An Idea on Physico-Chemical Parameters of Waters in Two Streams of Savannah Agro-Pastoral Zone, North Region of Cameroon

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Abstract: **- The present study was conducted on two rivers in an area with high agro-pastoral activity. The objective of this study was to assess the physico-chemical quality of water subjected to pressure from agro-pastoral activities since 1990. The water samples were collected and analyzed according to standard protocols. For this purpose, water temperature, dissolved oxygen, pH, electrical conductivity, TDS, suspended matter, color, turbidity, alkalinity, total hardness, manganese, nitrites, nitrates, ammonia and phosphates were analyzed. Luminosity, atmospheric humidity and air temperature were also measured to assess their influence on the physic-chemistry of the waters. The results show that the average values of color (325.86 ± 524.69 Plt-Co) and of alkalinity (107.57 ± 20.12 mg/L) are very high; the water temperature (25.79 ± 2.88 °C) is significantly and positively related to the air temperature (32.90 ± 2.96 °C) on the one hand, and significantly and negatively related to the atmospheric humidity (34.43 ± 13.49 %) at $p \leq 0.05$. Based on the physicochemical quality of the water, the sampling stations were classified into three classes. Class I groups very good quality water (stations WP1, WP4, WP2 and WP3), class II groups medium quality water (stations WB1 and WB2) and class III represents the worst water (WB3).**

Keywords: **water quality, physico-chemical parameters, meteorological factors, savannah, North Cameroon**

I-INTRODUCTION

Water is an essential resource for life. Living beings use it for their living environment, their food and their pleasure. It's a gift from God for nature [1]. Lately, the global aquatic environment has suffered from major degradation due to the uncontrolled dumping of industrial waste, the intensive use of chemicals in agriculture and the uncontrolled exploitation of these bodies of water [2]. Agro-pastoral activities carried out in watersheds contribute enormously to the degradation of the quality of surface water. Besides, with the advancement of drought and the scarcity of rains, surface water is becoming increasingly scarce in quantity and quality thus putting living organisms around it at risk [3], [4]. So the surface water available must be monitored and protected for the next generation. To monitor the quality of the savannah streams, we have chosen to analyze the waters of the Wayam Phacochère and Wayam Baptême streams. To do this, we used the measurement of temperature, color, turbidity, pH, TDS, electrical conductivity, dissolved oxygen, suspended matter, alkalinity, manganese, total hardness, nitrites, nitrates, ammonium and phosphates. Some meteorological parameters that could influence the physicochemical quality of surface water, namely air temperature, humidity and luminosity were measured. The objective of this study is to characterize the physicochemical quality of the waters of the Wayam Phacochère and Wayam Baptême streams.

II-MATERIAL AND METHODS

1 - Description of Sampling Sites

This study was conducted in a savannah area of the region of North Cameroon, Department of Mayo-Rey. The Mayo-Rey is located between 08 ° 40''N and 014 ° 11''E. The climate is of the Sudanese type and is subdivided into two seasons, a rainy season which can extend from April to October and a dry season going from November to March. The mean annual precipitation is 1044.1 mm, the mean annual temperature is 27.5 ° C and the mean annual humidity is 55.3% [5]. The Phacochère village was founded in 1990 in the National Program for Recolonization of Arable Land in the region of north Cameroon [6]. The population of this village is estimated in 2012 at 5080 inhabitants. This locality is a basin of agricultural and pastoral production. The main activities carried out are cotton, soybean, corn, peanuts and livestock farming [6]. Since then, the watersheds of this locality have been subject to considerable anthropogenic pressures. The Wayam Phacochère and Wayam Baptême rivers are located around the village called Phacochère. On the Wayam Phacochère stream, four (4) sampling stations were chosen WP1 (08°08'54.0"N, 015°08'01.7"E, 584 m), WP2 (08°08'54.1"N, 015°07'53.7"E, 576 m), WP3 (08°08'46.5"N,

015°07'46.2"E; 575 m) and WP4 (08°08'42.2"N, 015°07'43.0"E, 570 m) and on the Wayam Baptême stream three (3) stations were chosen WB1 (08°06'45.0"N, 015°08'15.2"E, 591 m), WB2 (08°06'46.9"N, 015°08'21.6"E, 571 m) and WB3 (08°06'48.3"N, 015°08'26.9"E , 564 m).

