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Seasonal Characterization of Water Quality in Lake dougba for the Purpose of Optimizing a Treatment System

Horo Sébastien Kone[1*], Ahbeauriet Ahmed Ouattara[1], Irié Appolinaire Gouré Bi[2], Benjamin Kouassi Yao[2]

[1]Departement des sciences et techniques de l'Université Alassane Ouattara BP v18 Bouake 01

[2]Nouvelles LAPISEN Génie des procédés, Institut National Polytechnique Felix Houphouët-Boigny, BP 1313 Yamoussoukro, Côte d'Ivoire

Corresponding Author: horosebastien@yahoo.fr

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Abstract

This study was initiated to better understand the varying physical and chemical parameters of the water in order to ensure its effective treatment. With rainfall ranging from 11.6 to 24.4 mm in 2018 and from 54 to 114 mm in 2023, the Yamoussoukro district receives ample rainfall. Average physical parameters such as temperature and pH are less affected by the dry and rainy seasons. In contrast to these two physical values, turbidity is very high during the dry season, with a maximum value of (7.83 ± 0.40) NTU, which accounts for the reddish color of the water. As for chemical parameters specifically COD and nitrate, the highest concentrations were observed during the rainiest months: 82.18 ± 0.19 mg/L and 103.23 ± 1.05 mg/L for COD and nitrate, respectively. Lake water with conductivity outside the (200–1,000) range specified by the WHO during the dry season has a higher bacterial load during the rainy season. Overall, the filter becomes saturated more quickly during the dry season than during the rainy season, resulting in a volume of 18 m^3 and 22 m^3 during the dry and rainy seasons, respectively.

Keywords: Lake water, turbidity, seasons, rainy, lake

INTRODUCTION

Access to drinking water remains one of the most controversial issues of recent decades, especially in Africa and specifically in rural areas, where more than 500 million people lack access to it (Hope and Ballon, 2021). Despite its abundance on the planet, most surface water remains inaccessible to the population, especially in rural areas (Debela et al., 2022). However, the accessible portion is subject to several factors that affect its quality. According to Fernando et al. (2023), sewage and industrial wastewater, as noted by Hasan et al. (2019), are primarily responsible for surface water pollution. Consequently, the impact of rainfall on surface water pollution remains less well understood. Some authors have demonstrated variations in certain parameters by taking into account the dry and rainy seasons. According to Matta et al. (2018), rainfall influences turbidity. They recorded a maximum value of 364 JTU during the monsoon.

Furthermore, the same authors reported a maximum value of 608 JTU in the Ganges River during the monsoon, compared to 19.15 JTU in winter (Matta et al., 2018). Following the findings of Matta et al. (2018), Christian et al. (2020) reported that turbidity varies from one season to another. Thus, in their study on the seasonal variation of physicochemical parameters in the Tapi estuary, Christian et al. (2020) observed that turbidity decreased from (152 ± 48.282) NTU before the monsoon to (54 ± 24.052) NTU during the monsoon. In addition to turbidity, rainfall may influence certain parameters. For this reason, since rainfall is the primary source of water for lakes which serve as a source of drinking water for certain urban areas in Ivory Coast, it is important to monitor variations in certain lake water parameters throughout the year. A thorough understanding of the various changes in lake water quality could be beneficial for optimizing water treatment and minimizing treatment costs.

METHODOLOGY

Study area

The study focuses on the lake of the locality of Dougba (Figure 1). Located in the Toumodi Department enjoys a lake that does not dry. However,

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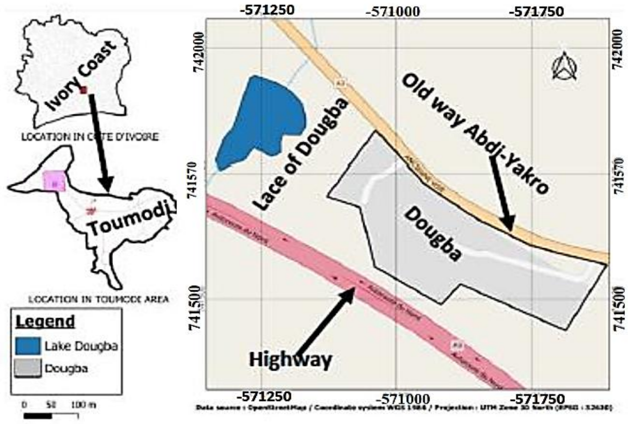

Figure 1. Geographic position of Dougba ***Addj***: *Abidjan;* ***Yakro***: *Yamoussoukr*

Water Samples

The water samples used in this study were collected from the lake near the village of Dougba, located 12 km from Yamoussoukro on the Abidjan-Yamoussoukro highway (Figures 1 and 2). Like all other lakes, this one is subject to climatic effects. During periods of drought, water levels drop due to reduced rainfall (Figure 2a). The water covers the entire lake bed during the rainy season (Figure b). The water is more turbid during the dry season than during the rainy season.

Figure 2. a) Appearance of the water during the dry season, b) Appearance of the water during the raining season

Characteristics of the Activated Carbon Used

The charcoal used for the filtration test was prepared using traditional methods by the author of this study. It was used, on the one hand, to remove 60.56% of nitrate in the study on nitrate removal conducted by Koné et al. (2022), and, second, to remove 85.71% of COD in his study on COD removal using artisanal activated carbon Koné et al., 2024). Several precursors can be used to produce activated carbon. Thus, while Priyanto et al. (2026), Andriani

Kholidah (2026), and Sekewael et al. (2015) used sugarcane bagasse, polyethylene terephthalate (PET) plastics, and cocoa shells and waste, respectively, to produce their activated carbon, the activated carbon precursor whose characteristics are summarized in Table 1 was produced from Borassus aethiopum. Based on characteristics such as specific surface area, pH at zero loading, and pore diameter, activated carbon could serve as a filter medium capable of improving the physical, chemical, and bacteriological parameters of the sampled lake water.

