

Physicochemical Quality of Tshopo River Water after Regideso SA/Kisangani Treatment, DR Congo in 2024

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Abstract

This study examined the physicochemical characteristics of water from the Tshopo River before it entered the REGIDESO SA/Kisangani treatment plant in the Democratic Republic of Congo during the year 2024. Sixty samples were collected and analyzed, with five samples taken each month at five- to seven-day intervals. Temperature (in situ), pH, turbidity, color, conductivity, oxidizable matter content, total alkalimetric titration, total hardness, free chlorine, nitrite ion content, and chloride ion content were evaluated. The following annual average values were obtained from these physicochemical analyses: temperature $26.97 \pm 0.78^\circ\text{C}$; pH 6.5 ± 0.34 ; total alkalimetric titration 0.0 ± 0.0 ; turbidity 2.42 ± 0.30 NTU. colour 8.4 ± 0.30 PtCo; conductivity 32.65 ± 3.96 $\mu\text{S}/\text{Cm}$; oxidizable matter content $1.75, \pm 0.26$ mg/L, alkalimetric titer 0.33 ± 0.12 °F, total hardness 0.07 ± 2.03 °F, free chlorine 1.13 ± 0.38 mg/L, nitrite ion content 0.02 ± 0.01 mg/L and chloride ion content 3.78 ± 0.43 mg/L. These water quality parameters showed highly significant differences between the four rainfall seasons of 2024, except for pH, simple alkali-sensitivity, oxidizable solids content, total hardness, nitrite ion content, and chloride ion content (respective p-values of 0.216, 0.441, 0.925, 0.598, and 0.483). This work contributed to highlighting the impact of treatment by REGIDESO SA/Kisangani on the physicochemical quality of the Tshopo River water at the REGIDESO SA/Kisangani plant. It would be important to replicate this study over three years to assess the plant's performance.

Keywords: Tshopo River, Kisangani, Physicochemical Analyses, Water Quality, Treated Water.

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1. INTRODUCTION

Water is an essential and indispensable resource for life, used in various activities (Samba, 2026; Nabila, 2025; Nabila and Chirine, 2025; Hamada, 2025; Poulin *et al.*, 2024). Its production and supply are necessary for sustainable development in all regions of the world (Demerd, 2009; Benamar, 2020a). Water on the Earth's surface is part of the hydrological cycle (Nansi, 2022; Nansi, 2025a). It is a component of all living matter and constitutes an important tool for development (Naminata *et al.*, 2022). It is also responsible for and indispensable in all biological and chemical activities (Yahmi and Zeroukhi, 2022). It is worth noting that three-quarters of the planet is covered in water (Nansi, 2025b).

Every time water is used, it becomes polluted and contaminated by pollutants from human and/or natural activities (Simbu *et al.*, 2022). Studies provided by United Nations agencies raise the alarm about the degradation of water resources (Bisimwa *et al.*, 2022).

This includes the study published by the World Bank in August 2019, entitled "Unknown Quality: The Invisible Water Crisis" (Damania *et al.*, 2019). The problem of access to drinking water, as defined by SDG 6, stems from unequal distribution worldwide and ongoing pollution of water resources by industry, agriculture, and urban runoff (Khemis, 2005; Alexis *et al.*, 2019).

In most developing countries, surface water quality is significantly degraded, particularly due to population growth. This underscores the need to assess the quality of this vital water resource in light of population increase (Saab *et al.*, 2007; Hébert, 1997; Hébert and Légaré, 2000; Giroux *et al.*, 2016; Tfeila *et al.*, 2016; Cloutier-Maden, 2025). The availability of data on water resources in general, and surface water in particular, contributes to better management of this resource (Dovonou *et al.*, 2023a). It is therefore essential to ascertain the (physicochemical) quality of our river water in order to develop appropriate treatment frameworks (Simon, 2018; Kazadi, 2012).

In the Democratic Republic of Congo (DRC) in general, and in the city of Kisangani in particular, populations rely on river water to meet their daily needs in various sectors, including the Tshopo River (Litumanya, 2018). However, the quality of this water is lacking in terms of physicochemical assessment upstream of industrial treatment. This study therefore aims to determine the physicochemical quality of the Tshopo River water (in 2024) at the outlet of the REGIDESO SA/Kisangani treatment plant.

