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Characterization of water quality in the river Lobo and tributaries Center-West of Côte d'Ivoire

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Key words: Chlorophyll a, Catchment area, River Lobo, Organic pollution, Eutrophic

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Abstract

The objective of the study is to assess the ecological quality of the river Lobo and its two main tributaries. To do this, spatio-seasonal measurements of physical, chemical and biological parameters were carried out in situ using a multiparameter and by assay in the laboratory. No significant variations were observed across the physicochemical parameters with the exception of orthophosphate at a spatial level. The concentration of chlorophyll a ranged from 57.67 µg/L to 149.91 µg/L while that of total phosphorus ranged from 5.58 mg/L to 25.85 mg/L at the river Lobo. These values fall within the range of values for the eutrophic state. Regarding organic pollution, the index values range from 2.47 to 3.13 indicating a moderate level of organic pollution in the river Goré, from moderate to high in the Lobo River, and a high level of organic pollution in the river Dé. Additionally, the Carlson trophic index suggests that the rivers are eutrophic. From the above results, it can be seen that the river Lobo and its main tributaries are impacted by organic pollution with enrichment in nutritive salts linked to the anthropic activities carried out in the basin. The waters in the upstream of the basin are more affected by human activities than those in the downstream.

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Introduction

Water is an essential resource upon which all life on Earth depends. However, watercourses that cover the surface of the Earth represents only a tiny fraction of the available freshwater, even though they are the main source of water for people in many parts of the world. Additionally, economic development is inevitably linked to the availability and quality of freshwater resources (Diop and Rekacewicz, 2003). In addition to supplying water for multiple uses, aquatic environments also have other functions that may not be well perceived but ensure the sustainability of previous uses. Finally, they provide life support for the habitats that they provide for the flora and fauna (Souchon *et al.*, 2002). Water resources are known as limited due to the rise in population pressure, associated to needs and human activities' impacts (Jackson *et al.*, 2001; UNEP, 1999). River Lobo, supplying Daloa town in its water requirements undergoing many pressures. Indeed, although treated for potability, this rivers' water gives unpleasant organoleptic properties. The variety of sources of pressure on aquatic environments (chemical and physical) associated with complex interactions is often poorly understood. The accumulation of these alterations has led to the need to develop integrative indicators for aquatic environments quality assessment. Thus, physico-chemical water criteria have been defined but prove to be inadequate and require supplementing with biological criteria for determining the ecological quality of aquatic environments (Renou, 2015). Phytoplankton organisms are increasingly being suggested by the DCE (water framework directive)as potential bio-indicators that respond to the trophic changes in water masses (Solheim, 2005; Bricker *et al.*, 2008; Domingues *et al.*, 2008; Devlin *et al.*, 2009; Spatharis and Tsirtsis, 2010; Ferreira *et al.*, 2011; Pinay *et al.*, 2018). As chlorophyll *a* is the main photosynthetic pigment in these microorganisms, its concentration in surface waters can be used to assess phytoplankton biomass and photosynthetic activity. Therefore, it is considered an ecological indicator of the aquatic environment. The aim of this work is to contribute to knowledge on Lobo river and its two tributaries using water quality indices.

Materials and methods

Description of study area

The catchment area of Lobo river is in west-central of Côte d'Ivoire, between 6°05' and 6°55' west longitude, and 6°02' and 7°55' north latitude (Fig. 1). Lobo river, which length is 597 km, originates south of the Séguéla region, and merges into Sassandra river near Loboville. Lobo has main tributaties: Dé and the Goré (Yao *et al.*, 2012). The vegetation of the basin consists of degraded forests (Kouassi *et al.*, 2020) related to perennial crops such as rubber, cashew, coffee, and cocoa, along with annual crops such as rice, cassava, yams, and garden produce.

