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Seasonal Variation of the Physico-Chemical Parameters and Irrigation Suitability of the Waters of the Tsieme River in Brazzaville (Congo)

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Abstract: Water is a basic need for all living beings, it contributes to sustainable development. The management of water resources is a major challenge in the world and for most developing countries. This work proposes to evaluate the physico-chemical quality and the suitability for irrigation of the Tsiémé River in Brazzaville (Congo) during two seasons (dry season 2021 and rainy season 2022). Eight (08) water samples were taken, four times (04) samples per season and then analyzed by physico-chemical methods. The results obtained during the 2021 dry season and the 2022 rainy season revealed temperatures exceeding the WHO standard (25°C), very soft and sometimes turbid waters (8.02-214.00 NTU) with pH values oscillating between 5.61 and 7.73, a low concentration of major and minor ions which confirms the low mineralization of this river. These low levels of major and minor ions show that these waters benefit from the geology of the environment crossed. The dissolved organic carbon and suspended matter contents exceed the WHO guideline values. The projection of water points on Piper's triangular diagram essentially highlights two chemical families: sodium and potassium bicarbonate waters and sodium and potassium chloride waters; the schoeller diagram confirms the facies observed in the Piper diagram. The concentration average of absordable sodium, determined from the SAR, varies from 2.88 to 5.33 meq/L in the dry season and from 0.2 to 2.78 meq/L in the rainy season. These waters belong to class S1 (SAR < 10). The water from the Tsiémé River contains a low amount of sodium and can be used for irrigation in almost any soil without fear of difficulties arising from the alkalinization point of view. Thus, the irrigation indices reveal that the Tsiémé River is of fairly good quality for irrigation.

Keywords: River Water, Seasonal Variation, Physico-Chemical Parameters, Suitability for Irrigation, Brazzaville, Congo

1. Introduction

Water is considered everywhere as the most fundamental and indispensable element of all natural resources. The management of water resources is a major challenge in the world and for most developing countries. Water used for human consumption is groundwater and surface water. Pollution of aquatic environments is closely linked to air and soil pollution due to the permanent interaction between these three compartments of the biosphere [1].

With the rise of anthropogenic activities caused by increasing urbanization, our environment is subject to many physical attacks caused by the production of waste of all kinds which generates pollution. As a result, most watercourses have undergone multiple alterations such as modification of the bed and banks, regulation of flows, industrial pollution and diffuse pollution linked to intensive agricultural practices, etc. These alterations can generate ecological degradation of the hydro system, making it unable to provide certain expected goods and services (decline in water quality and availability, disappearance of aquatic species, change in the structure of communities, etc.) [2].

The city of Brazzaville is crossed by many rivers which all flow into the Congo River. This city is part of a hydrogeological set of Batéké plateaus, a real water tower from which the great rivers of the Congo come. The hydrological regime of the rivers of Brazzaville is such that the water level increases in the rainy season (September to May) and drops in the dry season (June to August). The soils of Brazzaville are generally sandy-clayey, poor in organic matter and varied according to the nature of the source rock [3].

The population growth experienced by the city in recent decades has led to an increase in the quantities of waste produced by the populations. In the absence of an adequate sanitation system, all this waste of various kinds is dumped without control either on the ground, which constitutes piles of waste: emitting nauseating odors, or in the waterways surrounding environment with the consequent deterioration of their physicochemical, microbiological and organoleptic quality [4].

Surface waters, which constitute an ecosystem where many aquatic species live, are the most exposed to this threat since waterways have become major recipients of wastewater, waste and household waste. In rainy weather, runoff water dissolves several substances contained in household garbage dumps and other waste, then carries them into the surrounding waterways, thus causing water pollution [5].

Of good physicochemical quality upstream, the waters of these rivers are generally loaded with various elements as they cross the city and their quality deteriorates due to the fact that large quantities of substances generated by human activities are discharged into them [6]. The degradation of the quality of these waters has many consequences such as waterborne diseases, water pollution, eutrophication phenomena [7]. Thus, this work aims to assess the physico-chemical quality and suitability for irrigation of the waters of the Tsiémé River in Brazzaville (Congo) during two seasons.

2. Materials and Methods

2.1. Study Zone

The Republic of Congo is located in Central Africa, on either side of the equator. Its area is 342,000 km^2. It has a coastline of 170 km in length. It is bordered to the north by the Central African Republic and Cameroon, to the south by the Democratic Republic of Congo, and finally to the west by the Republic of Gabon. Its political capital is Brazzaville and Pointe Noire is its economic capital.