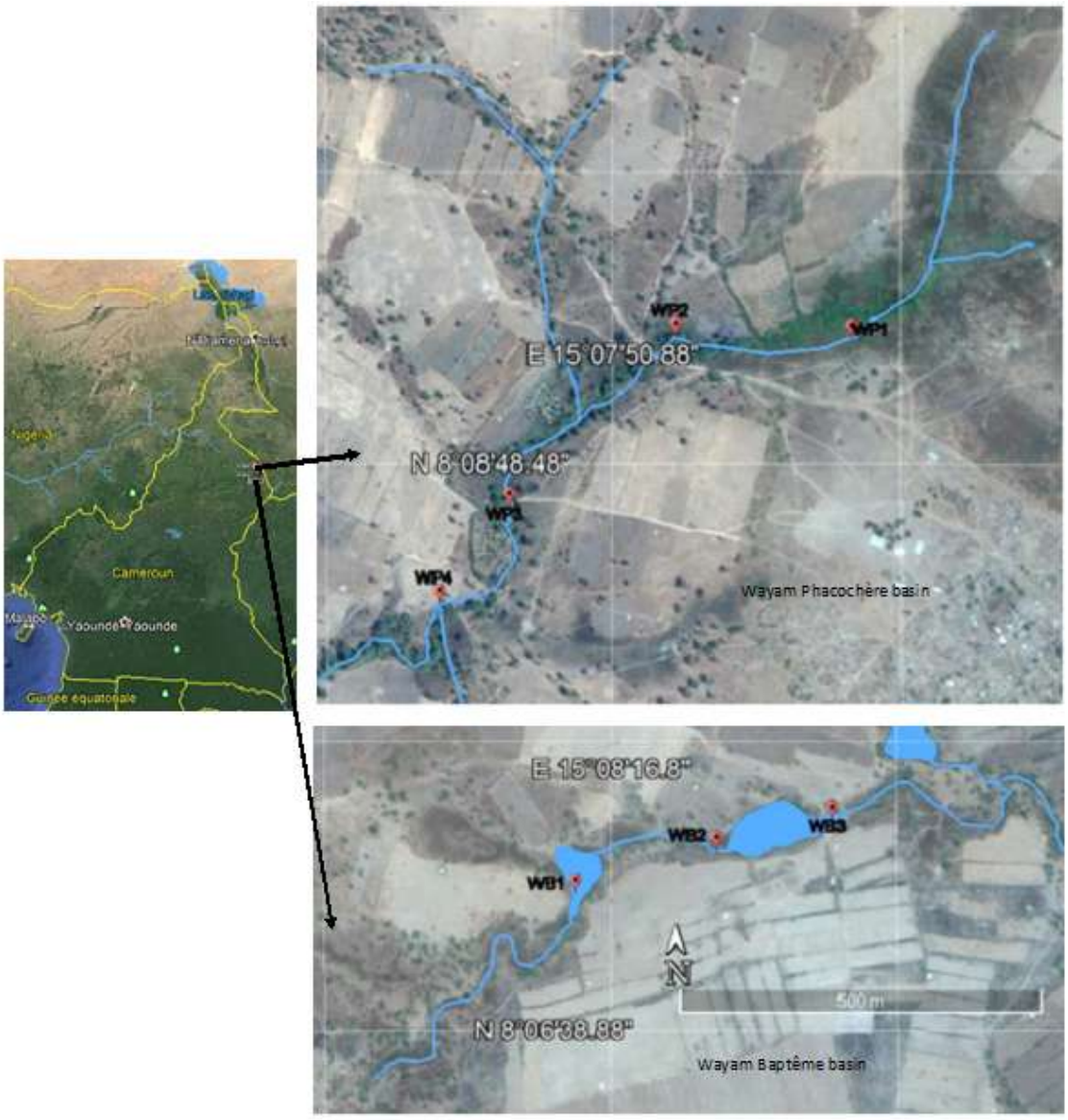

Figure 1: Sampling stations map

2 - Data Collecting

The study was conducted in the dry season, in a single sample from December 5 and 6, 2019 in the two streams. The geographic coordinates and elevation of the sampling stations were taken with the Gamin 60S GPS. The meteorological parameters were measured in the field using a Testo 610 thermo-hygrometer for air temperature and humidity; and using a Testo 540 luxmeter for luminosity. The physico-chemical analyzes were carried out both in the field and in the laboratory according to standard protocols [7], [8]. A total of fifteen (15) parameters caught our attention in this study. The temperature, dissolved oxygen, pH, electrical conductivity and TDS were measured using the Combo Water Quality Meter 86031. For laboratory analysis, water samples were taken from each station using 250 ml double-closure polyethylene bottles and transported to the laboratory in a refrigerated enclosure. Suspended matter, color, turbidity, alkalinity, total hardness, manganese, nitrites, nitrates, ammonium and phosphates were measured in the laboratory using a HydroTest HT1000 photometer.

3 - Data Analyses

The physicochemical data were analyzed using statistical tests of Rho correlation from Spearman and comparison K from Kruskal Wallis. The Spearman correlation test was performed to estimate the degrees of binding between the parameters

measured. The principal component analysis was used to project the stations and the parameters that characterize them onto the map. The grouping of the stations based on similarity of the physicochemical parameters was done using dendrogram. All analyzes were performed using XLSTAT 2007 software.