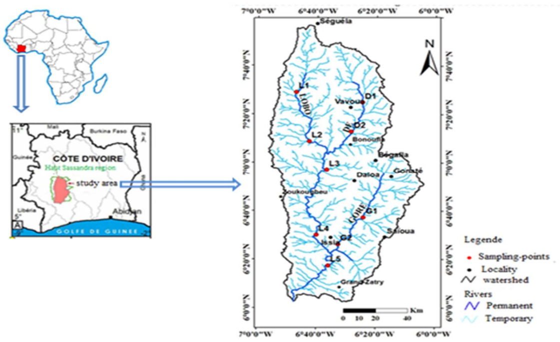

Fig. 1. Map of the study area (Lobo catchment) and sampling stations

Sampling stations and sampling periods

The stations were selected based on their accessibility, longitudinal profile, and the intensity of human activities. A total of nine stations were selected, with two stations sampled on each tributary (river Dé: D1 and D2; river Goré: G1 and G2), and five stations on the main course of the river Lobo (L1, L2, L3, L4 and L5) as shown in Table 1. Water samples were collected during five campaigns that took place from November 2018 to October 2019 (November, January, May, July, and October).

Physico-chemical parameters assessment

Water samples were collected from sampling stations near the water surface between 7 AM and 5 PM. A HQ40d multiparameter was used to measure parameters such as dissolved oxygen, conductivity, pH, and temperature. Regarding the nutrients (nitrites, nitrates, total nitrogen, orthophosphate, total phosphorus), water samples were collected in 350 mL dark bottles, kept cool in a cooler, and transported to the laboratory for analysis.

Table 2. Coordinates of sampling sites

		Localities	Sampling points	Coordinates x	Coordinates y
Tributary	River Dé	Pk11	D1	7°24'	6°24'
		Bonoufla-Bahoulifa Bridge	D2	7°12'	6°28'
	River Goré	Dépa	G2	6°26'	6°32'
		Gogoghué	G1	6°37'	6°24'
Principal course	River lobo	Mignouré	L1	7°29'	6°47'
		Babo	L2	7°8'	6°42'
		SODECI Station	L3	6°57'	6°36'
		Dobia	L4	6°30'	6°39'
		Roa	L5	6°16'	6°35'

Table 3. Grid evaluation of Organic Pollution Index (Leclercq, 2001)

Classes	NH_4^+ (mg/L)	NO_2^-(µg/L)	PO_4^{3-} (µg/L)	Limits	Organic Pollution Level
5	< 0.1	≤ 5	≤ 15	4.6 - 5.0	None
4	0.1 - 0.9	06-10	16 - 75	4.0 - 4.5	weak
3	1 - 2.4	11-50	76 - 250	3.0 - 3.9	Moderate
2	2.5 - 6	51 - 150	251 - 900	2.0 - 2.9	strong
1	> 6	> 150	> 900	1.0 - 1.9	Very strong

NH_4^+ : ammonium, NO_2^- : nitrites, PO_4^{3-}: orthophosphate

The measurement of ammonium, nitrates (NO_3-) and nitrites (NO_2-) was conducted using the molecular absorption spectrometric method in accordance to French Standard T 90-015, T 90-012 and T 90-013, respectively. The total phosphorous and ortho-phosphate measurements were performed according the French Standard T 90-023.

Determination of chlorophyll a

Chlorophyll *a* is an indicator of phytoplankton biomass in waters (Beauchesne and Duval, 2016; MDDEFP, 2013; Rolland and Jacquet, 2010). The quantification of chlorophyll *a* was carried out using the method proposed by Lorenzen (1967). To do so, 250 ml of sample were collected and filtered through GF/F membranes (Whatman) with a porosity of 0.7 µm in the field. The filters were then stored in aluminum foil to protect from light and heat. Chlorophyll was then extracted in Laboratory with 90% acetone. Chlorophyll content was obtained by readings at different wavelengths on a spectrophotometer (665 and 750 nm, before and after acidification). The concentration of chlorophyll *a* was estimated using the following equation:

$$\text{Chla}(\mu g/l) = \frac{26,7 * Va * (A1 - A2)}{Ve * L}$$

A1= absorbance before acidification (OD665-DO750); A2 = absorbance after acidification (OD665-DO750); Va: volume of acetone (ml); Ve: volume of filtered water (liter); L: optical path length of the cell (cm).