Brazzaville is an agglomeration located on the right bank of the Congo River downstream of the Stanley Pool with an area of 110 km^2 [3]. It is administratively divided into nine districts: Makélékélé, Bacongo, Poto-poto, Moungali, Ouenzé, Talangai, Madibou, Djiri [8]. This city enjoys a tropical climate called the "low Congolese" climate which is characterized by abundant rainfall (1.37 m of precipitation/year) with an average temperature of 25°C. The hydrographic network draining Brazzaville is entirely included in the watershed of the great Congo River. The Djiri materializes the northern limits of the city and the Tsagamani river to the south [3].

This study was carried out in the Tsiémé River (Figure 1) which crosses four (04) districts of the city of Brazzaville, in which water samples were taken: Djiri (Massengo), Mfilou (Bled), Ouenzé (Tsiemé) and Talangai (Talangai).

Figure 1 locates the study area while Figure 2 shows the sampling sites concerned.

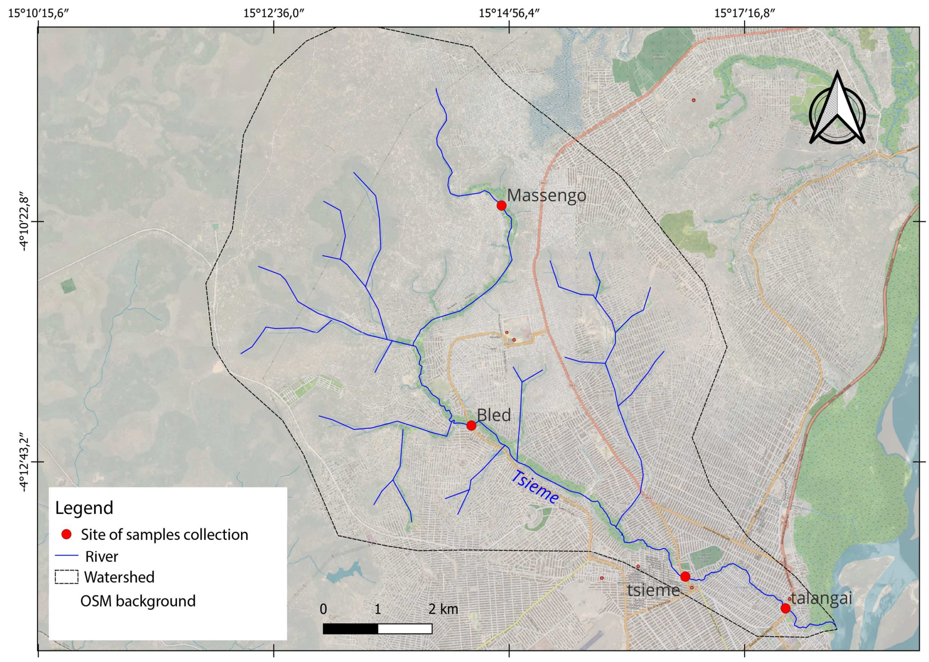

Figure 1. *Location of the study area.*

Photo 1 : sampling location of the Massengo site (Djiri)

Photo 2 : sampling location of the Bled site (Mfilou)

Photo 3 : sampling location of the Tsiémé site (Ouenzé)

Photo 4 : sampling location of the Talangai site (Talangai)

Figure 2. *Different sampling sites concerned by the study area.*

2.2. Water Sampling

Two sampling campaigns were carried out in the dry season 2021 and the rainy season 2022, respectively in August and April in the four (04) districts of Brazzaville. Four (04) samples were taken the same day in the Tsiémé River following the selected sampling sites (Massengo, Bled, Tsiémé, Talangai). The choice of the sampling area was based on accessibility, the nature of the discharges observed and the modes of use of the river by the local population.

At each sampling site, a representative sample of water was taken in one-litre plastic bottles, previously washed and rinsed with distilled water. The bottle was plunged against the current to a depth of about 15 cm using the method described by Rodier [9]. The water samples were transported under isothermal conditions between 4 and 6°C and are stored in the laboratory according to standard EN ISO 5667-3.

2.3. Physico-Chemical Analysis Methods

Different analytical methods were used to analyze the water samples.

