nyanga River is richer in sandstone (26%).In general, the physicochemical parameters of the three rivers are within the limits of the desired values for a better growth of many fish and other aquatics organisms. Overall, the waters are relatively well oxygenated, are weakly mineralized and are sufficiently transparent with a low concentration of nitrogen and phosphate nutrients, thus translating a stable ecological state of the three rivers.

Keywords: Physicochemical and hydromorphological parameters, Three Rivers, Gabon

Introduction

Fish lives for a long time in a hydrosystem (rivers, lakes, lagoons ...) when it finds a set of favorable environmental conditions (physicochemical and trophic environment) for its growth and reproduction (Lévêque, 1995). However, nowadays, around the world, many of aquatic ecosystems are seriously affected by human activities (fishing, agriculture, deforestation, various pollutions ...). As a result of population growth and survival requirements, these activities are intensifying, and the overexploitation of resources is usually the consequence. Faced to these disturbances and threats on the structure and on the biodiversity of aquatic ecosystems, it is urgent to undertake studies on the water quality of these environments in order to their preservation. A lot of methods exist nowadays to assess water quality of hydrosystems such as physical-chemical methods, biological methods… All of them are complementary to know more on the ecological status of hydrosystems.

In West Africa, a lot of studies have been done. We could mention among others those of Iltis and Lévêque (1982), Pouilly (1993), Lalèyè (1995), Chikou (2006), Montchowui *et al*. (2007), Ahouansou Montcho *et al.* (2011), Adandedjan (2012), with the aim of better preservation of resources. In Central Africa, with the exception of the Congo River basin (Dupré *et al*., 1996, Pwema 2004, Mbadu Zebe, 2011) studies on the physico-chemical quality of continental waters are rare. In Gabon, except for the Ogooué watershed, studied in its lower course (Loubens, 1966, Mbega, 2004) the physico-chemical and hydromorphological characteristics of the other main watersheds of the country (Nyanga, Komo, Ntem, Woleu) are almost unknown. Moreover, at the international level, Gabonese aquatic environments as a whole are absent from the FAO databases (Welcomme 1985, 1989, 2005, Van Den Boosche and Bernacsek., 1990).

The present study aims the characterization of some physicochemical and hydromorphological parameters of three rivers of Gabon (Rembo-Bongo, Ogooué and Nyanga) in order to constitute a database useful for the management of the aquatic environment.

Materials and Methods

Study area

The rivers investigated here concerned the Ogooué, Rembo Bongo and Nyanga in Gabon. The Ogooué, the first river sampled is the largest river in Gabon with 1,200 km long, and 214,000 km² of surface area. It has its source in the Batéké plateaus in the south-east of Gabon and travels more than 1000 km before flowing into the Atlantic Ocean to the west of Gabon (Fig. 1). The portion of the river concerned by our study is located in the lower basin between the Mboumi 1 site (00°62" S - 010°26' E) and Lamba 2 site (00°41'20.9" S - 010°13' E) in western center of Gabon (Fig.1). In this sector the average flow of water is 4260 m3/s. The maximum value is obtained in November (6481 m3/s) and the minimum in December (6106 m3/s).

Rembo Bongo (Fig.1), the second river sampled, is a small river of 200 km long and about 45 m wide. Little information about this coastal river is known. However, it is the most important tributary of the Ndougou lagoon (area = 630 km²), the largest lagoon in Gabon (Anonymous, 2008). Also, it is connected to several small rivers and lakes such as Douegui, Moanda, Mboula, Ngoungou, Mafoumi, Goré, Kivoro, Longo Longo. It also originates in the Chaillu Massif (Mount Birougou) in southern Gabon (Fig.1).

The portion of the river concerned by our study is located in the lower basin between the Mafoumi1 site (02°21 S - 010°09' E) and Moanda 2 site (02°25'S - 010°08'E) in northern of Ndougou lagoon (Fig.1)

The Nyanga River, is the second river in Gabon after the Ogooué by its length, 600 km and surface area (22400 km²).It takes also his source in the massif Chaillu (Birougou mount) in southern of Gabon (Fig.1). The portion of the river concerned by our study is located in the lower basin between Igotchi1 site (02°43' S - 010°30' E) and Mavanza 2 site (Fig.1). These three rivers are under the influence of the tropical equatorial climate (Rabenkogo, 2007) characterized mainly by two hydrological seasons: a rainy season of 8 months (September-April) and a dry season of 4 months (mid – May and August). Rainfall varies from 1900 to 2200 mm and decreases from south to north. However, the dry season is characterized by a small dry season from mid-December to mid-February, and the 8 months of the rainy seasons are interspersed with a small rainy season from mid-September to Mid-December and major rainy season from March to mid-June.

Sampling

The data were collected from June 2010 to July 2011, between 06:00 and 09:00 am of the morning, on all the sampled sites, at a rate of two collections per month according to the four hydrological season of the year, i.e. in great rain season (March in mid-May), in small rain season (September in mid-December), in great dry season (mid-May at August) and small dry season (mid-December at February).Twelve stations were selected in total, four stations per river.

The choice of these stations was particularly motivated by three main reasons: their accessibility in all seasons of the year, the various types of habitat encountered and the permanence of water all the year. The geographical coordinates of the stations were obtained by means of GPS (Global Position System).

The physicochemicals parameters pH, conductivity, temperature water, dissolved oxygen and saturation rate were measured by means of Hanna multiparameter HI 98130.

Transparency was measured by the Secchi disc. The depth was obtained using a string graduated in centimeter at the end of which there is a ballast.