I. MATERIALS AND METHODS

II.1. Study Area

The city of Kisangani, capital of Tshopo Province in the DRC, constituted the study area for this work. It is 428 meters above sea level. The water intake point (Fig. 1) on the Tshopo River ($0^{\circ}31'$ North latitude and $25^{\circ}11'4''$) served as the sampling point.

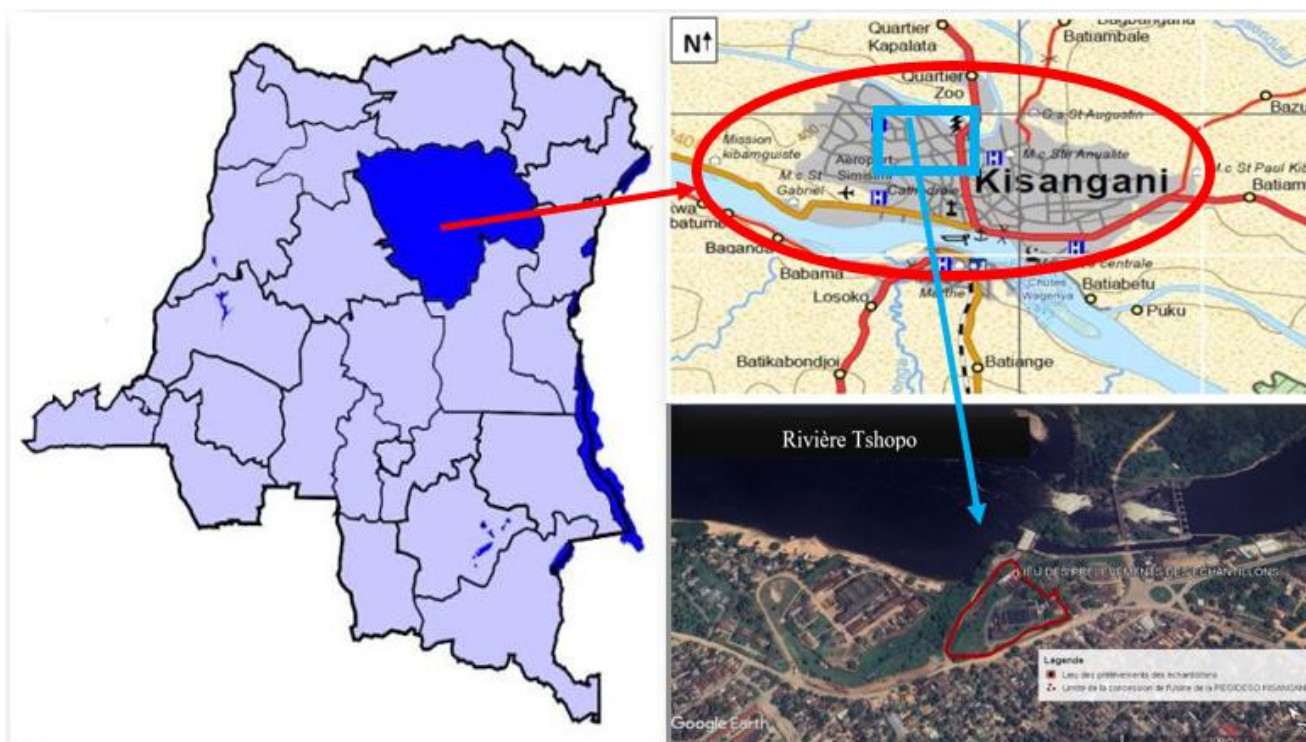


Figure 1: Location of sample collection site at the intake point on the Tshopo River in the City of Kisangani in the DRC

II.2. Materials

The water from the Tshopo River constituted the material for this scientific investigation. Sixty water samples (at a rate of 5 to 6 samples per month, spaced 5 to 7 days apart) were collected and sent directly to the REGIDESO SA/Kisangani laboratory for analysis.