Data analysis

Statistical tests were conducted on both physicochemical parameters and chlorophyll *a* in order to analyze their variation among different sampling sites. Before any analysis, normality test (Shapiro-Wilk test) and homogeneity test (Levene's test) were performed on variables distribution. For data that did not meet the normality and homogeneity conditions, Kruskal-Wallis non-parametric test was applied. Regarding parameters that met the normality and homogeneity conditions, they were subjected to the one-way ANOVA parametric test. For seasonal level, the non-parametric Mann-Whitney test was applied to test parameters variability. All of these tests are significant at a probability value lower than 0.05 ($p < 0.05$). Additionally, box plots were used to present the variations of the different parameters. These tests were conducted using PAST 3.24 software (Hammer *et al.*, 2001).

Determining pollution levels

Organic pollution index

The Organic Pollution Index (OPI) (Leclercq, 2001) has been used to assess the level of the organic pollution at sampling stations. It is computed based on measurements of ammonium NH_4^+ (mg/L), nitrites NO_2^- (µg/L) and orthophosphate PO_4^{3-} (µg/L) resulting from organic pollution.

Table 3. MDDELCC reference values for chlorophyll a and total phosphorus

Chl a (µg/L)	TP (mg/L)	Trophy level	Signification
0 - 3	< 0.01	Oligotrophic	Values standards recommended
03- 8	0.01 - 0.03	Mesotrophic	Values to be monitored (eutrophication)
> 8	> 0.03	Eutrophic	Problematic values

Chl*a*: Chlorophyll *a* , TP: Total Phosphorus

Table 4. Trophic class limits of Carlson Trophic State Index

TSI	Trophic Class	SD (m)	TP (µg/L)	Chl a (µg/L)
0-40	Oligotrophic	>8-4	0-12	0-2.6
40-50	Mesotrophic	4-2	12-24	2.6-7.3
50-70	Eutrophic	2-0.5	24-96	7.3-56
70-100+	Hypereutrophic	0.5 < 0.25	96-384 +	56-155 +

The OPI value for a sample is equal to the mean of the classes (Table 2) of the different cited parameters (Leclercq and Maquet, 1987; Leclercq, 2001). The index values are distributed into 5 pollution classes and are interpreted according to the following Table 2.

Trophic level of MDDELCC

The methodology for assessing the trophic level of different stations is that of the MDDELCC (Ministry of Sustainable Development, Environment and the Fight Against Climate Change). This method involves comparing values obtained during various campaigns with those of reference values from the MDDELCC (Table 3) concerning chlorophyll a and total phosphorus. Indeed, chlorophyll *a* is widely recognized as a crucial biological indicator in the assessment of the trophic status of aquatic environments. Similarly, phosphorus is directly linked to the trophic level as it is an essential and limiting element for the growth of microalgae.

Carlson trophic state index

The Carlson Trophic State Index, developed in 1977, is determined by measuring chlorophyll *a* (*Chla*) levels, transparency (*SD*), and total phosphorus (*TP*) (Table 4). This index was employed to assess the trophic state of the river Lobo and its two main tributaries. It is calculated based on the following equations:

$$CTSI = \frac{TSI_{SD} + TSI_{Chla} + TSI_{TP}}{3}$$

$$TSI_{SD} = 60 - 14.41 * \text{Ln}(SD)$$

$$TSI_{Chla} = 9.81 * \text{Ln}(Chla) + 30.6$$

$$TSI_{TP} = 14.42 * \text{Ln}(TP) + 4.15$$

Carlson Trophic State Index (CTSI)

SD: Secchi disk depth ; Ln: Neperian logarithm ; *TSI*: Trophic State Index

Results

The (Fig. 2) below illustrates the spatial variations in physicochemical parameters of the three rivers under study. According to the results of Kruskal-Wallis statistical tests, there were no significant differences between rivers for all parameters except orthophosphate, where a significant difference was found ($p<0.05$). This significant difference was observed between river Goré and the river Dé ($p=0.002$), and between the river Lobo and the river Dé ($p=0.002$).