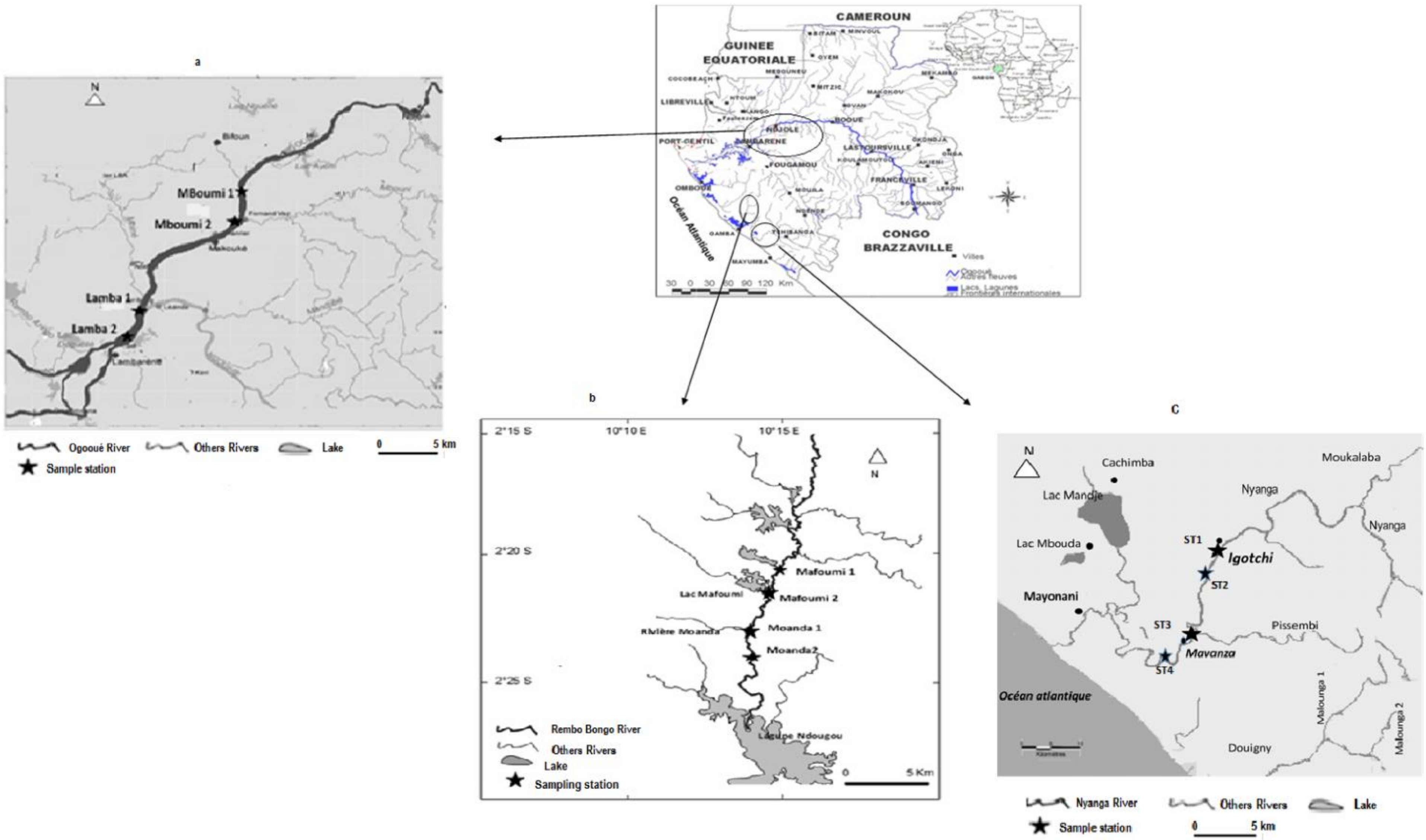

Figure 1 : Ogooué River (a), Nyanga River (b), Rembo Bongo River (c) and location of sampling station of physicochemical and hydromorphological parameters, ST1 = Igotchi 1, ST2 = Igotchi 2, ST3 = Mavanza 1, ST4 = Mavanza 2

The surface water velocity (Vs) was measured in the field using a float. To do this, we have timed the time taken by a float to travel a distance of 1 m measured at the decameter. This exercise was repeated three times per station. The velocity is then equal to the distance travelled (1 m) relative to the average time (in seconds). The current velocity (Vc) is: $Vc = 0.80 \times Vs$ (Adandédjan, 2012), it is expressed in (cm/s).Some nutrients such as nitrate, nitrite, and phosphate were also analyzed using a HAC 2000 spectrophotometer.

Additional sediment samples were collected at each station to analyze grain size using conventional techniques. Sand and fine fractions (clay + silt) were expressed as a percentage according to Intes and Le Luff, (1986)

Data analyses

The Shapiro-Wilk test (Shapiro-Wilk, 1965) was applied to verify whether the distribution of physico-chemical and hydromorphological parameters of each river is normal. The nonparametric tests of Kruskal-Wallis (1952) and Mann-Whitney (1947) were used. The Kruskal-Wallis test was used to test the variability of the parameters between all stations of the same river and between the different groups defined by the self-organizing map of Kohonen (SOM) (Kohonen, 1982 and 1995). The Mann-Whitney test was used to identify differences between stations or groups of stations and seasons taken two by two.

Spatial and seasonal variations of physico- chemical parameters of three rivers are expressed in the form of boxplot. In addition, these parameters were processed using the Kohonen self-organizing map (SOM) (Kohonen, 1982 and 1995) to order the sampling stations of the three rivers according to similarities environmental variables. In fact, based on quantization and topography errors, a Kohonen map of 25 cells (5 rows × 5 columns) was selected for projecting the 121 samples of the 12 sampling stations (Mavanza1, Mavanza 2, Igotchi 1, Igotchi 2, Mafoumi 1, Mafoumi 2, Moanda 1, Moanda 2, Lambarene 1, Lambaréné 2, Mboumi1, Mboumi2) respectively from the three rivers Nyanga, Ogooué and Rembo Bongo. Twelve physical, chemical and granulometric parameters (temperature, water clarity, depth, dissolved oxygen, the oxygen saturation level, total hardness, pH, and conductivity, sand percentages of sandstone, of limestone and fine particles) were used for the analysis.

The discriminant factor analysis (AFD) was applied to identify the environmental variables that best discriminate the groups defined by SOM from the environmental data matrix. Next, the significance of the AFD is tested by Monte Carlo permutation test (999 permutations).

The percentage of prediction of groups was obtained through the AFD analysis and validated by the "Mahalanobis" distance squared." Finally, the «leave-one -out " or against check is performed to evaluate the model's ability to predict for each predefined group membership of each site. The discriminatory power of each parameter has been highlighted by the test " λ " of Wilk All analyzes except neurons were conducted using Statistica Version 6 software.

Results

Spatial variations of physical and chemical parameters of waters of the three rivers were presented in Figure 2. Analysis of the variances using the Shapiro-Wilk test shows that the distribution is not normal ($p > 0.05$). Tables1 and 2 summarize the Kruskal-Wallis tests of spatial and seasonal variations of these physico-chemical parameters. The figure 3 illustrates the seasonal variations in physico-chemical descriptors of study environments.

Table 1: Synthesis of the results of the Kruskal-Wallis (H, p) comparison tests on the spatial variations of the physicochemical parameters of the three rivers.

Parameters	Rembo Bongo River		Nyanga River		Ogooué River	
	H	p	H	p	H	p
Water temperature	7.55	NS	1.688	NS	6.81	NS
Depth (m)	23.79	***	18.943	***	27.23	***
Transparency (cm)	1.46	NS	2.736	NS	6.30	NS
Current Velocity	8. 695	NS	6.47	NS	25.53	***
pH	0.83	NS	0.10	NS	2.62	NS
Conductivity (µS/cm)	5.59	NS	1.387	NS	0.986	NS
Dissolved Oxygen	1.39	NS	0.93	NS	0.143	NS
Rate saturation (%)	1.39	NS	0.83	NS	0.44	NS
Total Hardness (mg/L)	-	-	1.85	NS	7.67	*

NS = not significant; * = significant; *** = highly significant;

Table 2: Synthesis of the results of the Kruskal-Wallis (H, p) comparison tests on the seasonal variations of the physicochemical parameters of the three rivers.

Parameters	Rembo Bongo River		Nyanga River		Ogooué River	
	H	p	H	p	H	p
Water temperature (°C)	8.062	*	24.156	***	10.63	*
Depth (m)	7.86	*	8. 63	*	4.77	NS
Transparence (cm)	1.97	NS	22.998	***	18.080	***
Velocity of Current (cm/s)	5. 42	NS	20.794	***	2.06	NS
pH	17.117	***	1.84	NS	7.11	NS
Conductivity (µS/cm)	20.67	***	14.494	***	1.493	NS
Dissolved Oxygen (mg/L)	5.44	NS	19.900	***	4.48	NS
Rate saturation (%)	4.66	NS	18.283	***	4.84	NS
Total hardness ($CaCO_3$)	6.67	NS	-	-	15.54	***

NS = not significant; * = significant; *** = highly significant

Water temperature

In the Nyanga River (Fig. 2) the average temperature for the whole river was 26.08 ± 1.09°C. In the Rembo Bongo River (Fig.2) the average temperature for the whole river was 25.9 ± 1.05°C. In the Ogooué river (Fig. 2) the mean temperature for the whole river was 26.6 ± 0.61°C. Overall, the temperature did not vary significantly from one station to another on the three rivers ($p > 0.05$) (Fig. 2). However, the water temperatures of the three rivers varied significantly according to a seasonal cycle ($p < 0.05$) (Fig. 3).