The physicochemical parameters (temperature, pH, Cond, TDS) were measured in the field. Four (04) methods were used to determine the different physico-chemical parameters:

1. The potentiometric method to determine the temperature (T°C), the electrical conductivity (EC) and the total dissolved solids (TDS) was carried out using a Blacklights EZ-9909-SP Multiparameter according to the NFT90- standard. 008 or NF EN ISO 10523;
2. The titrimetric method for determining chloride ions (Cl-) according to ISO 9297, Dissolved Organic Carbon (DOC) according to ISO 20236: 2018, hardness according to NFT 90-003);
3. The nephelometric method to determine the turbidity with a Thermo scientific ORION AQUAfast brand device according to the NF ISO 7027 standard;
4. The spectrometric method for determining major ions using a La Motte SMART Spectro 2 2000-02 MN spectrophotometer according to standard NF EN 1483.

2.4. Data Processing

Two software programs were used to process the analysis results: Microsoft Excel 2010 made it possible to produce the histograms and to determine the distribution of the parameters studied according to the sampling campaigns, then the diagram software to generate the Piper and Wilcox diagrams and schoeller Berkalhoff [15].

2.5. Suitability for Irrigation of the Tsiémé River

2.5.1. Sodium Adsorption Ratio (SAR)

Surface and underground waters can be used for irrigation because of the effect of their mineral elements on plants, the sodium absorption rate or SAR must be taken into account, which is given by the following relationship [16]:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$$

2.5.2. Percentage of Sodium (%Na) According to Wilcox

It is based on the total concentration of dissolved salts and the percentage of sodium relative to other salts in the water. Wilcox also recommends taking into account the conductivity, i e. the salinity of the water, the danger of soil alkalinization and the concentrations of elements harmful to plants. Generally, plants do not tolerate sodium-saturated soils well. The Wilcox classification based on electrical conductivity and sodium content in water is defined by the following formula [16]:

$$\%Na = 100 \times \frac{[Na^{+}+K^{+}]}{[Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}]}$$

2.5.3. Permeability Index

The PI is used to reflect the applicability of waters for irrigation purposes. Water rich in minerals (Ca^{2+}, Mg^{2+}, Na^{+} and HCO^{3-}) can reduce aeration in the soil and hinder plant growth. The permeability index is given by the following formula:

$$\%IP = 100 \times \frac{Na^{+}+\sqrt{HCO_3^{-}}}{[Ca^{2+}+Mg^{2+}+Na^{+}]}$$

A PI of 75% or more indicates that the waters are suitable for irrigation (class I and class II), while a PI of 25% or less than the maximum permeability is considered unsuitable for irrigation (class III) [17].

3. Result and Discussion

Study of the variation of physico-chemical parameters

Temperature: Figure 3 shows that the means of temperature values measured in the dry season are between 26.2 and 30°C, and between 26.5 and 30.7°C during the rainy season; these values in both seasons exceed the WHO standard (25°C), the high temperature values are observed during the dry season. These results are similar to the work done by Dubey et al [13] in both seasons and consistent with those of Hubert [14] and Akatumbula et al [15] in the dry season.

This increase in temperature may be due to the variation in ambient temperature throughout the day during sample collection [13]. Too high a temperature can lead to dramatic situations of lack of dissolved oxygen which can lead to the disappearance of certain species, the release of phosphorus contained in the sediments; phosphorus becomes available for plants which use it to proliferate, hence the accelerated growth of algae [14].

Hydrogen Potential (pH): The average pH values observed in the sampling locations during the dry season and the rainy season (Figure 4) are respectively between 5.61 and 6.62, and 5.70 and 7.73, are close to neutrality and respect the standard, except for the bled site which has an acid pH during the two campaigns. These results are similar to those of the works carried out by Dubey et al [13]. Tchoumou et al [17]. and Abdoulaye et al [18] during the two seasons (rainy season and dry season) and during the rainy season by Ahoussi et al [19].

Acidity at the site (Bled) may be due to the presence of large quantities of organic matter in the water. Acidic water can promote the release of complexed metals from sediments. This phenomenon can be explained by the combined effect of significant photosynthetic activity, the lithological nature of the land crossed by the waters and anthropogenic activities [16].

Conductivity: The average values of the electrical conductivity of water in the study area are between 18 and 172 µS/cm in the rainy season and between 22 and 241 µS/cm in the dry season (Figure 5). During these two seasons, the waters are low in mineral content and the electrical conductivity values respect the WHO guideline value (400µs/cm); the lowest values are recorded during the rainy season, which may be due to the dilution phenomenon. These results are similar to those of the work carried out by Ahoussi et al [19] and Houeyi et al [20]. The low values of conductivity during the two seasons may be due to a low quantity of ions in solution in each site, which leads to low mineralization due to the nature of the terrain crossed (schistose or granitic) [21-22].