II.3. Methods

Seven physicochemical parameters were determined: temperature (in situ), pH (HANNA pH meter, Model: HI 2211), conductivity (HANNA conductivity meter, Model: HI 5321), color (HANNA colorimeter, Model: HI 96727), turbidity (HANNA turbidimeter, Model: HI 88713-ISO), oxidizable matter content (redox) and total alkalimetric titration (by acidimetry), total hardness or total hardness by compleximetry, nitrite ion content by HACH spectrophotometer, Model: DR 190, chloride ion content

by argentimetry, residual free chlorine with measurement of DPD No. 1 content. The values obtained from the different analyses were subjected to GraphPad (online) and Analysis of Variance tests using PAST 2 Version 2.17b software.

II. RESULTS AND DISCUSSION

III.1. Physicochemical Quality

The average values of the evaluated physicochemical parameters are shown in Table 1 below.

Table 1 Physicochemical Characteristics of the Tshopo River Water in 2024.

1.1. pH

The pH analysis of the treated water from the Tshopo River is illustrated in Fig. 2.

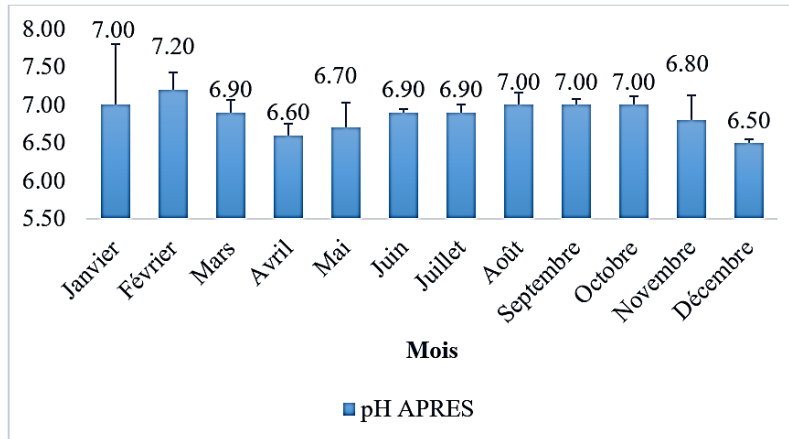


Figure 2: pH Graph

Figure 2 shows that the pH varies between 6.5 in December and 7.0 in January, August, September, and October throughout the year, compared to the pH values found by Merhabi and colleagues, which range from 6.35 (Ar site) to 8.24 (EAA-1 site) (F. Merhabi, *et al.*, 2019).

It should be noted that these pH values fall within the WHO guideline range of 6.5 to 8.5.

1.2. Turbidity

The results of the turbidity analysis of treated water from the Tshopo River are illustrated in Fig. 3.

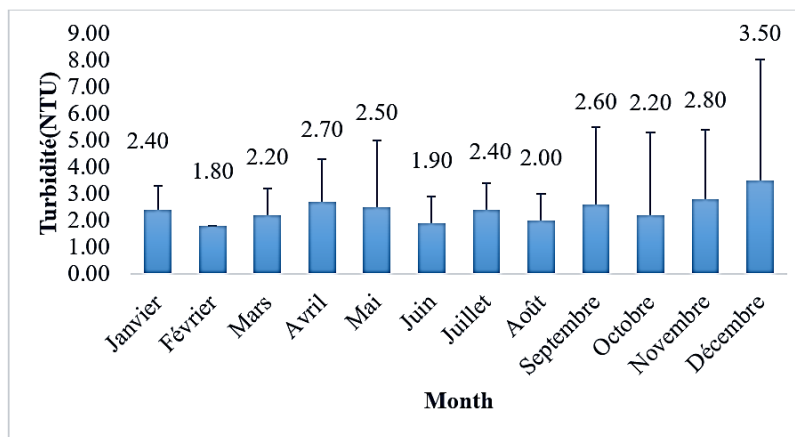


Figure 3: Turbidity Graph

Figure 3 shows that the turbidity of the treated water in December (3.50 NTU) is the highest compared to that of the treated water in June (1.90 NTU).