Depth

In the Nyanga River (Fig. 2) the average depth for the whole river was 4.5 ± 0.86 m. In the Rembo Bongo River (Fig. 2) the average depth of the whole river was 2.7 ± 0.65 m. In the Ogooué River (Fig. 2) the average depth for the whole River was 4.8 ± 0.93 m. Overall, this parameter varied greatly along the three rivers ($p < 0.001$) (Fig. 2). In addition, there is a slight variation in depth between different river and according to hydrological seasons ($p < 0.05$) showing lower values on Rembo Bongo at all times (Fig.3).

Transparency

In the Nyanga river (Fig. 2) the average transparency for the whole River was 79.65 ± 27.33 cm. In the Rembo Bongo River (Fig. 2) the average transparency for the whole River was 72.13 ± 8.79 cm. In the Ogooué River the average transparency for the whole River was 75 ± 10.32 cm. Thus, in all three rivers, the transparency did not vary significantly ($p > 0.05$) (Fig. 2) but showed a significant seasonal variation ($p < 0.05$) from one river to another (Fig.3).

Current velocity

In the Nyanga River (Fig. 2) the average flow velocity for the whole River was 24.26 ± 8.6 cm/s. In the Rembo Bongo River (Fig. 2) the average water velocity for the whole River was 29.72 ± 10.45 cm/s. In the Ogooué River (Fig. 2) the average velocity for the whole River was 52.36 ± 10.13 cm/s. Moreover, of the three rivers studied, only the Ogooué river experienced a highly significant longitudinal variation of the velocity ($p < 0.001$) (Fig. 2). Overall, the velocity of the current in the three rivers experienced significant seasonal variation ($p < 0.05$), with very low values in all periods on the Nyanga River (Fig. 3).

pH

In the Nyanga River (Fig. 2), water is basic with the average pH (pH = 8.1 ± 0.05). It was the same in the Rembo Bongo River (Average pH = 7.4 ± 0.14). In the Ogooué River (Fig. 2), water is acid with the average pH (pH = 6.6 ± 0.179). Overall, these pH values varied significantly in the three rivers ($p < 0.05$) (Fig. 2). However, the pH of the Rembo Bongo River varied considerably from one season to another ($p < 0.001$), which was not the case for the other two rivers (Fig.3).

Conductivity

In Nyanga River (Fig. 2) the average conductivity for the whole River was 64.1 ± 17. 06 µS/cm. In the Rembo Bongo River it was 61.6 ± 15. 04 µS/cm. In the Ogooué River (Fig. 2) the average conductivity of the whole River was 24.9 ± 1.55 µS/cm. Overall the conductivity values recorded on the Nyanga River were high ($p < 0.05$) while those obtained along the Ogooué River were relatively lower ($p < 0.05$)(Fig.2). Furthermore, the water conductivity values vary significantly according to a seasonal cycle ($p < 0.001$) on the Rembo Bongo and Nyanga rivers (Fig. 3) and they were very low during all seasons on the Ogooué River.

Dissolved oxygen and the saturation rate

In the Nyanga River (Fig. 2) the average of Oxygen for the whole River was 8.3 ± 1.23 mg/L (. In the river Rembo Bongo (Fig. 2) the average oxygen for the whole River was 7.7 ± 0.83 mg/L. In the Ogooué River (Fig. 2) the average conductivity for the whole River was 7 ± 0.16 mg/L. Overall changes inter- and intra- River were not significant ($p > 0.05$) (Fig. 2). On the seasonal plan no change was observed for the river Ogooué and Rembo Bongo about this parameter while for the Nyanga River the variation from 6.3 mg/L (GRS) to 12.7 mg / L (GDS) was highly significant ($p < 0.05$) (Fig. 3). Moreover, the most important peaks in dissolved oxygen concentrations were found in for the three rivers.

In the Nyanga River (Fig. 2) the average saturation rate for the whole River is 108.46 ± 16%. In the Rembo Bongo River (Fig. 2) the average saturation rate for the whole River was 98.9 ± 12.64%. In the Ogooué River (Fig. 2), the average saturation rate for the whole River was 88.95 ± 2.52%.For the whole the changes of this parameter in the three rivers were significant ($p < 0.05$) while in different study stations, they were not significant ($p > 0.05$) (Fig. 2). Furthermore, the oxygen saturation rate broadly followed the same trends as dissolved oxygen in the three streams according to the seasons (Pearson correlation $r = 0.99$; $p < 0.05$).

Total hardness

In Nyanga River (Fig. 2) the average hardness for the whole River was 45.56 ± 12.33 mg /L. In the river Rembo Bongo (Fig. 2) the average hardness for the whole of the river was 36.34 ± 7.89 mg/L. In the Ogooué River (Fig. 2) the average hardness for the whole River was 41.74 ± 12.24 mg/L. Overall hardness values have varied slightly along the Ogooué ($p < 0.05$) unlike the other two rivers (Fig. 2). The lowest values (20 mg/L) and the highest values (88 mg/L) of total hardness were found on the Ogooué River in rainy seasons while in the other rivers the highest values were observed in dry season (Fig. 3).