III - RESULTS AND DISCUSSION

1 - Results

The table 1 below shows the minimum, maximum and averages of the parameters measured. The Kruskal Wallis K test revealed no significant difference between the values of different parameters at all stations ($p \leq 0.05$). The humidity percentage is overall less than 55 %. The waters have a pH close to neutral and a high oxygen saturation rate. Many physico-chemical parameters are compared with European Union Standards for aquatic life in the table 1.

Table 1: Meteorological and physico-chemical parameters of Wayam Phacochère and Wayam Baptême streams

Variables	**Code**	**Minimum**	**Maximum**	**Mean ± SD**	**EU maximum for fisheries and aquatic life [9]**
Luminosity (lux)	Lux	1220.00	12708.00	5811.29±4832.98	
Humidity (%)	ϕ	19.20	54.50	34.43±13.49	
Air Temperature (°C)	AT	28.80	37.30	32.90±2.96	
Water temperature (°C)	WT	22.40	30.20	25.79±2.88	<25.00
pH (CU)	pH	6.02	7.39	6.82±0 .43	6.0 - 9.0
TDS (mg/L)	TDS	28.50	87.20	58.84±26.80	
Electrical conductivity (uS/Cm)	EC	56.70	174.70	117.86±53.68	180.00- 1000.00
Color (Plt-Co)	Color	61.00	1496.00	325.86±524.69	
Turbidity (FAU)	Turb	19.00	82.00	32.71±22.93	
Suspended solids (mg/L)	SS	57.00	137.00	96.71±24.19	<25.00
Dissolved oxygen (%)	DO%	54.00	97.20	82.83±15.15	>50.00
Alcalinity (mg/L $CaCO_3$)	Alca-CaC03	63.00	121.00	107.57±20.12	<11.00
Total hardness (mg/L $CaCO_4$)	Thard-CaCO3	22.00	34.00	26.00±4.44	<50.00
Manganese(mg/L MnO_4)	Mn-MnO4	0.96	2.19	1.71±0.49	
Nitrites (mg/L NO_2)	N-NO2	0.25	0.72	0.45±0.18	<0.03
Nitrates (mg/L NO_3)	N-NO3	0.71	1.70	1.04±0.34	
Ammonia (mg/L NH_3)	N-NH3	0.20	0.44	0.27±0.08	<1.00
Phosphates (mg/L PO_4)	P-PO4	0.76	1.46	0.92±0.25	