1.3. Color

The results of the color analysis of treated water from the Tshopo River are shown in Figure 4 below:

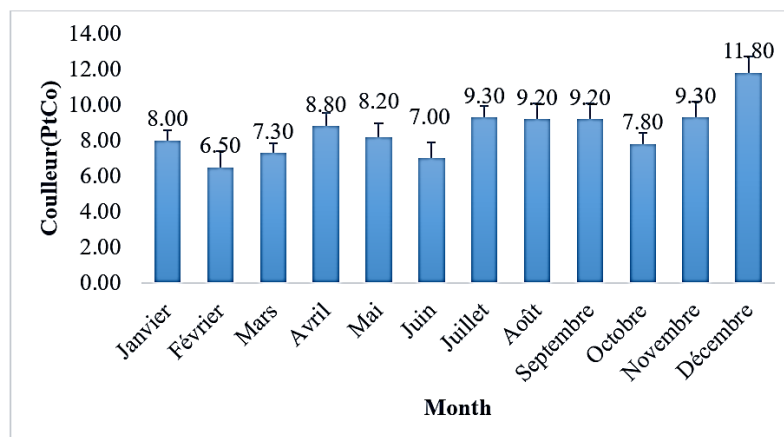


Figure 4: Color Graph

Note that December was the month of 2024 with the highest color value of 11.80 PtCo.

1.4. Conductivity

The conductivity results (Fig. 5) illustrate the trend for 2024.

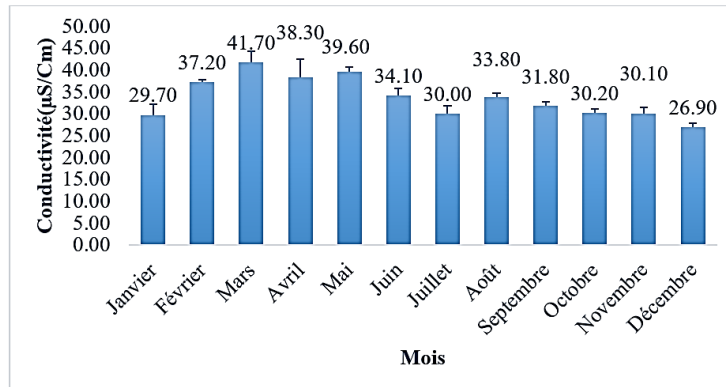


Figure 5: Conductivity Graph

The conductivity value for March was the highest of the year at 41.70 µS/cm.

The conductivity results from our study are lower compared to the conductivity results for the Okédama River water (1658 µS/cm, Adje, D.a. *et*

al.,2019a) and those obtained by Rukahusa (271 µS/cm, Rukahusa *et al.*,2022).

1.5. Temperature

The temperature of the treated water from the Tshopo River, shown in Fig. 6, peaked in June 2024.

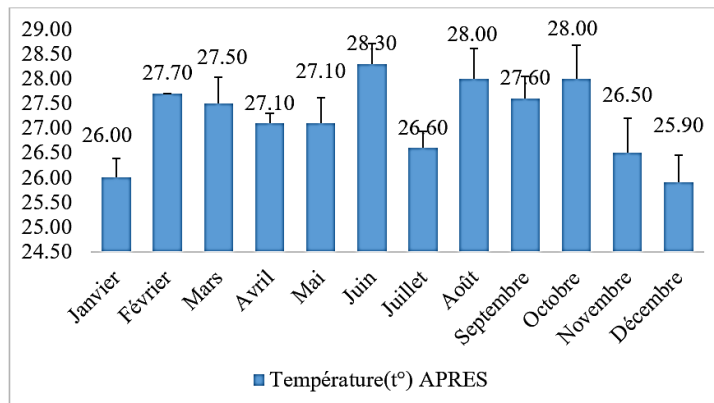


Figure 6: Temperature Graph

June recorded the highest temperature at 28.30°C, while December saw a lower temperature of 25.90°C. Similar to the values found by Adje *et al.*,2019, along the watercourse at 32.9°C and 28.1°C (Adje *et al.*, 2019b).