Table 1. Characteristics of activated carbon used

Properties	Units	Values
BET surface area	m^2/g	1431.61
Micropore surface area	m^2/g	1074
Sext / SBET		0.75 or 75 %
External surface area	m^2/g	1432
Total pore volume (Vpt)	cm^3/g	0.9715
Microporous volume	cm^3/g	0.2798
C		4.929
Pore diameter (DFT)	nm	2.76
Pore diameter (BJH)	nm	1.853
Iodine number	mg/g	958.09
Methylene blue index méthylène	mg/g	28.8
Ash content	%	2.89
pHi		5
Moisture content	%	4.04
Activation index	%	54.47
Properties		

Activated Carbon Filter Used

The activated carbon filter used to conduct the filtration test is shown in Figure 3. In the filter, the activated carbon was sandwiched between coarse sand (CS) and fine sand (FS).

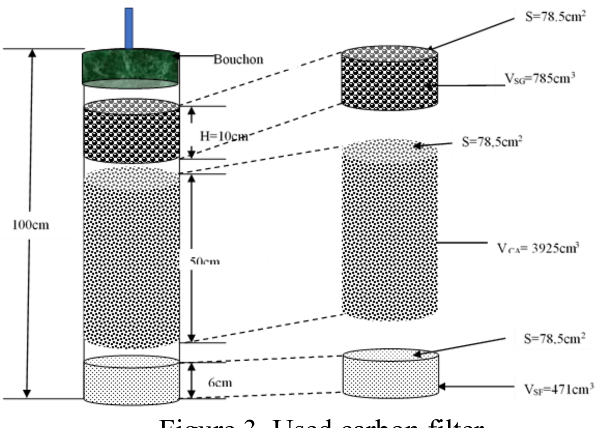

Figure 3. Used carbon filter

Analysis of the Physical and Chemical Parameters of Water Samples

Samples were collected using sterilized 200-mL plastic containers. To collect raw water samples, the container was submerged to a depth of approximately 30 cm. The sample was collected by holding the container horizontally at the water's surface before pulling it up in a scooping motion. To characterize the lake water, samples were collected throughout 20218. However, meteorological data from the years 2018 and 2023 were used to compare precipitation trends. These two years were chosen because of the availability of rainfall data for the full 12 months. The sampling point was selected at the lake water intake. A treatment system had been installed near the lake. This system includes a well that receives water drawn from the lake via a pipeline. Thus, sampling during 2018 was conducted throughout the entire year. Fifteen samples were collected each month, with one sample taken per day during both the dry season and the rainy season, with a one-day interval between each sampling. A sodium thiosulfate solution with a concentration of 100 g/L was used to preserve the samples after adding a few drops, and the samples were refrigerated at 4. Finally, the samples were analyzed monthly after the 15th sample of the month was collected. Next, the parameters not measured in situ (nitrate, COD, calcium ions, hardness, carbonates, alkalinity, and suspended solids) were determined in the laboratory according to the standard water analysis methods proposed by Rodier et al. (2009). Following the methods described by Rodier et al. (2009), the concentrations of COD, nitrate, and phosphate were determined using a JASCO V-750 visible spectrophotometer at wavelengths of 620 nm, 415 nm, and 880 nm, respectively. The equipment used for the analyses is listed in Table 2.

Table 2. Equipment Used

equipment	Marque	Origin	Utilisation
Balance	Ohaus	China	Weighing the various substrate samples
Conductivity Meter	Hanna	Portugal	Measuring conductivity, TDS, and salinity
pH Meter	Hanna	Roumania	Measuring pH
UV-Vis Spectrophoto meter	Jasco	Japan	Reading the concentrations of the parameters being analyzed
Turbidity Meter	wtw	Germany	Measuring turbidity
COD meter			Preparing samples for COD

RESULTS AND DISCUSSION

Raw Water Characteristics

The average values of the physicochemical characteristics of the water in Lake Dougba over two periods of the year are shown in Table 3. The results reveal that the lake water does not meet the quality standards set by the WHO (2011). Indeed, certain physicochemical parameters (conductivity, pH, turbidity, COD, and NO_3^-) and bacteriological parameters exceed WHO standards. This is the case for turbidity, chemical oxygen demand (COD), and nitrate (NO_3^-), which varied depending on the season. This corroborates the findings of CAWST (2013), which states that surface water quality is strongly influenced by the season and the types of rocks and soils through which it flows. In addition to these parameters, the water contains very little suspended solids, with a slight increase during the dry season. Unlike the parameters mentioned above, other parameters such as hardness, temperature, Mg^{2+}, Ca^{2+}, PO_4^{3-}, $CaCO_3$, TAC, and SO_4^{2-} comply with WHO standards regardless of the sampling period. Thus, based on this information, it can be concluded that the water in Lake Dougba is soft and has an acceptable temperature. However, since water quality is determined by all the parameters considered under WHO standards, this water cannot be consumed without prior treatment. Indeed, with concentrations of E. coli and total coliforms of 10 and 50 CFU/100 mL, respectively, during the dry season and 30 and 70 CFU/100 mL during the rainy season, the lake water does not meet WHO standards (2011), which are 0 CFU/100 mL for E. coli and 1.5 CFU/100 mL for total coliforms. The increase in bacterial concentrations during the rainy season is believed to be linked to runoff, which carries human waste responsible in part for the presence of E. coli and total coliforms. In addition to the bacterial factor, the color of the lake water indicates that it is not safe to drink, as, according to the WHO standards, safe drinking water is colorless. This strong discoloration of the water during the dry season is due to dust particles. Indeed, the rare rains that fell during the dry season carried these dust particles via runoff.