The temperature varied from 26.5°C to 29.8°C in the Dé river. This parameter varied from 25.06°C to 28.89°C and from 26°C to 30.3°C of 28.25°C ± 1.02°C respectively in the Goré and Lobo rivers.

pH values varied from 5.62 to 7.72 in the Dé river, from 5.63 to 7.29 in the Goré river and from 5.56 to 7.56 in the Lobo river.

For conductivity, the extreme values are 77.1 $\mu S.cm^{-1}$ and 319 $\mu S.cm^{-1}$ in the Dé river. In the Goré river, it varied from 110.1 $\mu S\ cm^{-1}$ to 245 $\mu S\ cm^{-1}$. The Lobo river recorded 78 $\mu S.cm^{-1}$ for minimum and 283 $\mu S.cm^{-1}$ for maximum values.

In the Dé river, the value of dissolved oxygen varied from 1.12 $mg.L^{-1}$ to 5.91 $mg.L^{-1}$. This parameter fluctuated from 2.04 $mg.L^{-1}$ to 6.5 $mg.L^{-1}$ for the Goré River and from 2.27 mg.L-1 to 6.9 $mg.L^{-1}$ for the Lobo River.

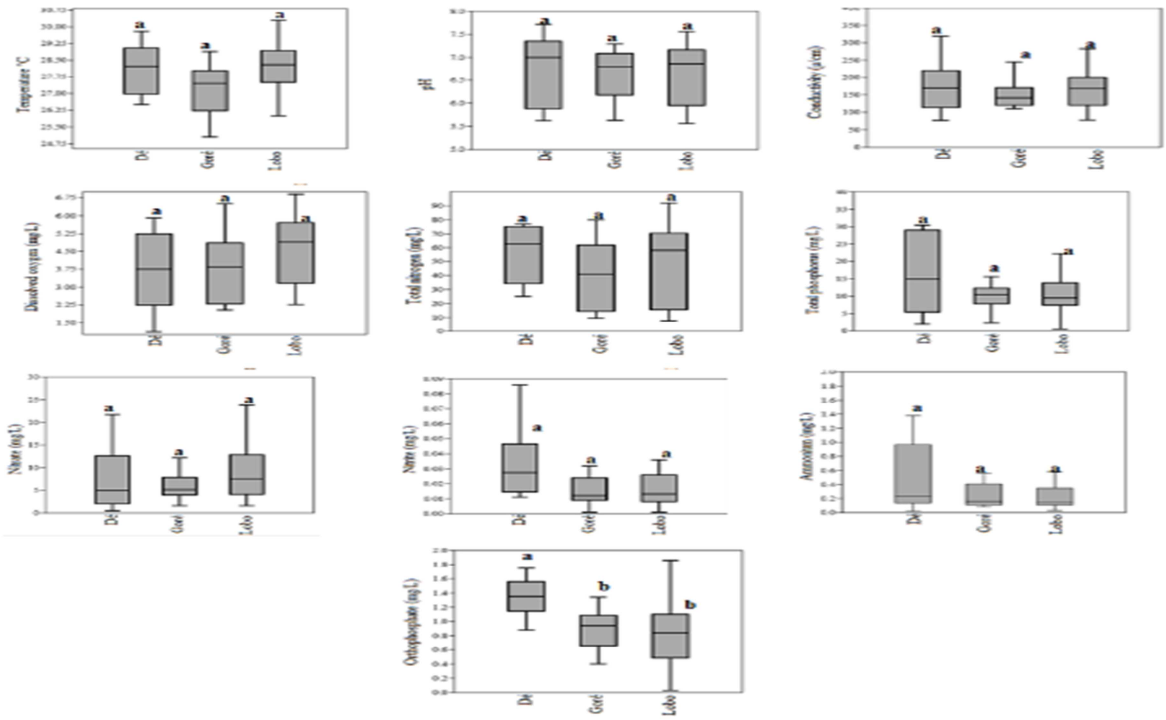

Fig. 2. Spatial variations in physico-chemical parameters in the River Lobo and its two tributaries. Boxplots having a letter (a or b) in common do not differ significantly (Kruskal-Wallis $p > 0.05$);