1.6. Oxidizable Matter

The results of the water analysis of the Tshopo River, specifically the physicochemical parameter of oxidizable matter, are illustrated in Figure 7.

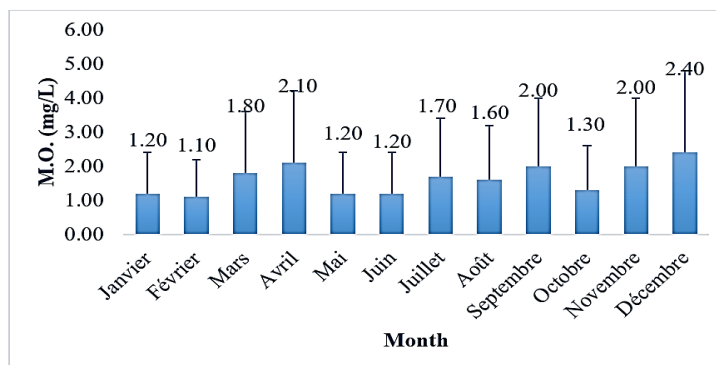


Figure 7: Oxidizable Matter Graph

The oxidizable matter values for December, at 2.40 mg/L, are the highest of all months in 2024. This compares to 3.61 mg/L found by Benamar (Benamar, A. *et al.*,2020b) and 3.45 mg/L by Abdoulay (Abdoulay *et al.*,2013).

1.7. Total Alkalinity

The results of the water analysis of the Tshopo River, specifically the physicochemical parameter of total alkalinity, are illustrated in Figure 8 below:

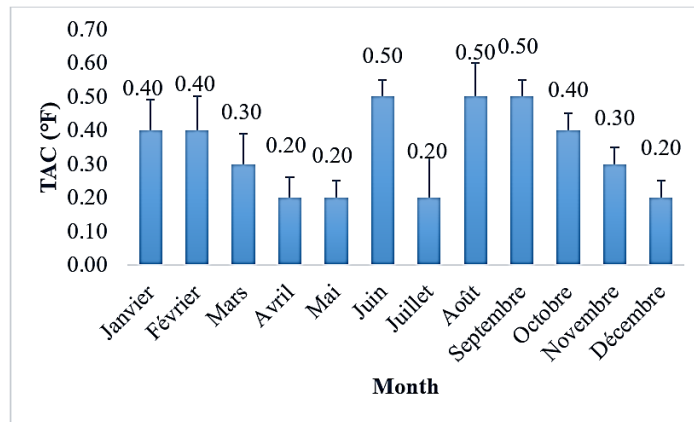


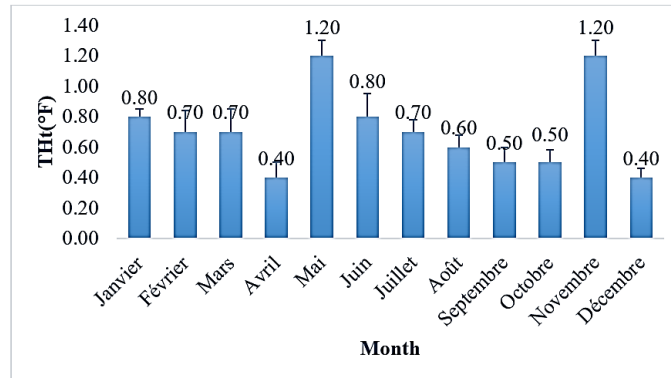
Figure 8: Total Alkalinity Graph

The pre-treatment total alkalinity values are 0.50°F higher than the post-treatment values found by Yao and colleagues in "Evaluation of the chemical potability of groundwater in a tropical watershed: the

case of Southwest Côte d'Ivoire," where they found 10.8°F (Yao *et al.*,2013).

II.2.8. Total Hardness

The months of May and November are the only ones in which we observed peaks of 1.20°F.



III.2.9. Free chlorine content

The results of water analysis from the Tshopo River for physicochemical parameter of complete free chlorine titer are illustrated in Figure 9 below.