The main component biplot analysis shows the cartographic presentation of the stations and the physico-chemical and meteorological parameters on two axes (see figure 2). In total, the main axes provide 80.87 % of the information, i.e. 43.70 % in F1 and 37.17 % in F2. The variables humidity, TDS, EC, Color, total hardness, nitrites, phosphates and the stations WP2, WB1 contribute a lot to the formation of the F1 axis. Parameters like luminosity, pH, manganese and stations WP1, WB2 participate in the formation of the F2 axis. Along the F1 axis in negative coordinates, the stations WP2, WP3 and WP4 are characterized by high values of electrical conductivity, humidity and TDS. And in positive coordinates, the high values of air temperature, water temperature, dissolved oxygen, color, turbidity, total hardness and phosphates characterize the station WB1. Along axis F2, in negative coordinates, stations WB2 and WB3 are characterized by water with a neutral pH. And in positive coordinates, the WP1 station is characterized by high values of luminosity, alkalinity and manganese. The ascending hierarchical classification based on the physico-chemical quality of the station waters distinguishes three (3) groups with 97% similarity (see figure 3). The group I show the stations WP2, WP3, WP4 and WP1; the group II has the stations WB1 and WB2. The WB3 station represents the group III.

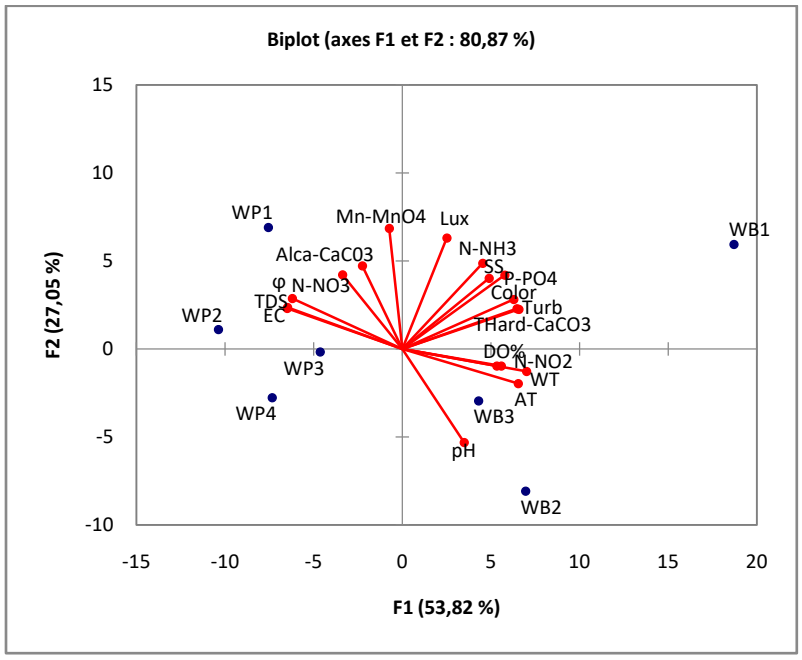

Figure 2: Biplot of sampling stations and the physico-chemical parameters of water in two axes of PCA

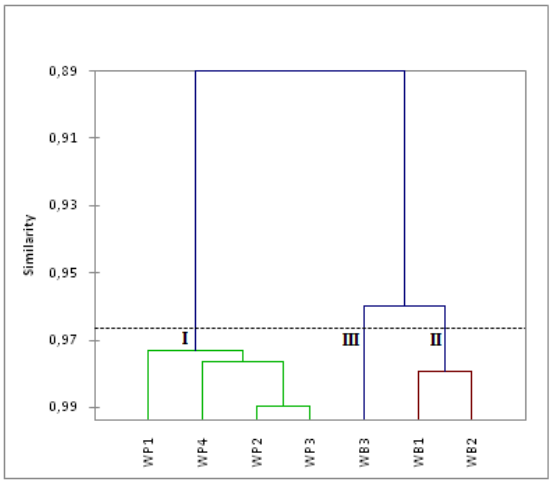

Figure 3: Dendrogram highlighting the grouping of sampling stations based on their physico-chemical and meteorological variables