Table 5. Seasonal variation physico-chemical parameters

Parameters	River Dé			River Goré			River Lobo		
	DS	RS	*p*-value	DS	RS	*p*-value	DS	RS	*p*-value
Temp.	28.61± 0.8 [a]	27.81± 1.26 [a]	0.33	27.51± 1.77 [a]	26.97± 0.79 [a]	0.59	28.98± 032 [a]	27.76± 1.04 [b]	0.001
Dissolved oxygen (mg/L)	4± 0.87 [a]	3.43± 2.06 [a]	0.91	5.1± 1.35 [a]	3.08± 1.03 [b]	0.042	5.29± 1.12 [a]	3.90± 1.46 [b]	0.028
pH	5.95± 0.44 [a]	7.30± 0.31 [b]	0.014	6.10± 0.35 [a]	7.01± 0.2 [b]	0.014	5.85± 0.21 [a]	7.08± 0.31 [b]	3.5.10^{-5}
Conductivity (µS/cm)	242± 73.5 [a]	129.37± 54 [b]	0.04	161.5± 61.41 [a]	142.45± 25.73 [a]	0.09	158.3± 64.04 [a]	160.54± 40.81 [a]	0.67
Nitrites (mg/L)	0.044± 0.02 [a]	0.025± 0.017 [a]	0.45	0.016± 0.005 [a]	0.015± 0.012 [a]	0.45	0.024± 0.008 [a]	0.01± 0.007 [b]	0.002
Nitrates (mg/L)	11.8± 8.7 [a]	4.87± 3.98 [a]	0.33	6.32± 4.53 [a]	5.79± 2.39 [a]	0.91	9.66± 7.42 [a]	8.47± 6.32 [a]	0.69
Total nitrogen (mg/L)	54.5± 24.31 [a]	56.5± 21.88 [a]	1	13.5± 2.79 [a]	58± 15.65 [b]	0.01	24.49± 23.65 [a]	61.9± 16.13 [b]	0.0029
Orthophosphate (mg/L)	1.425± 0.22 [a]	1.67± 0.27 [a]	0.39	1.01± 0.17 [a]	0.81± 0.34 [a]	0.24	1± 0.22 [a]	0.72± 0.5 [a]	0.05
Total phosphorus (mg/L)	17.38± 14.68 [a]	15.5± 10 [a]	0.74	8.82± 4.74 [a]	10.77± 2.98 [a]	0.74	11.49± 6.09 [a]	10.11± 4.59 [a]	0.91

The concentration of nitrite varied from 0.011 $mg.L^{-1}$ to 0.086 $mg.L^{-1}$ for the river Dé. from 0.001 $mg.L^{-1}$ to 0.032 $mg.L^{-1}$ for the river Goré and from 0.001 $mg.L^{-1}$ to 0.36 $mg.L^{-1}$ for the river Lobo. Nitrate content ranged from 0.5 $mg.L^{-1}$ to 21.7 $mg.L^{-1}$ for the Dé river, from 1.6 $mg.L^{-1}$ to 12.2 $mg.L^{-1}$ for the Goré river and from 1.6 $mg.L^{-1}$ to 23.8 $mg.L^{-1}$for the Lobo river. Ammonium concentrations ranged from 0.02 $mg.L^{-1}$ to 1.38 $mg.L^{-1}$ in the Dé river, from 0.08 $mg.L^{-1}$ to 0.56 $mg.L^{-1}$ and from 0.03 $mg.L^{-1}$ to 0.58 $mg.L^{-1}$ in the Goré and Lobo rivers respectively.

Total nitrogen values varied from 25 $mg.L^{-1}$ to 77 $mg.L^{-1}$ in the Dé river, from 9.5 $mg.L^{-1}$ to 80 $mg.L^{-1}$ and from 7.4 $mg.L^{-1}$ to 92 $mg.L^{-1}$ Goré and Lobo rivers respectively. Orthophosphate varied from 0.88 $mg.L^{-1}$ to 1.75 $mg.L^{-1}$

in the Dé River, from 0.4 $mg.L^{-1}$ to 1.34 $mg.L^{-1}$ and from 0.03 $mg.L^{-1}$ to 1.86 $mg.L^{-1}$ respectively in the Goré and Lobo rivers.