Table 3. Average Values for the Characteristics of Raw Water from Lake Dougba

Parameters	Dry season	Rainy season	WHO standards (2011)
DCO	58.88	82.18	< 30 mg/L
pH	6.49	6.81	6.5-8.5
Temperature	28.2	26.85	< 30° C
Turbidity	7.83	5.75	< 1 NTU
Mg^{2+}	0.16	0.164	
Hardness	6.22	6.46	≤ 30 °f
Ca^{2+}	6. 06	6.295	
PO_4^{3-}	0.01	0.02	< 0.4 mg/L
$CaCO_3$	0.583	0.73	
Conductivity	154.95	254.45	200-1000 µS/cm
NO_3^-	39.73	103.23	< 50 mg/L
TAC	0.456	0.376	≤500 mg/L
COT	18.89	12.831	
NT	0.67	1.66	
E. Coli	10	30	0 UFC /100 ml
Total coliforms	50	70	≤1.5UFC/100 ml
Color	Very reddish	Less reddish	colorless
MES	26	18.60	< 25 mg/L
Sulfates	16.5	10.86	< 250 mg/L

Rainfall in the Bélier Region

The Bélier region, with the city of Toumodi as its capital, is a transitional zone. Rainfall varies by season, as shown in Figure 4. According to this figure, rainfall of less than 100 mm is recorded during the months of January, February, October, November, and December, based on SODEXAM rainfall data from 2018 and 2023. As for the other months of the year, they show rainfall of more than 100 mm. Thus, these seven months mark the rainy season, with peak rainfall occurring in April. However, it is evident that 2018 was a particularly wet year, as rainfall was recorded in every month. This variation in rainfall could have an impact on the quality of the lake's water, for which rainfall is the primary source of replenishment.

Impact of Rainfall on Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC)

The variation in the chemical oxygen demand (COD) of the lake water is shown in Figure 5. COD varies from one season to another. Its highest values are observed during the rainy season. However, the difference between the two seasons is not statistically significant, with a p-value of 0.006854. Nevertheless, the increase in chemical oxygen demand (COD) during the rainy season could be due to certain climatic factors. Indeed, runoff carries all kinds of compounds as it feeds into the lake. Among these compounds is organic matter. Thus, the increase in COD during the rainy season can be explained by the presence of organic matter in runoff, which is the lake's main source of inflow. The same finding was reported by Christian et al. (2020) during the rainy season. These authors obtained values of (235 ± 96.16) mg/L and (118 ± 31.73) mg/L during the monsoon and after the monsoon, respectively. Although the COD level during the dry season is lower than that during the rainy season, it remains above the WHO (2011) recommendation (≤ 30 mg/L). The COD values exceeding the standard during both seasons may be linked to a lack of outflow from the lake. Indeed, Garzon-Vidueira et al. (2020) reported that a lack of outflow leads to an increase in the concentration of pollutants such as nitrate and COD. Like COD, TOC varied throughout 2023 (Figure 6). This variation is consistent with that of COD.

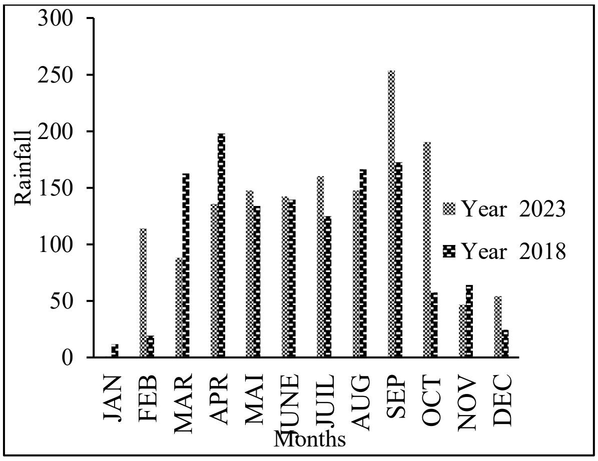

Figure 4. Rainfall Variations in the Yamoussoukro District for the Years 2018 and 2023