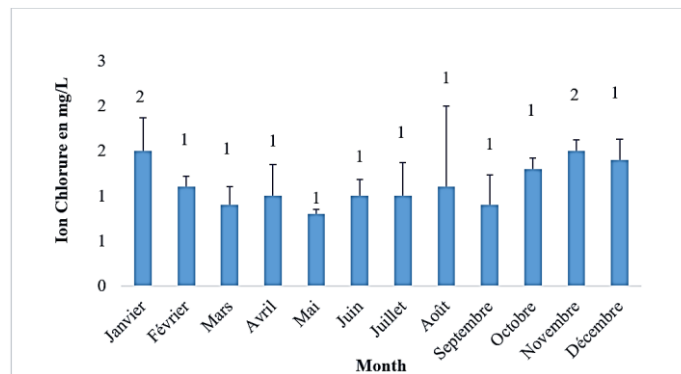


Fig. 9: Free chlorine content graph

The free chlorine values of May are the lowest (with a monthly average value of 0.8 mg/L) compared to those of the months of January and November are higher (with a monthly average value of 1.5 mg/L).

III.2.11. Chloride ion

The results of water analysis from the Tshopo River for physicochemical parameter of chloride ion titer are illustrated in Figure 10 below:

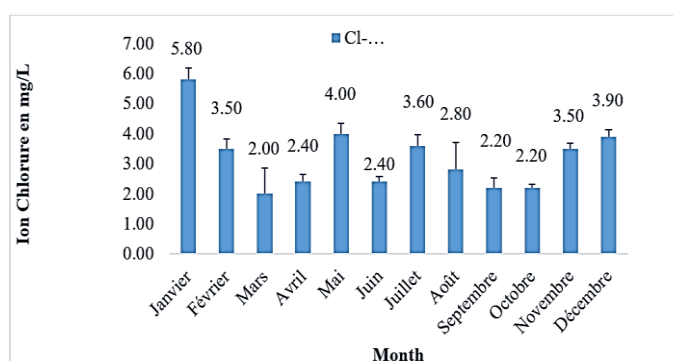


Fig. 10: Chloride ion graph

The value of oxidizable materials in the month of March is the lowest (with a monthly average value of 2.0 mg/L) compared to that of the month of January is higher (with a monthly average value of 5.8 mg/L).

The average values of the physicochemical parameters evaluated are shown in Table 1 below:

Table 1: Physicochemical characteristics of the water of the Tshopo River in 2024

Mois 2024	pH	TA	TAC	THT	M.O	Cl ₂	Coul.	Turb	NO ₂	Cl ⁻	Cond	t(°C)
Janvier	6,80	0,00	0,50	0,80	1,70	1,10	8,60	2,4	0,02	3,80	31,00	26,60
Février	6,90	0,00	0,30	0,70	1,20	1,50	8,20	2,40	0,02	3,80	29,60	26,00
Mars	7,20	0,00	0,40	0,70	1,10	1,10	6,40	1,80	0,02	5,80	36,50	27,60
Avril	6,60	0,00	0,20	0,40	2,10	0,90	8,80	2,60	0,02	2,10	39,20	27,10
Mai	6,80	0,00	0,20	1,40	1,40	0,80	8,00	2,50	0,01	2,40	39,70	27,2
Juin	6,90	0,00	0,40	0,80	1,20	0,90	7,20	1,9	0,02	4	33,9	28,4
Juillet	6,80	0,00	0,50	0,70	1,60	1,10	8,00	2,20	0,02	3,60	31,00	27,10
Août	6,90	0,00	0,40	0,60	1,00	1,50	8,20	2,50	0,02	4,20	33,20	27,10
Septembre	7,00	0,00	0,40	0,50	2,10	1,10	9,00	2,50	0,02	4,30	32,30	27,30
Octobre	7,00	0,00	0,20	0,50	2,00	1,40	9,00	2,50	0,02	2,80	28,20	27,30
Novembre	6,80	0,00	0,20	1,40	1,40	0,80	10,20	3,00	0,02	4,30	27,40	26,20
Décembre	6,50	0,00	0,20	0,40	2,00	1,40	9,20	2,70	0,03	4,30	28,60	25,70
Moyenne	6,5	0	0,33	0,74	1,75	1,13	8,4	2,42	0,02	3,78	32,55	26,97
	±0,34		±0,12	±2,03	±0,26	±0,38	±0,84	±0,30	±0,01	±0,43	±3,96	±0,78

It appears from table 1 that the temperature of June is the highest, i.e. 28.30°C, and that of December is the lowest (25.70°C). These results exactly reflect the characteristic temperature of the equatorial climate. The similar values of 29.80 and 24.10 °C were recorded by (Koji *et al.*,2022).