For total phosphorus, the extreme values are 1.9 $mg.L^{-1}$ to 30.5 $mg.L^{-1}$ in the Dé river. This parameter fluctuated from 2.3 $mg.L^{-1}$ to 15.6 $mg.L^{-1}$ for the Goré river and from 0.5 mg L^{-1} to 22.2 mg L^{-1} for the Lobo river.

Seasonal variations in physico-chemical parameters
Seasonal variations of physicochemical variables are presented in Table 5. In general, parameter averages are higher in the dry season than in the rainy season, except for pH and total nitrogen. A significant difference (Mann-Whitney U test, $p < 0.05$) was recorded between the two seasons for pH, conductivity, dissolved oxygen, nitrites, and total nitrogen values.

Regarding temperature, it varied from 25.06°C to 29.5°C during the dry season and from 25.7°C to 30.3°C during the rainy season. Concerning pH, it ranged from 5.56 to 6.58 during the dry season and from 6.36 to 7.72 during the rainy season.

Regarding conductivity, values ranged from 78 µS.cm-1 to 383 µS.cm-1 during the dry season and 77.1 µS.cm-1 to 225 µS.cm-1 during the rainy season.

As for dissolved oxygen, the means varied from 3.3 mg.L-1 to 6.9 mg.L-1 and 1.12 mg.L-1 to 6.71 mg.L-1 respectively for the dry and rainy seasons. Nitrite measurements fluctuated from 0.005 mg.L-1 to 0.086 mg.L-1 during the dry season and 0.001 mg.L-1 to 0.051 mg.L-1 during the rainy season.

Regarding nitrates, values fluctuated from 0.5 mg.L-1 to 23.8 mg.L-1 during the dry season and from 1.6 mg.L-1 to 21.7 mg.L-1 during the rainy season.

Total nitrogen values varied from 7.4 mg.L-1 to 77 mg.L-1 during the dry season and from 25 mg.L-1 to 92 mg.L-1 during the rainy season.

The concentration of orthophosphate ranged from 0.72 mg.L-1 to 1.75 mg.L-1 in the dry season and from 0.03 mg.L-1 to 1.86 mg.L-1 in the rainy season.

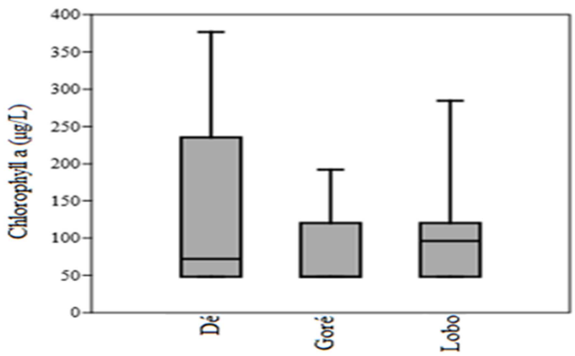

Fig. 3. Spatial variation of chlorophyll *a*

Total phosphorus values varied from 2.3 mg.L-1 to 30.5 mg.L-1 during the dry season and from 0.5 mg.L-1 to 28.9 mg.L-1 during the rainy season.

Spatial variation of chlorophyll a

The chlorophyll *a* concentration in the hydrosystem is presented in (Fig. 3). The Kruskal-Wallis test indicated no significant difference (p (0.714) > 0.05) between the various rivers. Concerning the Dé River, chlorophyll *a* concentration ranged from 48.06 µg/L to 376.72 µg/L with an average of 141.46 ± 130.64 µg/L. As for the Gsoré River, chlorophyll *a* varied from 48.06 µg/L to 192.24 µg/L with an average of 86.50 ± 59.07 µg/L. At Lobo River site, the mean chlorophyll *a* concentration is 99.49 ± 70.72 µg/L with extreme values ranging from 48.06 µg/L to 284.48 µg/L.

Seasonal variations of chlorophyll a

During the dry season in all hydrosystems except for river Lobo, the chlorophyll-a averages are high. The average values during the dry season range from 60.07 ± 24.03 µg/L to 209.48 ± 186.45 µg/L and from 85.82 ± 42.89 µg/L to 104.13 ± 70.74 µg/L during the rainy season (Table 6). No significant variation was observed between the seasons for the parameter tested, according to the Mann-Whitney U (p>0.05).