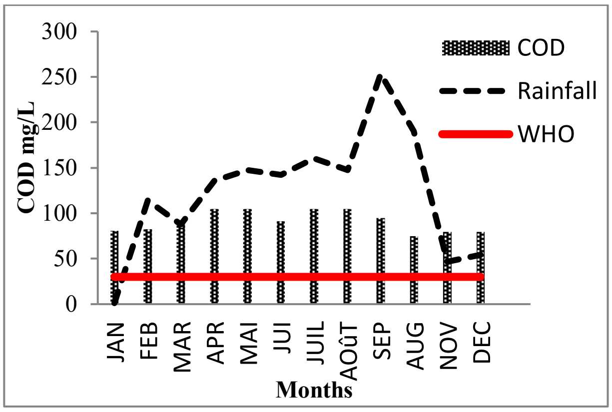

Figure 5. Seasonal Variation in COD

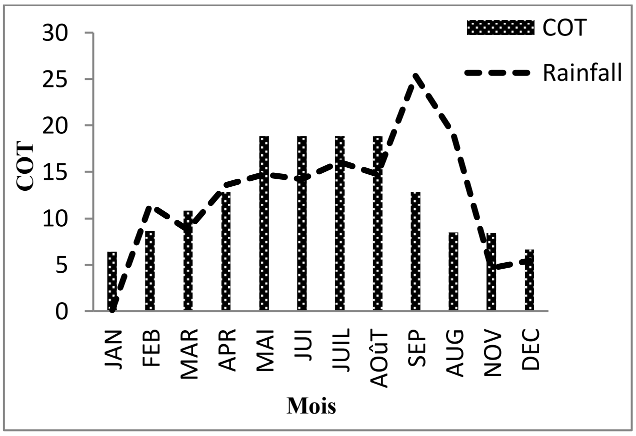

Figure 6. Seasonal Variation in COT

Impact of Rainfall on Nitrate and Total Nitrogen

Figure 7 shows the variation in nitrate levels in water. The analysis reveals that nitrate levels fluctuate throughout the year, with high values during the rainy season. Known for its role in lake eutrophication, nitrate is a chemical compound whose concentration in drinking water must not exceed 50 mg/L (WHO, 2011). In fact, during the nitrification process, nitrate is converted into nitrogen oxides such as nitrites, which cause methemoglobinemia, especially in infants. Its concentration can vary depending on the season (WHO, 2011). In this study, there is a significant difference between nitrate concentrations during the dry and rainy seasons. High nitrate concentrations are observed during the rainy season, with values ranging from 100.66 to 108.83 mg/L. These values exceed the WHO standard (2011). This increase is believed to be linked to human activities such as vegetable farming, which uses fertilizers high in nitrogen. Indeed, runoff water feeding the lake carries nitrate-enriched residues from the surrounding fields. This finding is consistent with that of Pratap et al. (2018), who observed an increase of (5.12 ± 0.44) mg/L during the rainy season. Similarly, the European Commission (2010) and Garzon-Vidueira et al. (2020) reported a 50% increase in nitrate levels in a river linked to agricultural activities. This increase in nitrate due to human activities was also noted by Shi et al. (2019).

These authors reported that 7.2% of the nitrate came from fertilizer use and 66% from agricultural activities. Apart from nitrate inputs from runoff, rain alone could contribute to the increase in nitrate levels in the lake. In fact, Shi et al. (2019) reported the contribution of precipitation to the increase in nitrate in the water. In addition to washing away fertilizers, runoff could carry both soil particles containing nitrate ions and domestic wastewater. This has already been supported by the study by Shi et al. (2019), who found proportions of 10.5 % and 71.3% for soil particles and wastewater, respectively. During the dry season, nitrate concentrations are low, ranging from 32.72 to 44.675 mg/L. These values comply with the WHO standard (< 50 mg/L) (2011). Like nitrate, total nitrogen varies with rainfall (Figure 8). High values of 2.66 mg/L are observed during the rainy season, which runs from March to September. This increase during the rainy season is thought to be linked to atmospheric nitrogen inputs.

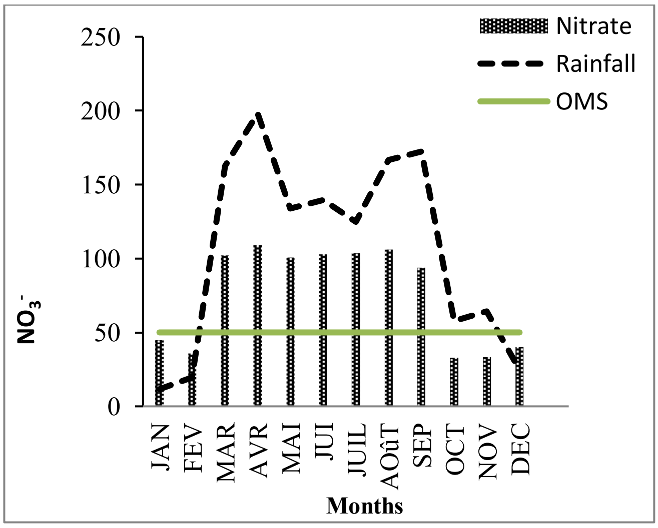

Figure 7. Seasonal Variation in Nitrate

Impact of Precipitation on Temperature

Water temperature is a key parameter for consumers. It influences certain parameters such as conductivity. Its seasonal variation is shown in Figure 9`. The highest temperatures are recorded during the dry season. Temperatures ranged from (26.5 to 27.65 ± 1) °C during the dry season and from (26.05 to 26.7 ± 1) °C during the rainy season. This increase in temperature during the dry season could be explained by the fact that this period is characterized by greater sunshine. Indeed, since the lake water is not replenished by rainfall, which has become rare, it is exposed to solar radiation, which raises its temperature. A similar observation was made by Christian et al. (2020), Hong et al. (2021), and Damotharan et al. (2024). These authors all agree that strong sunlight raises water temperature. They also noted that temperatures ranged from 20 to 33 °C as the season transitioned from the rainy season to the dry season.