2 - Discussion

Water quality is very often linked to anthropogenic disturbance of the catchment area or of the stream which can alter in the long term the physico-chemical quality of water [1], [10]. Temperature is an important ecological factor. It affects the speed of biological and chemical processes and the dissolution of gases like oxygen. In this case, we note that the water temperature is strongly influenced by the air temperature (0.893) and the atmospheric humidity (-0.929) at $p \leq 0.5$ (see table 2). However, these values remain slightly higher than those obtained by other authors in the forest part of Central Africa [11]–[17], but lower than those obtained in the waters of Mayo Kaliao (23.5 - 38.0 °C) [18]. The pH is an element which depends directly on the nature of the substrate [19] or of the organic matter when evaporation is important. It will, therefore, express the acidity or basicity of the material leached by the water [20]. In the case of this study, the pH varied between 6.02 and 7.39 CU. Compared to the values obtained by [11], [14], [21], [22], the pH values of the waters of these two streams are close to neutral. For TDS, EC, color, turbidity and SS, the values are all slightly higher than those recommended by [9], [23] with peak values of 1496 Plt-Co for color at the station and 137 mg/L for the suspended solids at station WB1. To this end, some authors point out that the waters are more turbid and colored as the density of suspended particles is high [8]. The electrical conductivity values obtained are low compared to those evaluated on the waters of El Beid in 1982 in the savannah zone of northern Cameroon (95 µS/Cm - 175 µS/Cm) [24]. Overall, these values are higher than those obtained on the Nguito stream in the Central African Republic in 2018 [17], but not higher than European Union recommendation for aquatic life [9]. The values of alkalinity and total hardness obtained in these two savannah streams are higher than those generally obtained in southern Cameroon [21], [25]. The manganese contents are between 0.96 and 2.19 mg/L with an average of 1.71 ± 0.49 mg/L. Manganese is a mineral found naturally in rocks and soil, but it can nevertheless be introduced by a source of pollution [26], [27]. Manganese can make water turbid and at low doses, it produces dark brown or black spots by oxidation on objects it comes into contact with [28], [29]. Although manganese appears to be harmless in swimming waters, it could poison the nervous system [30]. The percentage of saturation in dissolved oxygen (82.83 ± 15.15 %) testifies to good oxygenation of the waters and would be favorable for the proper functioning of these hydro-systems. The solubility of oxygen in stream water depends mainly on water temperature and salinity [23], [31]. These oxygen contents join those obtained in the Méfou watershed in the south-centre

ecological region of Cameroon [14]. Total hardness and alkalinity are elements found in natural waters. They result from reactions of carbonate rocks rich in calcium and magnesium [32]. The average values of alkalinity (107.57 ± 20.12 mg/L) and total hardness (26.00 ± 4.44 mg/L) obtained in this study would indicate the presence of rocks rich in calcium and magnesium. The nutrient contents (nitrites, nitrates, ammonium and phosphates) are low compared to those obtained on Olézoa in 2017 [33], but higher if we compare them with the values obtained on Nsapé [12] and Abouda [14]. The literature note that phosphates and ammonium contents exceeding respectively 0.2 mg/L and 0.3 mg/L in natural waters would indicate a beginning of enrichment of the environment in nutritive elements [8]. In this study, these elements are more complex, because during the dry season the phenomenon of evaporation promotes the concentration of mineral salts in the water. Bush fires on the other hand, calcines and mineralizes organic waste, plants and animal organisms which are slow to bury at the origin of the production of mineral and are leached in surface waters. When the rainy season arrives, the runoff will then carry the mineral salts from these fires in the streams and enriched with elements such as nitrates, ammonium, calcium or magnesium carbonate, potassium or sodium [24]. However, the ammonium dissolved in water can come from decomposing organic matter or directly introduced into the water through human activities. In unpolluted natural waters, the ammonium content may not exceed 0.02 mg/L [32], [34].