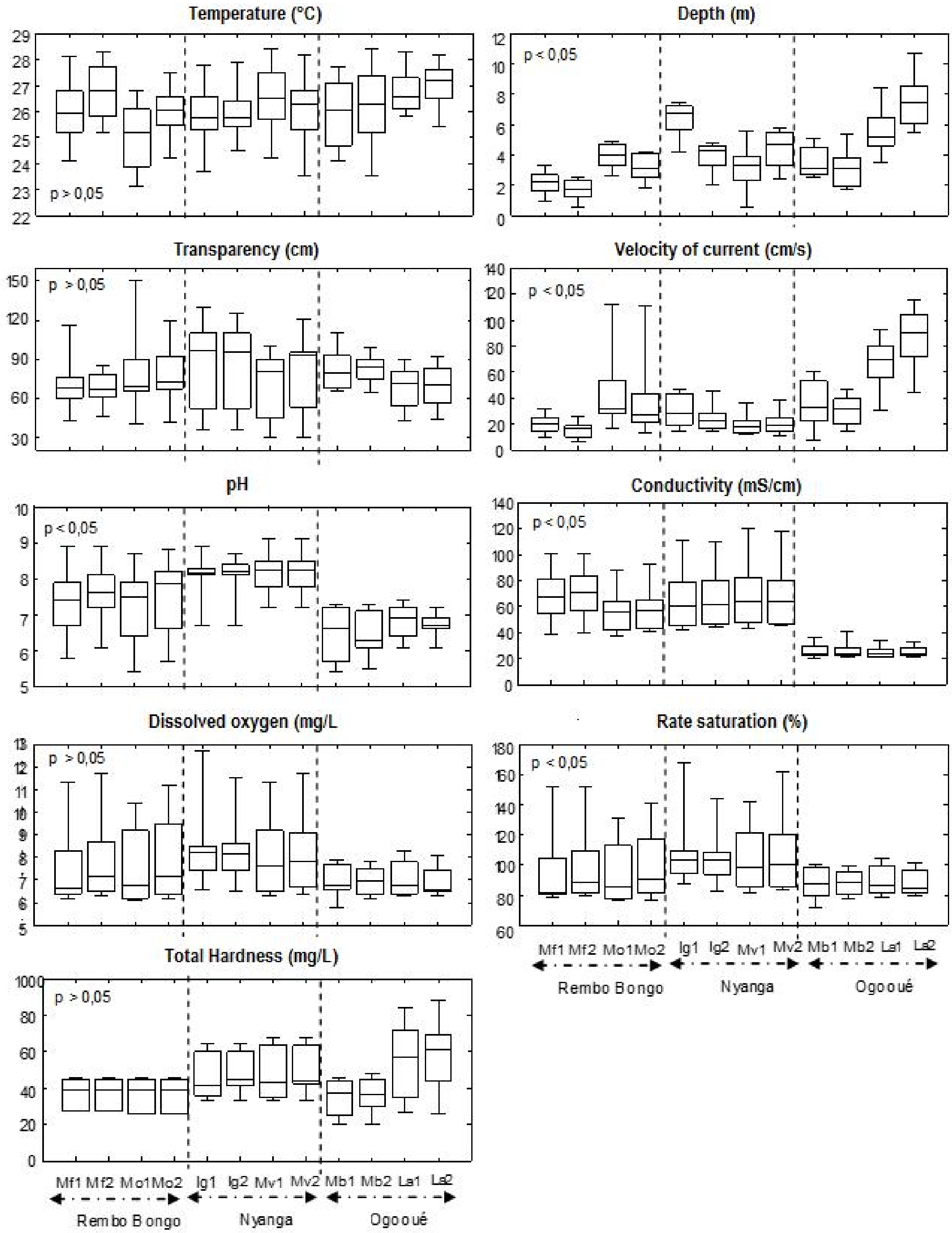

Figure 2: Spatial variations of the physical parameters of Rembo Bongo, Ogooué and Nyanga rivers of Gabon. Mf1 Mafoumi = 1; Mafoumi mf2 = 2; Mo1 Moanda = 1; Moanda Mo2 = 2; Ig1 = Igotchi 1; Igotchi ig2 = 2; Mv1 Mavanza = 1; Mv2 Mavanza = 2; Mb1 Mboumi = 1; Mb2 Mboumi = upstream ; Lambaréné La1 = 1; A2 = Lambaréné 2. Figures 1 and 2 respectively represent in "downstream" and «upstream«of sampling station. P represents the result of the Kruskal-Wallis test of the environmental variables compared of the three rivers.

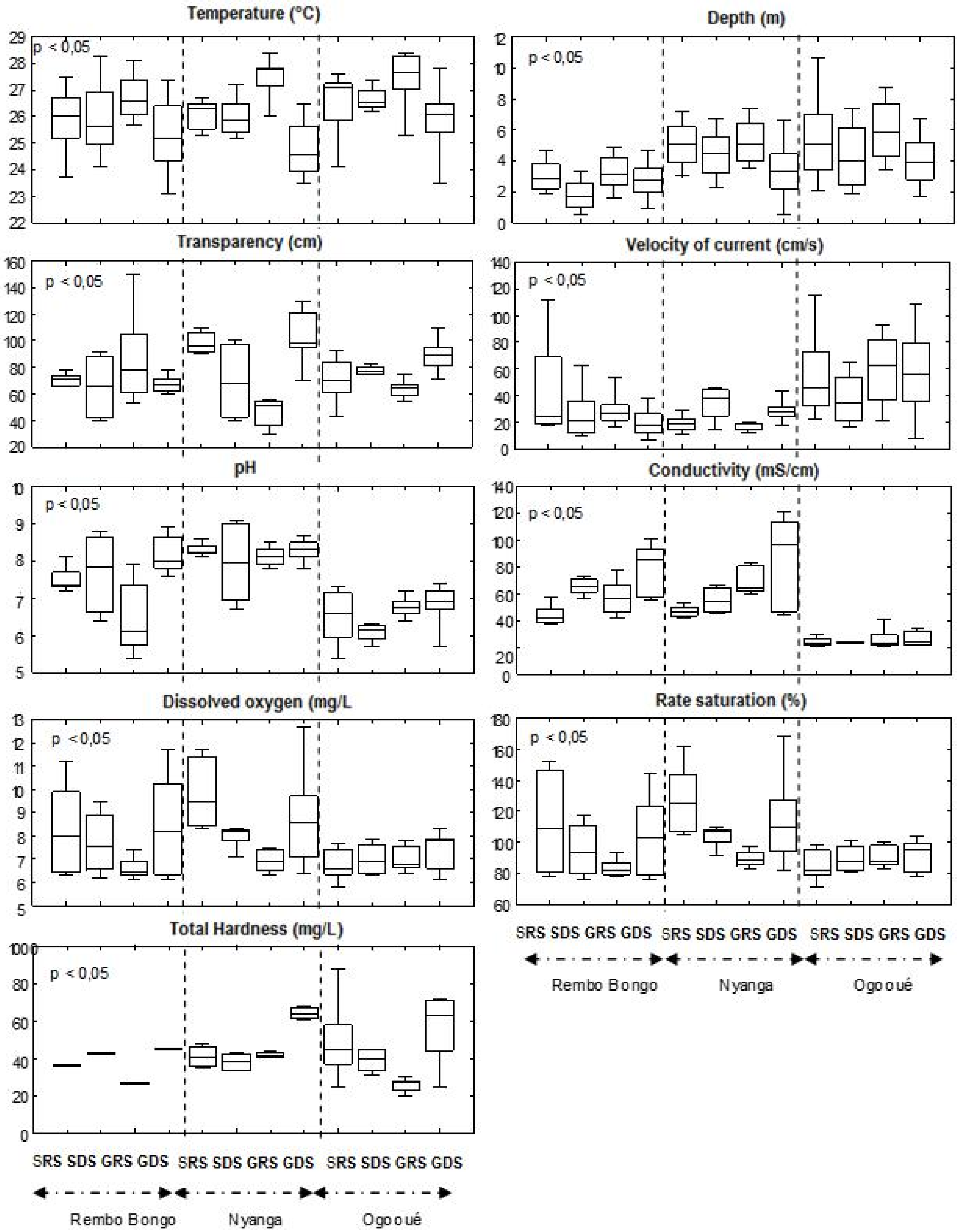

Figure3: Seasonal variations of physico- chemical parameters of river Rembo Bongo, Ogooué and Nyanga over the period of the study. SRS = small rainy season, SDS = Small dry season, GRS = Great rainy season, GDS = Great dry season. P is the result of Kruskal -Wallis comparison between classes of water environmental variables.

Granulometry

Figure 4 shows the result of granulometric analysis of the substrates of the three study area. In fact, the bottom of Ogooué River is rich in fine particles composed of clay (30%) and silt (25%) showing a higher siltation rates. The Nyanga River bottom is dotted of the sandstone (26%), while the Rembo Bongo River is dotted with clay (37%). But, the three rivers are composed of more than 50% of sand.

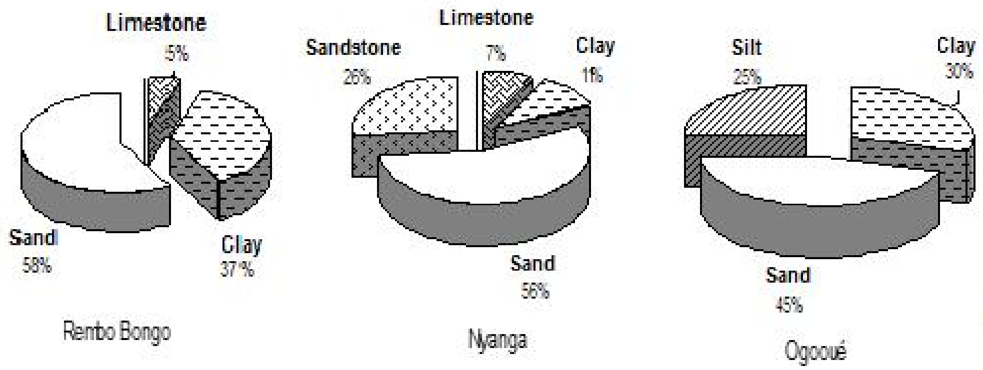

Figure 4: Results of granulometric analysis of the substrates of the three rivers.