The pH value of the month of March is higher, i.e. 7.20 while that of the month of December 6.50 is low. We note that the pH values of the Revere Tshopo are slightly acidic unlike the pH values of 7.80 of Lubumbashi river water in the DRC (Kalala; *et al.*,2016) and those of the pH of the Kinyankonge river in Burundi 7.35 and 9.32 (Buhungu *et al.*,2018) which are basic.

Furthermore, it turns out that the turbidity of November has higher values 3.00NTU compared to that of March 1.80NTU. Turbidity between seasons of the

year shows significant variation during the months. The same trend was recorded at the Tilé River in N'Zérékoré, Republic of Guinea with the highest value at 44.33 NTU and the lowest value at 6.29 NTU (Keita *et al.*,2025).

We also note from Table 1 that the color of the month of November is the highest, i.e. 10.20PtCo and that of March is the lowest, 6.40PtCo following precipitation in the region.

In addition, the conductivity of May is the highest, i.e. 39.7µS/cm, while that of December is the lowest, i.e. 27.4µS/cm. It should be noted that the conductivity of the Gombe River (DRC) showed during the dry season and the rainy season, the respective values of 440.5 and 355 µS/cm in 2016 (Akatumbila, *et al.*,2016).

Furthermore, it is observed that the value of oxidizable materials in the months of April and September are higher at 2.10 mg/L compared to that of the month of August which is the lowest at 1.0 mg/L. The same trend is observed for the Oum Er Rbia river (Maoc) with values of 0.84 and 3.61 mg/L (Benamar, *et al.*,2020c).

It also appears that the complete alcalimetric titer for the month of January is low 0.5°F compared to

those of March and May which are 1.5°F during the year of 2024. Our values are less than those of Yao, and his team in 2013 in his study on evaluation of the chemical potability of groundwater in a tropical watershed: case of the South-West of Côte d'Ivoire (Yao *et al.*,2013)

III.2. Water qualities according to rainfall seasons

The averages of the quality parameters of the rainfall seasons of the water of the Tshopo River are reported in Table 2 below:

Table 2: Average water quality parameters for the Tshopo River during the 2024 rainy season.

AnnuelS Saisons	Long dry seaso	Short rainy season	Short dry season	Big rainy season
Pluviométrie 2024 (Climate-Data, 2024)	Décembre, Janaury et February	March, Avril et May	June et July	Août, Septembre, Octobre et Novembre
pH	6,76±0,2	6,86±0,3	6,87±0,1	6,93±0,2
TA	0±00	0±0	0±0,1	0±0
TAC	0,35±0,35	0,29±0,1	0,47±0,1	0,33±0,1
THT	0,63±0,63	0,84±1,2	0,75±0,1	0,76±1
M.O	1,64±0,4	1,52±0,5	1,38±0,2	1,63±0,5
CL-RESIDUEL	1,29±0,3	0,95±0,2	1±0,3	1,19±0,3
COLOR	8,87±0,8	7,73±1,2	7,6±0,8	9,1±1,1
TURBIDITY	0,3±0,3	2,29±0,4	2,05±0,2	2,64±0,3
NO2	0,02±0,0	0,02±0	0,02±0,0	0,02±0
Cl-	3,96±0,4	1,8±1,8	3,82±0,4	3,8±0,7
CONDUCT	29,73±1,5	2,9±2,9	32,44±2,0	30,15±2,8
Température	26,11±0,6	27,31±0,4	27,75±0,8	26,96±0,7

The table above shows that the temperature and pH are of the same order of magnitude during the short dry season and the long rainy season, at 27.31°C and 6.86 respectively. The pH is higher during the long rainy season (6.93). Research by Dovonou's team (Dovonou *et al.*,2023b) on the Agbado River yielded pH values of 7.03 during the rainy season and 7.05 during the dry season. Meanwhile, the pH values for the Kwilu and Ngongo Rivers in the DRC are 7.62 for the Kwilu and 7.12 for the Ngongo (Munzamba and Kungsi, 2018).