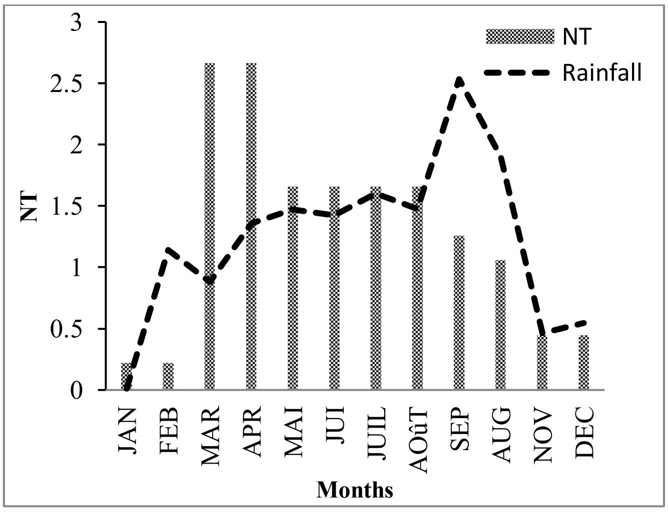

Figure 8. Seasonal Variation in Total Nitrogen

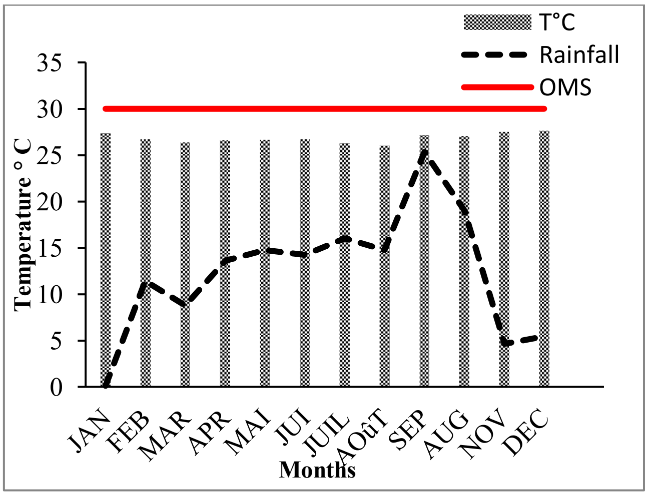

Figure 9. Seasonal Variation in Temperature

Furthermore, high turbidity during the dry season could be responsible for this slight rise in temperature, according to Sallam and Elsayed (2018). In fact, the most visible impact is related to the lake's low water level during this period. Despite the visible impact of the drought on the lake, the difference between the temperature values is not statistically significant, with a p-value of 0.006283. However, during both seasons, the water temperatures of Lake Dougba comply with the WHO (2011) standard (≤ 30°C).

Impact of Precipitation on Hydrogen Ion Concentration (pH)

An evaluation of pH levels over the two periods reveals that there is no significant difference between water pH levels during the two seasons. Indeed, the Wilcoxon test, with a p-value of 0.5128, indicates a non-significant difference. However, with averages of (6.49 ± 0.20) and (6.81 ± 0.20) for the dry and rainy seasons, respectively, the rainy season is the one in which all pH values comply with the standard (WHO, 2011). Figure 10 shows that the lowest pH values are recorded during the dry season. This finding is consistent with that of Sallam and Elsayed (2018). Indeed, they noted that pH values ranged from 8.36 to 8.48 during the rainy season, compared to 8.41 to 8.1 during the dry season from November to March. This decrease could be explained by the effect of photosynthesis, as highlighted by Elewa et al. (2007) and Sallam and Elsayed (2018). With the release of CO_2 associated with photosynthesis and high temperatures that promote its conversion to carbonate, these authors, as well as Christian et al. (2020), suggest that photosynthesis is partly responsible for the decrease in pH. In addition, the high levels of sunlight during this period contributed to a reduction in the water surface area and, consequently, an increase in pollutant concentrations. Therefore, given that removing water from an acidic aqueous solution lowers its pH, this could explain the low pH values observed during the lake's low-water period.

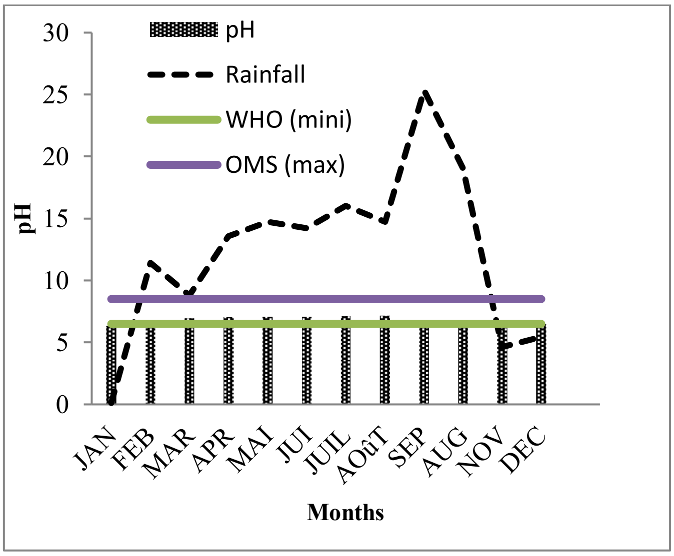

Figure 10. Seasonal Variation in pH

Furthermore, the increase in pH during the rainy season is likely due to the dilution effect. Given that adding water to an acidic aqueous solution raises its pH, this could explain the rise in pH during the rainy season caused by runoff from precipitation. Gadhia et al. (2012) made a similar observation. According to these authors, the inflow of runoff water causes dilution, which leads to increased alkalinity and, consequently, higher pH levels during the rainy season.

Impact of Rainfall on Turbidity

The seasonal variation in turbidity is shown in Figure 11. The average turbidity values obtained differ from one season to another. They range from 8.085 to 13.07 NTU during the dry season and from 5.325 to 6.95 NTU during the rainy season. The breakdown of the 12 months of the year into dry and rainy periods shows that the lake water is more turbid during the dry season than during the rainy season. Indeed, when comparing the dry season to the rainy season, a significant difference (p-value = 0.002196) exists between the seasons. Turbidity levels during the dry season are approximately 1.5 NTU higher than those during the rainy season. Several factors could explain this variation. However, the most noticeable impact is climate change and its associated effects. Indeed, the dry season is marked by heavy rains, and the resulting runoff carries dust particles (colloidal particles) that mix with the lake water, making it more turbid. Thus, it has been observed that turbidity is high after heavy rainfall. Several studies have reached similar conclusions. This seasonal variation in turbidity was reported by Matta et al. (2018).