Similarity

Figure 5 shows the hierarchical classification of the cells produced by the Kohonen map based on the physicochemical parameters of the three rivers. 25 cells are divided into three groups (I to III). The numbers (1 to 25) correspond to the cell numbers and the Roman numerals (I to III) represent the groups selected.

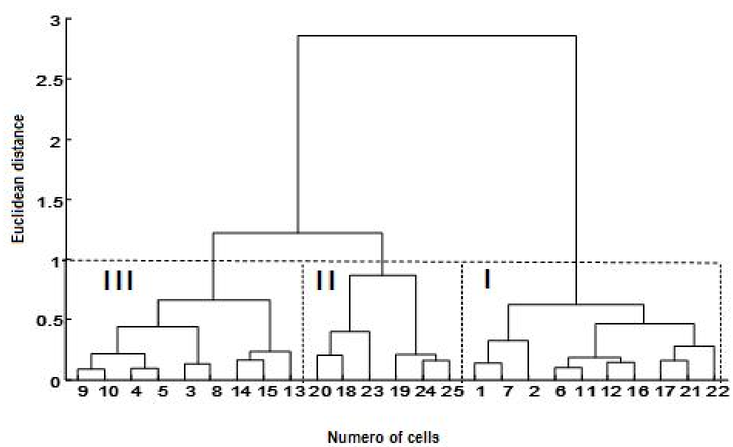

Figure 5: Hierarchical classification of cells of the Kohonen map on the basis of the physico -chemical parameters measured on streams with the Ward method and Euclidean distance as distance assembly. The numbers (1 to 25) correspond to the numbers cells, the Roman numerals (I to III) represent the selected groups

Figure 6 of the Kohonen map shows the distribution of samples collected in the three rivers based on physicochemical parameters. The groups defined by the map are numbered from I to III and the cells corresponding to each group are differentiated by common characteristic features.

The sampling sites for each river were represented by the codes. Thus the codes A1 (Station Mafoumi 1), A2 (Mafoumi 2), M1 (Moanda 1), M2 (Moanda 2) correspond to the Rembo Bongo River, codes I1 (Igotchi1), I2 (Igotchi 2), V1 (Mavanza 1), V2 (Mavanza 2) correspond to the Nyanga River, codes L1 (Lambaréné 1), L2 (Lambaréné 2), B1 (Mboumi 1), B2 (Mboumi 2) correspond to the Ogooué River.

The second and third numbers, ranging from 1 to 4, indicate the sampling seasons (small rainy season = 1, short dry season = 2, large rainy season = 3, large dry season = 4). The numbers from 1 to 25 in the cell angle represent cell numbers

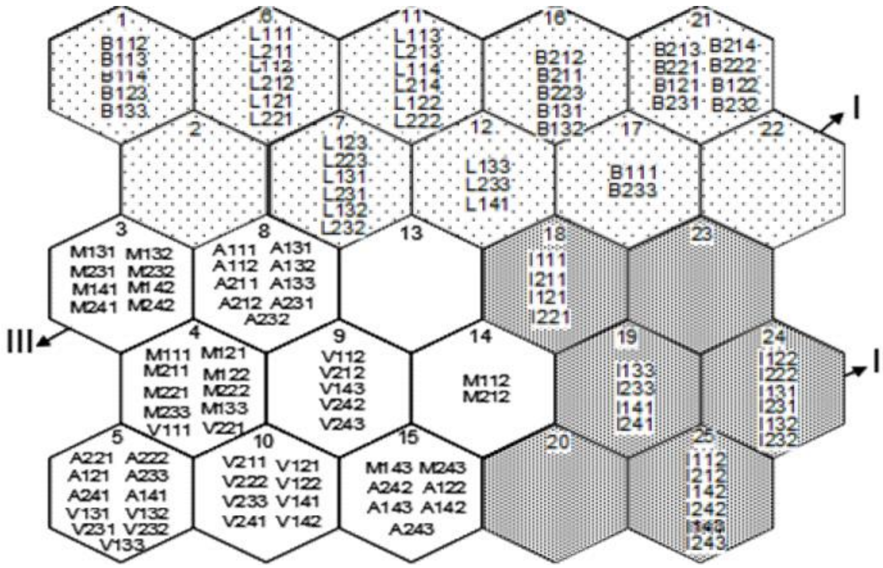

Figure 6: Distribution of samples collected from rivers on the map of Kohonen from environmental variables . The defined groups are numbered from I to III and the corresponding cells are labeled with different features ; A1; A2 ; B1 ; B2 ; I1; I2; L1; L2; M1; M2; V1 and V2 are the sampling sites of the codes from the three rivers (A1 = Mafoumi 1 , A2 = Mafoumi 2,M1= Moanda1, M2 = Moanda2, I1= Igotchi1, I2 = Igotchi 2, V1 = Mavanza 1, V2 = Mavanza 2, L1 = Lambaréné1, L2 = Lambaréné 2, B1 = Mboumi 1, B2 = Mboumi 2). The second and third numbers next (1-4) indicate the sampling seasons (short rains = 1, Small dry season =2, rainy season = 3, long dry season = 4). The numbers 1 to 25 in terms of the numbers of cells represent cells

The discriminant analysis (AFD) carried out on these groups showed that they were well predicted at 100% and distinct (the significance test of the distance between the centers of gravity is highly significant: $p < 0.001$). The discriminating power of the parameter s was highlighted by the "λ" Wilk test (Tab.3). Seven physicochemical parameters showed a significant discriminating power ($p \leq 0.05$) for the different defined groups. These parameters are the depth, the conductivity, the velocity current and the rate of limestone, sandstone, sand and fine particles.

Table 3: Environmental parameters have a significant discriminative power of the groups defined for all waterways according to Kohonen map (λ Wilk test at the 0.05 level)

Effects	a	p
Depth (m)	0.76330	0.000000
Conductivity (µS/cm)	0.9576	0.02664
Velocity of current (cm/s)	0.83598	0.000007
Total Hardness (%)	0.28726	0.000000
Clay + Silt (%)	0.793204	0.000000
Sand (%)	0.361665	0.000000
Sandstone (%)	0.29450	0.000000

Thus, group I was composed of 41 samples from only stations Ogooué River (Mboumi 1 Mboumi 2 Lambaréné1 and Lambaréné 2).It is characterized by physical parameters such as water temperature, depth, transparency and current velocity, two of which have a very significant discriminating power (Fig.5, Fig.6, and Tab.3).Group II gathered 20 samples exclusively from stations Igotchi 1 and Igotchi 2 of Nyanga River.It is characterized by pH, transparency, limestone and sandstone values relatively high (Fig.6;Fig.8; Tab.3.10).The group III is composed of 60 samples consisting essentially of samples of the river Rembo Bongo (40 samples from Mafoumi stations 1 and 2; Moanda 1 and 2) and those from Mavanza stations 1 and 2 of Nyangariver. This assembly is characterized essentially by the granulometrics parameters (Sand, fine particles and sandstone) high (Fig.7, Fig.8; Tab .3).