River pollution status

The pollution level of river Lobo and its two tributaries (Dé and Goré) was assessed using the Organic Pollution Index (OPI). The index values range between 2.47 and 3.13, indicating two levels of organic pollution (moderate and severe).

Table 6. Seasonal variations in chlorophyll *a*

River	Value of chlorophyll *a*		
	Dry season	Rainy season	*Value*
Dé	209.48 ± 186.45 [a]	96.12 ± 60.79[a]	0.56
Goré	60.07 ± 24.03 [a]	104.13 ± 70.74 [a]	0.39
Lobo	123.79 ± 97.15[a]	85.82 ± 42.49[a]	0.46

Average values in a row having a letter (a or b) in common do not differ significantly (Mann-Whitney test, $p > 0.05$).

Table 7. Organic pollution Index of study stations in Lobo watershed

Stations	Rivers Dé		Rivers Goré		Rivers Lobo				
	D1	D2	G1	G2	L1	L2	L3	L4	L5
OIP value	2.80	2.47	3.07	3.00	2.80	2.60	2.93	3.00	3.13
Pollution organique Level	Strong	Strong	Moderate	Moderate	Strong	Strong	Strong	Moderate	Moderate

OIP : Organic Pollution Index

Table 8. Trophy status of the river Lobo and tributaries

Stations	River Dé		River Goré		River Lobo				
	D1	D2	G1	G2	L1	L2	L3	L4	L5
TP (mg/L)	6.24	25.85	11.82	8.16	10.34	12.9	9.39	5.58	15.09
Chl *a* (µg/L)	149.91	133.02	86.51	86.51	95.34	142.63	124.96	76.9	57.67
Trophy status	Eutrophic		Eutrophic		Eutrophic				

The river Dé exhibits high levels of organic pollution, while the river Goré presents moderate levels. The river Lobo showcases moderate to severe levels of organic pollution (Table 7).

Trophic status of hydrosystems

Total phosphorus

According to the MDDELCC reference values, a concentration of 0.01 mg/L of phosphorus corresponds to the beginning of the mesotrophic trophic level, and at over 0.03 mg/L of phosphorus, the trophic level is considered eutrophic (Fig. 4). The values obtained for total phosphorus are above 0.03 mg/L.

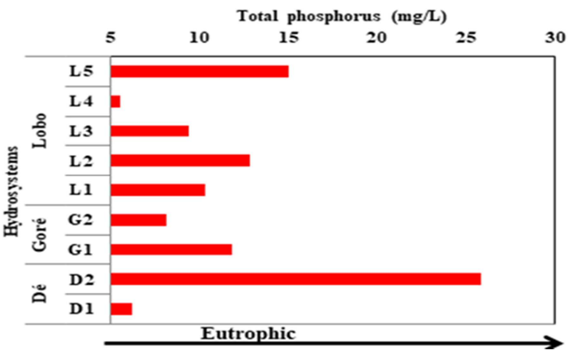

Fig. 4. Trophic state of Lobo river and its tributaries defined according to MDDELEC value of phosphorus

Chlorophyll a

Regarding Chlorophyll *a*, the eutrophic state is reached for values above 8 µg/L. This study shows that all values are higher than 8, indicating that all water courses have a eutrophic state (Fig. 5).

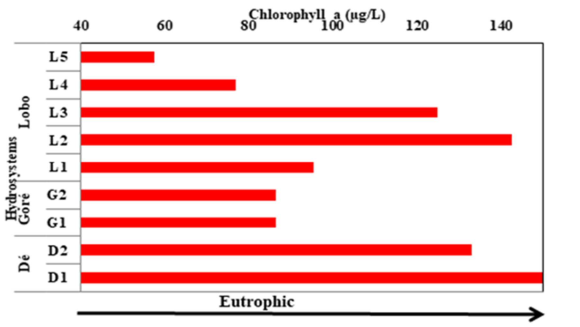

Fig. 5. Trophic state of Lobo river and its tributaries defined according to MDDELEC values of Chlorophyll *a*