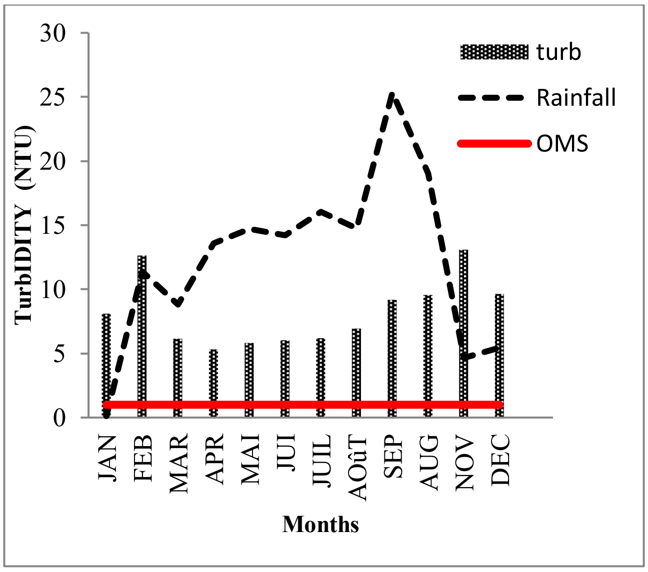

Figure 11. Seasonal Variation in Turbidity

These authors recorded turbidity values of 608 JTU and 19.15 JTU in the Ganges River during the monsoon and winter, respectively. Similarly, Gadhia et al. (2012) noted that turbidity is higher before the monsoon than during the monsoon. They obtained values of (152 ± 48.282) NTU and (54 ± 24.052) NTU, respectively. Like the others, Solano-Rivera et al. (2019) observed an increase in turbidity of up to 900 NTU or even 1,000 NTU for a rise in water level of 1.4 m and 2.86 m, respectively, and Mi et al. (2019) observed an increase of 1.2 to 2.4 NFU during the dry season at Lake Tibetan. Beyond runoff caused by rainfall, the lake's static conditions and temperature could be responsible for the turbidity observed during both periods (Miljojkovic et al., 2019). Since high temperatures were recorded during the dry season, with an average of 27.5 °C, this would explain the high turbidity observed, consistent with the findings of Miljojkovic et al. (2019). According to these authors, turbidity is influenced by temperature, which causes it to increase as temperature rises.

Impact of Rainfall on Phosphate

The seasonal variation in phosphate concentration is shown in Figure 12. It appears that phosphate is not a limiting pollutant for water quality in Lake Dougba. In fact, phosphate concentrations during both seasons are well below the maximum value of 0.4 mg/L set by the WHO. However, phosphate concentrations increase slightly during the rainy season. This increase, which is not harmful to the population or the lake, could be linked to the lake's inflow of runoff water, which may have carried a small fraction of phosphate from residues of human activities such as vegetable farming practiced around the lake. This observation is fully consistent with that of Hasan et al. (2019). Indeed, these authors reported that 70 % of surface water pollution in Bangladesh stems from pesticides. According to them, 60.4 % of these pesticides consist of organophosphates. This explains the increase in phosphorus in river water when these pesticides enter the water. Its assessment is being conducted because of its contribution to the growth of aquatic plants such as freshwater lettuce, which, once dead, increase organic matter and subsequently lead to eutrophication. Given the WHO standard, which requires a value of < 0.4 mg/L for all water intended for consumption, Dougba's water would meet quality standards if phosphate levels were the only quality parameter for drinking water.

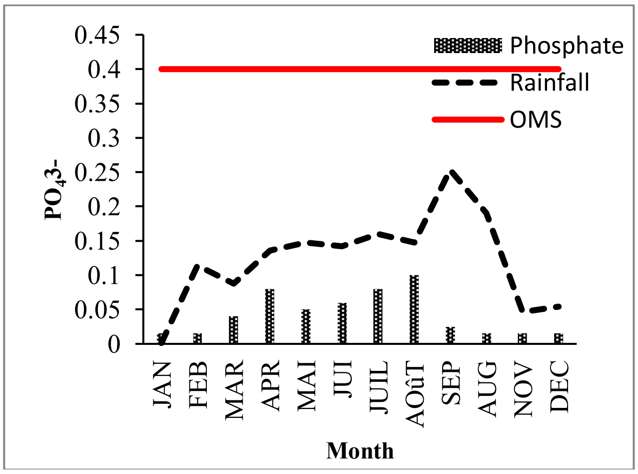

Figure 12. Seasonal Variation in Phosphate

Impact of Rainfall on Calcium and Conductivity

Figure 13 shows the variation in the conductivity of the water in Lake Dougba. By comparing the variation in rainfall with that of conductivity, it becomes clear that during the rainy season, conductivity levels are low. However, the highest values are recorded during months when rainfall is low. This decrease in conductivity during the rainy season is likely due to the dilution effect. Indeed, runoff dilutes the lake water as it flows into the lake. This dilution reduces the high concentration of cations. This observation was also made by Christian et al. (2020) and Izonfuo and Bariweni (2001).