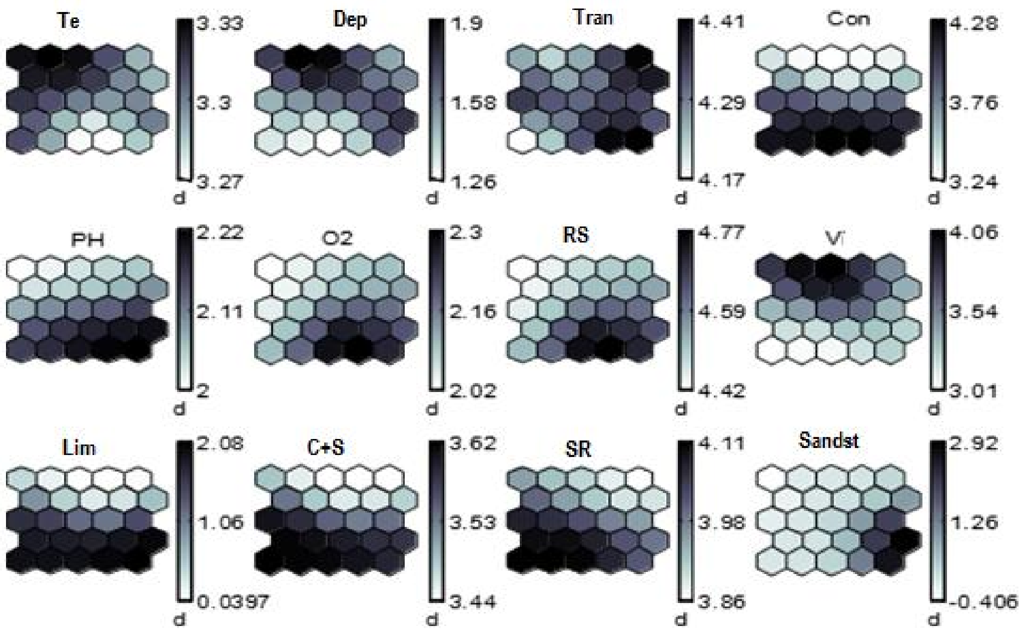

Figure7: Gradient values of each environmental variable on the Kohonen map. Dark color = strong values; light color = low values; d = scale, Te = temperature (°C); Depth. = Dep (m) Tran = Transparency (cm) ; Con = conductivity (S / cm) , O2 = dissolved oxygen (mg / L) , Rs = Rate saturation (%), V = velocity (cm / s), Lim =% limestone ; C + S = clay and silt rate (%), sand rate (%) = SR, Sandstone = Sandst

Variation of nutrients

Figure 8 presented seasonal variation of nutrients into rivers during the study. Nitrates values ranged from 0.13 mg/L during small dry season to 0.029 mg/L for the other seasons on the Rembo Bongo River.Its values ranged from 0.029 to 0.04 mg/L on the Nyanga River all times while on the Ogoouéthey ranged from 2.45 mg/L during the small rainy season to 0.001 mg/L for any other season.Nitrite values were the same in all rivers. They ranged from 0.019 to 0.042 mg/L on Rembo Bongo, 0.033 mg/L on the Nyanga River and 0.08 mg/L on the Ogooué River.The phosphate levels were lowest in Ogooué with values ranged from 0.029 in any period to 0.22 mg/L in the small rainy season. In the Rembo Bongo River, they ranged from 0.046 to 2.75 mg/L while in Nyanga River the rates ranged from 0.16 to 1.53 mg/L.Overall these levels of dissolved salts showed no significant longitudinal variation intra- rivers with the exception of phosphates ($p < 0.01$ on the Ogooué).As for seasonal variations, nitrates and nitrites varied very significantly ($p < 0.01$) on the Ogooué River.

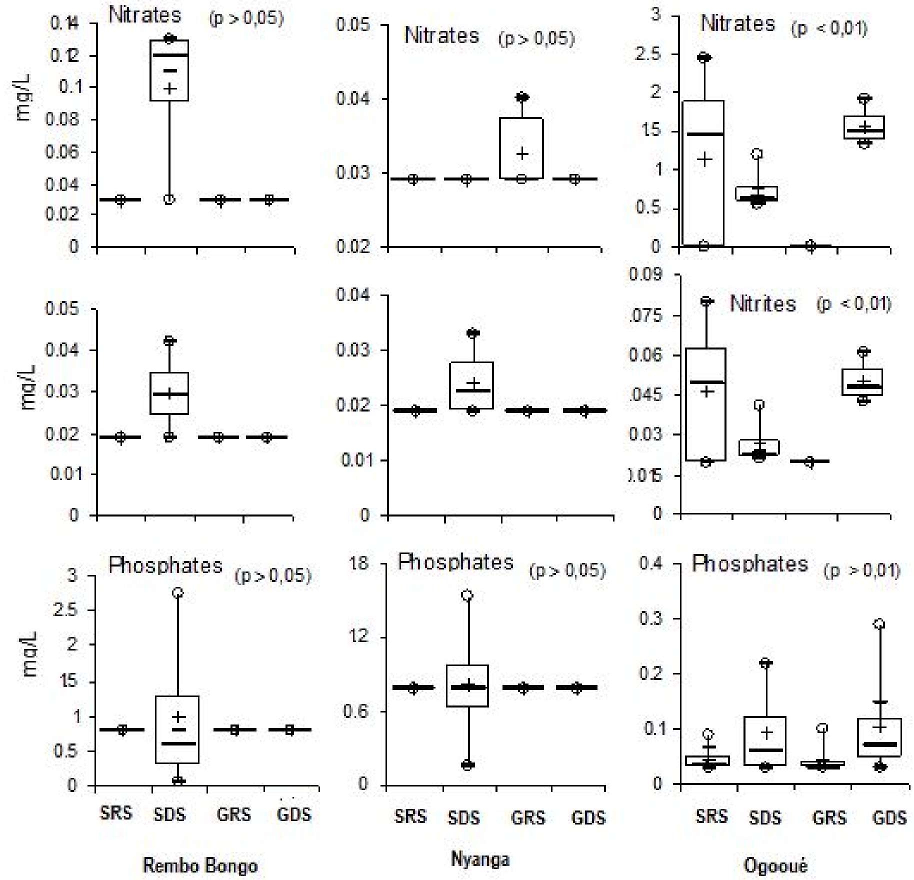

Figure 8 seasonal variation of nutrients into rivers during the study. P is the result of the Kruskal Wallis test.

Discussion

The study of physical and chemical quality of the water of the three rivers allows to make some overall observations and analyzes. The bottom of these three rivers is very sandy. They certainly undergo the action of a strong erosion related to the physical and chemical processes such as the winds, the strong currents and the dissolving action of the water (Anonymous, 2009a).

The waters were generally basic in Nyanga and Rembo Bongo rivers except in Ogooué River where they are acidic. Seasonal changes of pH were observed in the three rivers and the peaks were higher in the dry season. These variations are in part a result of hydroclimatics variations. In fact in equatorial geographic region, the long dry season is marked by a significant decline of rainfall, by a reduction of flow, an increase in evaporation and finally an increasein pH and transparency (Mbega, 2004).Conversely the massive precipitation of the small rains are accompanied by increased flow and the exogenous inputs from the soil leaching. The combination of these two phenomena cause a reduction in pH and transparency (Mbega, 2004). Furthermore, the pH values obtained in all three ecosystem accurately reflect changes of physico-chemical parameters then these pH changes are fairly well correlated with those of the hardness. Overall, pH values are within the tolerable range (5 to 9) of most aquatic species (Ahouansou Montcho et al., 2011).The Rembo Bongo and Nyanga rivers with annual pH ranging from 7 to 8 are considered to be low alkalinity hydrosystems after Nisbet and Verneaux (1970). The acidity of the Ogooué River is consistent with the results of Mbega (2004).

Furthermore, with a total hardness ranged from 26 to 88 mg/L of CaCo3 the waters of these three ecosystem are generallypure, that is to say weakly rich in calcium and magnesium salts in the form of carbonates and bicarbonates (Zerbi, 2004). However, with a high total hardness close to 90 mg / L in the short rainy season, the waters of the Ogooué river are moderately hard, ie ranged from 75 to 150 mg/L of CaCO3 according to the classification According to Zerbi (2004).