IV - CONCLUSION

In this savannah area where drought is advancing rapidly and where the quantity and quality of water are degraded, water monitoring is becoming a priority for both scientists and public authorities. This is, moreover, an issue raised to the highest level in the development policy of the Cameroonian government. We have carried out this study on physico-chemical and meteorological parameters to have an idea on water quality in this part of Cameroon. In this study, the physico-chemical characterization of the waters showed three groups, namely group I (WP1, WP2, WP3 and WP4), group II (WB1 and WB2) and group (WB3). Globally, the quality of water of these streams is good and favorable for fisheries and aquatic life.

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Conflicts of Interest: the authors declare no conflict of interest.

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Table 2: Spearman correlation matrix o water quality and meteorological indicators of the 7 stations of the Phacochère streams

Variables codes	Alt	ϕ	AT	Lux	WT	pH	TDS	EC	DO%	Color	Turb	SS	Alca-$CaC0_3$	THard-$CaCO_3$	Mn-MnO_4	N-NO_2	N-NO_3	N-NH_3	P-PO_4
Alt	1																		
ϕ	0,143	1																	
AT	0,036	-0,929*	1																
Lux	0,857	-0,071	0,143	1															
WT	-0,036	-0,929*	0,893	0,107	1														
pH	-0,179	-0,607	0,679	-0,214	0,714	1													
TDS	0,464	0,857*	-0,750	0,179	-0,857*	-0,571	1												
EC	0,464	0,857*	-0,750	0,179	-0,857*	-0,571	1,000*	1											
DO%	-0,107	-0,821*	0,679	0,036	0,857*	0,321	-0,786*	-0,786	1										
Color	0,250	-0,607	0,679	0,250	0,679	0,143	-0,536	-0,536	0,786*	1									
Turb	0,288	-0,631	0,721	0,324	0,703	0,180	-0,559	-0,559	0,757	0,991*	1								
SS	0,429	-0,429	0,429	0,643	0,357	-0,321	-0,286	-0,286	0,536	0,750	0,775*	1							
Alca-$CaC0_3$	-0,072	0,090	-0,234	0,378	-0,252	-0,523	-0,036	-0,036	-0,162	-0,234	-0,173	0,378	1						
THard-$CaCO_3$	0,218	-0,709	0,655	0,491	0,764	0,145	-0,691	-0,691	0,818*	0,818*	0,853*	0,818*	0,211	1					
Mn-MnO_4	0,857*	0,071	-0,036	0,929*	-0,107	-0,464	0,393	0,393	-0,036	0,179	0,216	0,643	0,360	0,327	1				
N-NO_2	0,143	-0,464	0,500	0,107	0,714	0,357	-0,571	-0,571	0,750	0,821*	0,811*	0,393	-0,378	0,727	-0,071	1			
N-NO_3	0,429	0,607	-0,679	0,286	-0,429	-0,286	0,643	0,643	-0,357	-0,464	-0,487	-0,321	-0,036	-0,327	0,357	-0,143	1		
N-NH_3	0,577	-0,126	-0,018	0,739	0,180	-0,090	0,108	0,108	0,198	-0,018	0,009	0,306	0,273	0,358	0,721	0,054	0,613	1	
P-PO_4	0,595	-0,360	0,342	0,865*	0,450	-0,054	-0,270	-0,270	0,432	0,505	0,573	0,757	0,409	0,826*	0,703	0,468	0,108	0,700	1

*Only values bearing a star * are significant correlations at the level p≤0,05.*