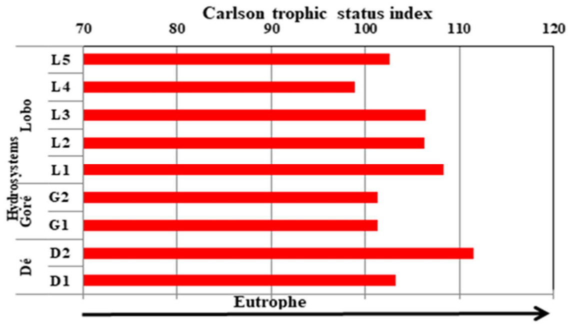

Fig. 6. Carlson trophic status index of Lobo River and tributaries

The results indicate that the concentrations of chlorophyll *a* and total phosphorus are significantly high, revealing a eutrophic state. All the recorded values exceed 8 µg/L for chlorophyll *a* and 0.1 mg/L for phosphorus based on the MDDELCC reference values (Table 8).

Carlson trophic status index

Only one class was obtained after calculating the Carlson trophic index. This result indicates that the aquatic systems are eutrophic (Fig. 6).

Discussion

The spatio-temporal variations in physicochemical parameters of Lobo river and tributaries were analyzed. Spatially, except for phosphate, the other measured parameters did not show significant variations from one river to another. This similarity in physicochemical values could be attributed to the natural conditions of the watershed. Indeed, these rivers drain their waters on geologic substrates that have physico-chemical properties that are very similar. Furthermore, there is a connection between the tributaries and the river Lobo. The observed differences would be related to the activities of the riverside communities (Yapo *et al.*, 2008; Groga et al., 2017).

In terms of temporal aspect, only the pH displayed significant variation across all rivers. This may be attributed to water runoff carrying watershed elements into hydro systems, as well as sampling periods (Lavoie *et al.*, 2003) or chemical and biological processes in the environments (Groga *et al.*, 2017). The highest nutrient values in the hydrosystems were 0.086 mg/L for nitrites, 23.8 mg/L for nitrates, 92 mg/L for total nitrogen, 1.86 mg/L for orthophosphates and 30.5 mg/L for total phosphorus. These concentrations exceed those obtained by (Groga *et al.*, 2017), who stated that nitrogen and phosphorus concentrations arise from plant decomposition by bacteria. Such concentrations may also arise from leaching of cultivated land during rainy periods, as reported by Majaliwa *et al.* (2004), Azanga *et al.* (2016), and Buhungu *et al.* (2018).

Regarding chlorophyll *a*, no significant variations were recorded spatially or seasonally. However, higher values were observed during the dry season, which could be explained by sunlight being an important factor for photosynthesis and beneficial for the development of phytoplankton, hence the increase in biomass in these environments.

The Organic Pollution Index (IPO) calculated indicated that the stations exhibit moderate to high organic pollution as the values range between 2.47 and 3.13. In addition, the rivers are eutrophic according to the Carlson Trophic Index and the reference values established by the MDDELCC. This ecological degradation can be attributed to anthropogenic activities such as agriculture and livestock rearing. According to Deguy *et al.* (2018), the degradation of the Lobo river's quality results from erosion of its watershed due to deforestation linked to agriculture. The same author states that the Lobo watershed is highly anthropogenic as it represents the new coffee-cocoa loop. The River Dé was most affected as there were subsistence farming and animal feces in the vicinity during the study period, confirming the practice of anthropogenic activities.

Conclusion

The assessment of the water quality of River Lobo and its two tributaries (Dé and Goré) using the Organic Pollution Index and trophic values established by the MDDELCC (Ministry of Sustainable Development, Environment, and Fight Against Climate Change) has revealed that the Lobo watershed is impacted by anthropogenic activities taking place. The levels of pollution obtained from the IPO range from moderate to high. Regarding the trophic state of the hydrosystems, analysis and comparison to the MDDELCC threshold values revealed that all of the hydrosystems fall under the eutrophic category. In view of this worrying ecological situation, an action plan and local sustainable development strategies need to be put in place to preserve the hydrosystems studied.

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