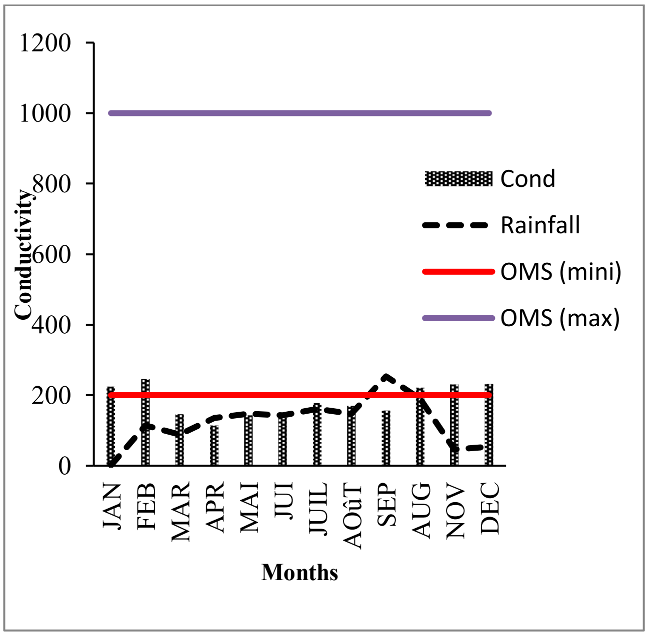

Figure 13. Seasonal Variation in Conductivity

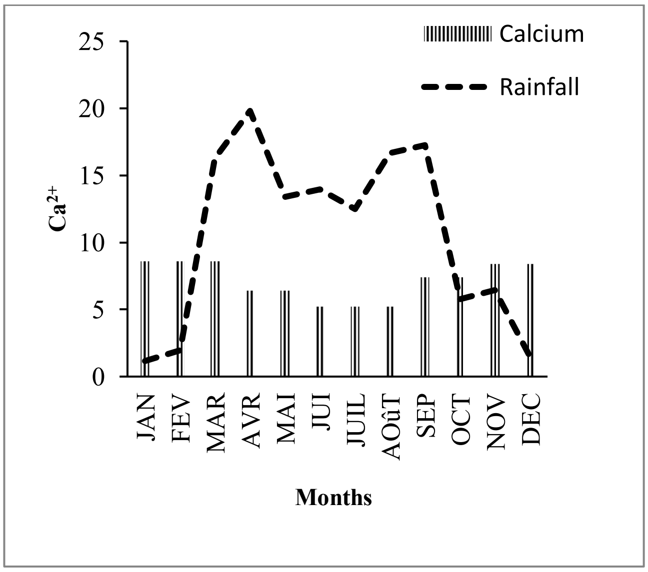

Figure 14. Seasonal Variation in Calcium

According to these authors, the low values during the rainy season are likely due to the dilution effect. They noted that conductivity decreases when rainfall is abundant. Since calcium is known to contribute to increased conductivity, its analysis is shown in Figure 62. Just like conductivity, calcium levels are slightly lower during the rainy season than during the dry season (Figure 14). Thus, in agreement with Rodier et al. (2009), calcium is indeed partly responsible for conductivity.

Study of Metals in Lake Water

The water in Lake Dougba contains heavy metals Table 4. Based on the annual average values for metals listed in Table 4, cadmium has a concentration of 8.45, which exceeds the WHO standards limit of 5. However, all metals except mercury are present, even though their concentrations are below the WHO standards limits. Statistical Analysis of the Physical and Chemical Parameters of Lake Dougba's Water.

Table 4. Average Metal Values

Metals	Units	Annual Average Values	WHO standards
Lead	μg/ L	8.68	10
Mercury	μg/ L	0	0
Cadmium	μg/L	8.45	5
Arsenic	μg/L	4.82	10
Chromium	μg/L	4.53	50
Nickel	μg/L	0.97	20
Copper	mg/L	0.65	2
Zinc	mg/L	2.27	≤ 5.0
Manganese	mg/L	0.01	0.05
Cobalt	mg/L	0.06	1

The water in Lake Dougba is contaminated with heavy metals. A statistical analysis of heavy metals and turbidity resulted in Table 5. The eigenvalues serve as a key indicator for the factors identified by Koné et al. (2022). A factor is considered if its eigenvalue is equal to or greater than 1. Thus, based on this principle, three factors were considered. Factors 1, 2, and 3 were selected to determine the distribution of metals in the water of Lake Dougba. In addition to selecting the factors, a correlation matrix was generated (Table 5) to identify the relationships between metals based on the selected factors. A correlation is considered significant when it is greater than or equal to 0.70 (Kouakou et al., 2016).

Based on the correlation matrix (Table 6), principal component analysis reveals that several metals interact with one another. Lead interacts with metals such as nickel, cadmium, and zinc. Indeed, the respective correlations of 0.77, 0.72, and 0.71 are significant. As for cadmium, it interacts only with arsenic (r = 0.81) and nickel (0.74). In addition to these interactions, arsenic interacts with zinc, with a correlation coefficient of r = 0.73. Of all the metals, only cadmium interacts with turbidity.