Also, even though the role of hardness in water productivity is still poorly known, in general, according to the author, the hard water without excess of 200 to 300 mg/L of $CaCO_3$ is suitable.

The values of current velocity were generally weak for all water courseduring the large and small dry season when the depth is low. However, the lowest value was recorded in the Ogooué river. This result can be explained by the fact that during these periods of low rainfall, water levels drop dramatically and the widths of the main course are shrinking. In places the stagnant water pockets form and the sandbanks appear. Everything generally contributes to slow currents and reduce the speed of movement of water in some places, even though it is known that the decrease of the surface of water course increases the flow (Kabre, 2009).

Overall, the conductivity of the water was very low but still lower on the Ogooué than on the others water course in all seasons. Low conductivity for these ecosystem is synonymous with low mineralization of fresh water. It is known that this parameter which varies according to the temperature and the mobility of the water is closely related to the nature and the concentration of dissolved substances but also to their ionic charge and ionizing capacity (Derwich *et al*, 2010; .Ali Ben *et al*, 2012). The waters of the ogooué River are less loaded with dissolved salts than those of the other two rivers and appear less productive (Mbadu Zebe, 2011). Our results corroborate with the observations of Mbega (2004) which have also obtained a very low average conductivity (24.4 µS/cm) close to our observations in the Ogooué forest zone, corresponding to the sampling stations. However, seasonal variations in all three rivers of this parameter may be due either to increased intake of dissolved substances from the surrounding watersheds during rainfall or to contaminated water supplies from human activities, agriculture, urban development, or tourism activities along the various basins.

The levels of dissolved oxygen and water saturation in the Ogooué basin have generally been lower than those of other basins. Moreover, the oxygen level of the Nyanga River during the rainy season was significantly different from the oxygen level in the dry season. However, these three water course are well oxygenated ($\geq$ 5 mg/L) and oxygen levels are within the limit of desired values for better growth for many fish (Zerbi, 2004).Strong seasonal variations in oxygen levels in the Nyanga River may be the result of collecting our data along shorelines, areas overgrown by aquatic vegetation. It is known at the beginning of the rainy season that the decomposition of organic matter, including leaves, decreases dissolved oxygen levels (Olukolajo *et al.*, 2009).

The transparency values in the three rivers ranged from 30.2 cm to 150 cm during the study period. Overall, the waters of these three water systems may be considered transparent, which has the effect of facilitating penetration of the light, to promote photosynthesis and better primary production. These waters have low concentration of suspended solids and are within the desirable limits for fish growth as stated Offem *et al*., (2009). Also, in the Ogooué River it was found that the waters were more transparent, and therefore low loaded with suspended matter during the rainy season. We believe that there have been disruptions of the rainy cycle during our study period due to the effects of climate change. Indeed, the months of March and April are generally the rainiest of the year in Gabon while during our study period, this was not the case.

The concentrations of nitrogen and phosphate nutrients are generally low in all three rivers These results show that the three rivers are still in a good ecological status; indeed the concentrations of nitrogen compounds does not yet appear to pose real problems of toxicity to wildlife and aquatic flora. However, the effects of anthropogenic actions along these rivers begin with be felt especially during the short dry season when nutrient levels are higher, probably due to domestic waste and the untreated discharge of agro- Food or chemical fertilizers.

Comparison of three rivers by the SOM map reveals discrimination based mainly on hydrological parameters (depth, velocity) mineralization parameters (conductivity, hardness) and particle size. The Ogooué river (group 1) distinguishes itself from other rivers by the power discriminating very significant of its depth, the speed of its current and its total hardness. These three parameters explain in part the difference in hydrological functioning of the Ogooué River compared to the other two rivers. Indeed, it has been observed, for example, that this river is the deepest, with low currents, low conductivity and moderately rich water calcium and magnesium.

Furthermore, the Nyanga river (Group II), differs significantly from other rivers by the discriminating power of the sandstones observed at the bottom of the river and its high transparency. These sandstones which are sedimentary rocks composed of coarse sand masses consolidated (Anonymous, 2009b) actually come from erosion and weathering of rocks rich in quartz (granite, gneiss) under the action of currents prevailing there in this river. The accumulation of these sandstone clusters is probably the origin of the fall of Igotchi in the Nyanga River and in the environment of the sampling station.

The Rembo Bongo (group III) is distinguished from other groups particularly by its granulometrics parameters Sand, fine particles and sandstone. This assemblage confirms that the Rembo Bongo and Nyanga rivers have a geological nature of soils that are globally close but distinct in terms of proportions. Indeed, their soils are made up of sand to more than 50% each, with a rate of clay greater than or equal to 5% each. But the bottom of the Nyanga river is sprinkled with clay at 11% versus 37% for the Rembo Bongo River. Moreover, considering that the geological nature of the substrate determines the shape and density of the water systems in riverine environments (Kabre, 2009), we can then think that in the Rembo Bongo river the water network is dense and developed.There is indeed many tributaries (Douegui, Moanda, Mboula, Ngoungou ... Fig.1) and large bodies of water (Mafoumi, Goré, Kivoro, Longo Longo ... Fig 1) (Pinkstone, 1996). Thus, this river would be subject to the weak interaction with groundwater and depend for the bulk of its supplies of surface water. In contrast to the Nyanga River permeable rocks (limestone, sand, sandstone) has a sparse and incomplete network because groundwater flows become essential (Kabre, 2009). According Lemoalle (2006) surface waters of such rivers would be accompanied by a volume at least as important as that which flows in its alluvium. Its water regime would then be more stable than that of the Rembo Bongo River because benefiting both the supply of rainwater and groundwater. In addition, water transfer times are longer, and surface hydrologic events tend to be attenuated (Lemoalle, 2006).

Conclusion

Some physicochemical parameters of three rivers of Gabon namely Rembo Bongo, Ogooué and Nyanga, were studied in order to constitute a useful database for the understanding of their functioning. At the end of the present study it is remembered that in the sites studied these three rivers share the following elements: They are fairly well oxygenated with values globally close to 5mg / L; pH and transparency are within acceptable limits for good growth for most aquatic organisms; the mineralization parameters (conductivity, hardness) are low overall and indicate the low mineralization of the rivers; the waters are transparent and the average depths do not exceed 5 meters; the current velocity is generally low according to the hydrological seasons and varies according to the depth of each river.

However, in the specific characteristics of these rivers we can observe some differences. In fact, the river Ogooue is very distinct from the other two rivers by its depth, the speed of its current and the total hardness. If in the surface the Rembo Bongo River and the Nyanga River is 55% rich in sand, in the depth the Rembo River is dominated by clay while and the Nyanga River is dominated by sandstone. In addition, the Nyanga River appears to have a more stable water regime thanks to a steady supply of rainwater and groundwater, while that of the Rembo Bongo River appears to depend mainly on surface water and its dendritic network.

Acknowledgments

We thank the Smithsonian Institution of Gamba (Gabon), Shell-Gabon, the Forestry and Environmental Training Network of Central Africa (RIFFEAC), WWF-Gamba (Gabon), the National School of Water and Forests (Gabon) And the National Agency of National Parks (ANPN), the Hydrobiology and Aquaculture Laboratory of Agronomic faculty from AbomeyCalavi University (Benin) for their multifaceted contributions in the collection of data and the realization of this document.

References

Adandédjan D. 2012. Diversité et déterminisme des peuplements de macro invertébrés benthiques de deux lagunes du Bénin: la Lagune de Porto-Novo et la Lagune Côtière. Thèse de doctorat, Université Abomey –Calavi, Bénin, 241p.