Turbidity is highest during the long rainy season (9.1 NTU). This stems from the fact that when the volume of water increases during this period, the suspended solids content also increases, resulting in higher turbidity. It should also be noted that during periods of heavy rainfall, soil erosion can cause the water current to carry large quantities of suspended solids, potentially leading to increased turbidity (Li *et al.*,2024). This would explain the value of 13.48 NTU in November and December. The work of Menye and his collaborators (Menye *et al.*,2012) on the Soumsoum River in Cameroon recorded a turbidity of 16 NTU during the dry season and 126 NTU during the rainy season (the color value for the short rainy season). It should be noted that the lowest turbidity value of 7.95 NTU is found during the short dry season, between June and July, which corresponds to the period when the water color has the lowest value of 132.25 PtCo. However, color is not directly related to turbidity; the nature of the substances

in solution strongly influences the water color. The highest color value of 215.57 PtCo does not correspond to high turbidity. As for conductivity, its highest value of 25.90 µS/cm corresponds to the short dry season, indicating the presence of a high concentration of ions in solution. The lowest value is found during the long rainy season. The water conductivity is 18.50 µS/cm. Indeed, the significant dilution due to the increased water volume would decrease the electrolyte content, and therefore the conductivity.

The oxidizable matter content is highest during the short rainy season (June and July) at 1.38 mg/L, but the lowest value is found during the period from June to July. This correspond to the lowest values for turbidity and color, although these parameters are not directly correlated.

Finally, the alkalinity is high at 1.47°F during the short rainy season and lowest during the long rainy season.

The short rainy season shows a high profile in four parameters, namely pH, color, oxidizable matter, and alkalinity. Conversely, the short dry season records minimum values for temperature, pH, turbidity, and oxidizable matter.

After various ANOVA tests applied to the values of the physicochemical parameters The study

revealed highly significant differences between the four seasons (in 2024) in terms of temperature (p-value 8.01×10^{-8}), turbidity (p-value 8.73×10^{-5}), color (p-value 0.0002281), conductivity (p-value 2.09×10^{-14}), oxidizable matter content (p-value 1.27×10^{-10}), alkali content (p-value 0.004002), and chlorine content (p-value 0.003338). The remaining parameters were pH (p-value 0.2167), total hardness (p-value 0.9246), oxidizable matter content (p-value 0.4411), nitrite ion content (p-value 0.5976), and chloride ion content (p-value 0.4832) did not show significant differences.

CONCLUSION

This study aimed to determine the physicochemical quality of treated water from the Tshopo River at the REGIDESO SA/Kisangani plant during the year 2024. The following annual average values were obtained from these physicochemical analyses : temperature $26.97 \pm 0.78^\circ\text{C}$; pH 6.5 ± 0.34 ; simple alkali 0 ± 0 ; turbidity 2.42 ± 0.30 NTU ; color 8.4 ± 0.30 PtCo ; conductivity 32.65 ± 3.96 $\mu\text{S}/\text{cm}$; oxidizable solids content 1.75 ± 0.26 mg/L ; alkali 0.33 ± 0.12 °F ; Total hardness 0.07 ± 2.03 °F, free chlorine 1.13 ± 0.38 mg/L, nitrite ion concentration 0.02 ± 0.01 mg/L, and chloride ion concentration 3.78 ± 0.43 mg/L. These quality parameters showed highly significant differences between the four rainy seasons of 2024, except for pH, simple alkali-millimetry, oxidizable solids content, total hardness, nitrite ion concentration, and chloride ion concentration (respective p-values of 0.216, 1.00, 0.441, 0.925, 0.598, and 0.483). We suggest that studies be conducted over two years to confirm our observations and help REGIDES SA/Kisangani adjust the treatment process.

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