Table 5. Eigenvalues

Factors	Eigenvalues	% of Total Variance	Cumulative Eigenvalues	Cumulative %
1	4.58	45.83	4.58	45.83
2	2.34	23.44	6.93	69.28
3	1.14	11.38	8.07	80.66

Table 6. Correlation matrix

V	Pb	Cd	Ars	Cr	Ni	Cu	Zn	Mn	Co	Tur
Pb	1									
Cd	0.72	1								
Ars	0.52	0.81	1							
Cr	0.47	-0.01	-0.10	1						
Ni	0.77	0.74	0.49	0.32	1					
Cu	-0.01	0.09	0.24	0.37	0.35	1				
Zn	0.71	0.59	0.73	0.34	0.61	0.27	1			
Mn	-0.31	0.01	-0.01	-0.46	-0.35	-0.47	-0.54	1		
Co	-0.33	-0.41	-0.12	0.51	-0.30	0.54	0.08	-0.19	1	
Tur	-0.61	-0.68	-0.62	-0.22	-0.51	-0.34	-0.61	0.25	-0.05	1

**V= Values*

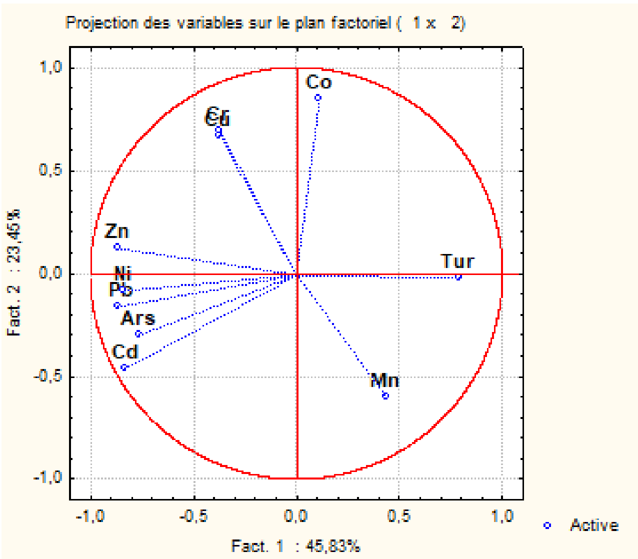

Figure 15. Principal component analysis based on factors 1 and 2

The distribution of metals according to factors 1 and 2 (Figure 15) yields four groups. The first group consists of Pb, As, Cd, and Ni. The second group consists of Zn, Cu, and Cr. The third and fourth groups consist of Co and Mn, respectively. Just like factors 1 and 2, the projection onto factors 1 and 3 (Figure 16) yields four groups. Group 1 consists of Ni, Pb, and Cr. Group 2 consists of Cu, Zn, Cd, and As. The third group includes Mn and Co. No metals are influenced by turbidity.

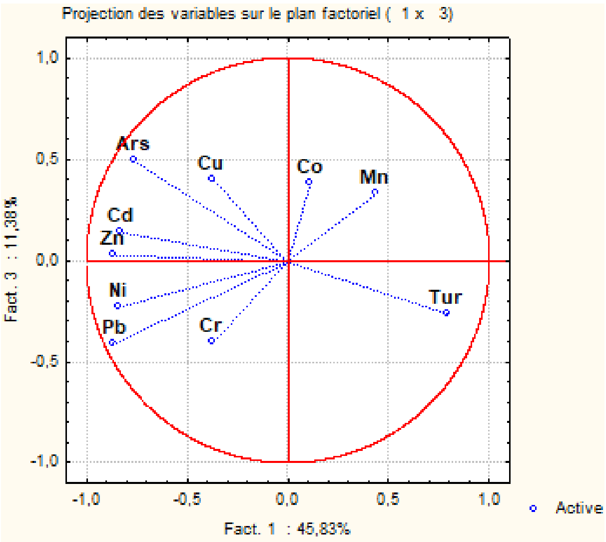

Figure 16. Principal component analysis based on factors 1 and 3

Impact of Rainfall on the Lifespan of the Carbon Filter

Figure 17 shows turbidity removal through a carbon filter over two seasons. Since turbidity is highest during the dry season, when the water is heavily discolored, only 18 m^3 of water is treated, compared to 22 m^3 during the rainy season.

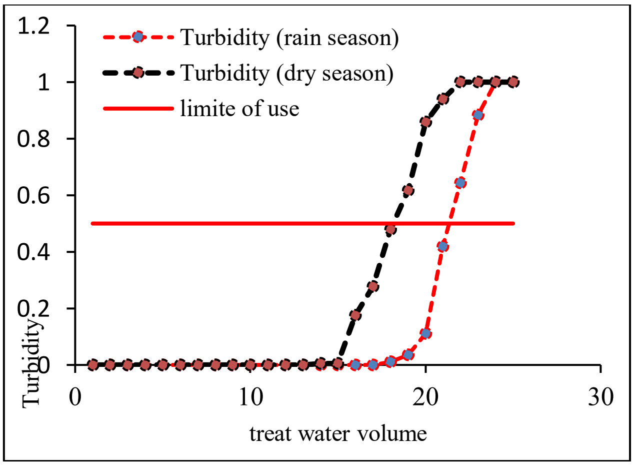

Figure 17. Volume of water treated, taking turbidity into account

High turbidity caused by particles leads to clogging during filtration. This results in rapid filter saturation. This finding corroborates that of Koné et al. (2021), who observed lower volumes of treated water when comparing raw water with high nitrate loads to water with low nitrate loads in their study of relative breakthrough curves. In addition to Koné et al. (2021), the authors Onyango et al. (2009), Albayati et al. (2020), and Cruz-Olivares et al. (2021) observed shorter breakthrough times. Breakthrough times for high pollutant concentrations during filtration.

CONCLUSION

The physical, chemical, and bacteriological parameters obtained during the characterization of the lake's seasonal waters show that these parameters vary from season to season. Overall, the lake water remains unsafe for drinking throughout the year and requires treatment before consumption. High levels of nutrients such as nitrate during the rainy season, as well as high bacterial counts, underscore the urgent need to raise public awareness about the excessive use of fertilizers by vegetable farmers around the lake and the necessity of no longer defecating outside of latrines. This study should be conducted in all communities where surface water is consumed in order to reduce the health risks associated with drinking this water.

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