Ahouansou Montcho, S, Chikou, A., Lalèyè, P., &Linsenmair, K. E. 2011. Population structure and reproductive biology of *Schilbe intermedius* (Teleostei: Schilbeidae) in the Pendjari River, Benin.

Ali Ben, M., Abdelkader hahlaoui, Habib Rour, E.I. 2012. Évaluation de la pollution physico-chimique des eaux de l'Oued Khoumane (Moulay Idriss Zerhoun, Maroc) Int. J. Biol. Chem. Sci. 6(6), 7096 -7111.

Anonyme. 2008. Plan de gestion de Moukalaba Doudou (version1). Rapport d'étude ANPN, Gabon. 108 p.

Anonyme. 2009a. Les Sables : origines et formation géologique. Micosoft encarta 1993-2008.

Anonyme. 2009b. Les Grés. Microsoft encarta 1993-2008.

Chikou A. 2006. Étude de la démographie et de l'exploitation halieutique de six espèces de poissons-chats (Teleostei, Siluriformes) dans le delta de l'Ouémé au Bénin. Thèse de doctorat, Université de Liège, Faculté des sciences, Belgique, 469 p.

Dupré B., Gaillardet J., ROUSSEAU D., & Allègre C J. 1996. Major and trace elements of river-borne matériel: The Congo Basin. Geochimica&Cosmochimica Acta 60(8), 1301-1321.

Kabre, A. 2009. Composante hydrologiques. Ecologie des milieux aquatiques. MFH2 Espace faunistiques et Halieutiques. Université Polytechnique de Bobodioulasso, Burkinafaso, pp.1-3.

Kruskal, W.H., & Wallis, W. A. 1952. Use of ranks in one-criterion variance analysis. Journal of the American Statistical Association 47 (260), 583-621.

Kohonen, T. 1982. Self-organized formation of topologically correct feature maps. Biology Cybernet, 43, 59-69.

Kohonen, T. 1995.Self-Organizing Maps. Springer-Verlag, Berlin, Heidelberg, 362 p.

Lalèyè AP. 1995. - Ecologie comparée de deux espèces de Chrysichthys, poissons siluriformes (Claroteidae) du complexe lagunaire lac Nokoué-Lagune de Porto-Novo au Bénin. Thèse de doctorat en Sciences. Université de Liège (Belgique), 199 p.

Lemoalle, J. 2006. La diversité des milieux aquatiques. In Lévêque D., &Paugy .D 2006. - Les poissons des eaux continentales africaines (diversité, écologie, utilisation par l'homme), Paris : Presse, IRD 573p

Lévêque C., &Herbinet P. 1982. Caractères méristiques et biologie d'*Eutropiusmentalis(Pisces, Schilbeidae)* dans les Rivières de Cote d'ivoire.Cah. O. R.S. T.O.M., Rev, Zool. Afr., 96 (2): 367-392.

Loubens G. 1966. Biologie de *Polydactylus quadrifilis* dans le bas Ogooué (Gabon). Peuplement en poissons des eaux saumâtres et son origine. Faculté des Sciences de l'Université de Paris. Thèse de Doctorat 140 p.

Mann, H. B.,& Whitney, D. R. 1947. "On a test of whether one of two random variables is stochastically larger than the other". Annals of MathematicalStatistics, 18, 50-60.

MbaduZebe, V. 2011. Biologie des espèces du genre Distichodus Muller et Troschel, 1845 (Distichodontidae) du Pool Malebo (Fleuve Congo) en rapport avec les mécanismes d'exploitation de leurs niches trophiques, thèse de doctorat l'Université de Kinshasa –Université de Namur, Congo RDC-Belgique, 363p.

Mbega, J. D. 2004. Biodiversité des poissons du bassin inférieur de l'Ogooué (Gabon). Faculté notre Dame de la Paix de Namur, Département de Biologie, Thèse doctorale, Universitaire de Namur, Belgique, 514 p.

Montchowui E., Lalèyè P., Philippart J C. & Poncin P. 2007. Biologie de la reproduction de Labeoparvus Boulenger, 1902 (Cypriniforme, Cyprinidae) dans le bassin du Fleuve de l'Ouémé au Bénin (Afrique de l'Ouest. Cahier d'éthologie. 22 (2): 61-80.

Nisbet, M., et Verneaux . 1970. Composantes chimiques des eaux courantes, Anales de limnologie 6(2), 161-190.

Ihak, R, & Gentleman, R.R. 1996. A language for data analysis and graphics, Journal of Computational and Graphical Statistics 5, 299-314.

Intes, A, &LeLoeuff, P. 1986. Les Annelides Polychètes de Côte d'Ivoire. IV- Relation faune-sédiments. Cahier ORSTOM, série océanographie, 21 (1), 53-88.

Offem, B.O, Samsons, Y.A, and Omoniyi, I.T. 2009. Trophic ecology of commercially important fishes in the Cross River, Nigeria. The Journal of Animal & plant Sciences, 19 (1), 37-44.

Olukolajo, O.S, & Ayo-Olalusi, C. I. 2009. Aspects of ecology and biology of the cichlid, *Tilapia mariae* from two adjacent low-brackish water lagoons in Nigeria. African Journal of Agricultural Research. 4(5), 474-483.

Pinkstone, E. 1996. Study of the fishery resources of Ndogo Lagoon. Gamba protected Areas complex. Ministère des Eaux et Forêts. Gabon -WWF.45 p

Pouilly M. 1993. Habitat, éco morphologie et structure des peuplements de poissons dans trois petits cours d'eau tropicaux de Guinée. Rev. Hydrobiology. trop. 26(4) : 313-325.

Pwema K V. 2004. Étude écologique comparée de trois espèces de Labeo (Cyprinidae) du Pool Malebo, Fleuve Congo. Mémoire de DEC, Faculté des Sciences, FUNDP-Namur, Belgique. 43 p.

Rabenkogo, N. 2007. Le littoral du Nkomi (Gabon). Contribution géographique à la conservation des milieux naturels. Thèse de doctorat en géographie et Aménagement de l'espace. Université Paul Valery-Montpellier III (France), 307 p.

Shapiro SS, & Wilk MB. 1965. An analysis of variance test for normality (complete samples). Biometrika, 52, 591 – 611

Welcome R L. 1985. River Fisheries. 330 p Tech. Pap. N°262.Rome: FAO. FAO Fish.

Welcome R L. 1989. Review of the Present State of Knowledge of Fish Stocks and Fisheries of African Rivers. In. DODGE DP. (ed.) Proc. of the International Large Rive Symposium. Ontario, Canada: Department of Fisheries and Oceans pp. 515-531.

Van den Booshe JP, &Bernacsek GM. 1990. Source Book for the Inland Fishery Resources of Africa. Vol. 1 and 2. Rome,FAO, Cifa Tech. Pap., 18/1, 18/2, 411 p.,240p.

Welcome R L. 2005. River Fisheries in Africa: Their Past, Present & Future. Mimeo.

Zerbi, A. 2004. Introduction à la gestion de la qualité de l'eau en aquacultre. Creufop. Université des sciences et Techniques du Languedoc-Roussillon, Montpellier II, France, 67p.

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Hydrobiology
DOI:10.22192/ijarbs.2018.05.04.019	

How to cite this article:
Jean Félicien Liwouwou, Delphine Adandedjan, Jean Daniel Mbega, Philippe Lalèyè. (2018). Comparative characterization of some physicochemical and hydromorphological parameters from three rivers of Gabon: Rembo Bongo, Ogooué and Nyanga. Int. J. Adv. Res. Biol. Sci. 5(4): 186-201.
DOI: http://dx.doi.org/10.22192/ijarbs.2018.05.04.019