Total Dissolved Salts: The average TDS values during the dry season are around 18-172 µS/Cm and 22-241 µS/Cm during the rainy season (Figure 6), an increase is observed in the rainy season and a decrease in the dry season and are correlated with conductivity. This increase may be due to the phenomenon of runoff during the rainy season, which could cause the presence of other substances in the water or the geological nature of the terrain crossed [9-23]. These results are similar to those of the work carried out by Houeyi et al [20].

Turbidity: The average turbidity values in the dry season vary between 8.02 and 12.1 NTU and between 35.9 and 214 NTU in the rainy season (Figure 7). All the values of these sites do not comply with the WHO guideline value (5 NTU). The highest turbidity values during the rainy season may be due to the runoff phenomenon which causes an increase in suspended particles (organic debris, clays, microscopic organisms, etc.) and contributes to reducing photosynthesis and lowering the carbon content. dissolved oxygen, due to the presence of biodegradable colloids [23-24]. The results are similar to those of the work carried out by Tchoumou et al [17] and Abdoulaye et al [25] in the rainy season.

Suspended solids: Figure 8 presents the average values of suspended solids concentrations which fluctuate between 6.7 and 10.75 mg/L in the dry season and 12 and 152 mg/L in the rainy season. These results do not respect the guideline value established by the WHO (<1mg/L). This fluctuation in the rainy season may be due to the phenomenon of runoff or leaching [23]. Such an increase can also lead to warming of the water, which will have an effect on the aquatic environment [26]. High levels of suspended solids can be considered a form of pollution. These results are similar to those of the work carried out by Merhabi et al [27] and Brahim et al [28] in the two seasons of the year.

Nitrates: The average nitrate values during the dry season oscillate between 0 and 31mg/L and from 2 to 17mg/L in the rainy season (Figure 19). During both seasons the values respect the WHO guide value (50mg/L). We notice that only Tsiemé and Talangai have high nitrate concentrations. The presence of nitrates in these two sampling points may be due to the presence of chemical fertilizers used for the surrounding agricultural activities [29-30].

Hardness: Figure 9 shows that the average hardness values during the dry season vary between 4 and 40 mg/L $CaCO_3$ and during the rainy season between 17.1 and 51.4 mg/L $CaCO_3$. Compared to the values found during the two seasons of the year, it can be said that these waters are of a soft nature. This variation would be linked to the lithological nature of the aquifer formation and in particular to its magnesium and calcium composition [31]. These results are similar to those of the works carried out by Tchoumou et al [17] and Brahim et al [28] in the two seasons.

Silica: The average values of silica observed in figure 18, during the dry season vary from 9 to 12 mg/L and from 4 to 12 mg/L in the rainy season. The majority of sites respected the WHO guideline value (≤ 10 mg/L) during the two campaigns except Tsiemé (12 mg/L) in the dry season and Talangai (12 mg/L) in the rainy season. The presence of silica in the water has no harmful effect on aquatic life [34]; it depends on the lithology, the rate of erosion and the climate [32].

Fluorides: Figure 17 shows that the average fluoride values during the dry season vary between 0 and 0.04 mg/L and between 0 and 0.12 mg/L in the rainy season. These values respect the WHO guide value of 1.5mg/L, silica is the most abundant element in the earth's crust, we can say that the fluoride in the water comes from a natural source given the low concentrations observed [33].

Sulphate: Figure 14 shows that the average sulphate values vary between 6 and 9 mg/L in the dry season and between 6 and 18 mg/L in the rainy season. These values respect the WHO guide value (250mg/L) during the two seasons. As these values respect the WHO limit value, it can be said that the presence of sulphate in the various waterways is of natural origin. The natural origins of sulphates are rainwater and the dissolution of evaporitic sedimentary rocks, in particular gypsum ($CaSO_4$), but also pyrite (FeS) and more rarely magmatic rocks (Galena, blende, pyrite) [34]. These results are similar to those of the work carried out by Tchoumou et al [17] and Millogo et al [35] in the two seasons.

Chloride: The results show that the concentration of chlorides varies between 3.2 and 10.6 mg/L in the dry season and between 2 and 15.9 mg/L in the rainy season (figure 16). The average values observed in the study area meet the WHO standard (250 mg/L). These results are similar to those of the work carried out by Millogo et al [35] and Akatumbula et al [15], the presence of chloride in natural waters depends on the geology of the soil or the nature of the terrain crossed [16].

Bicarbonates: The results of the analyzes of the first campaign (dry season) show that the concentration varies between 25.6 and 64.63mg/L and that of the second campaign (rainy season) between 14.63 and 90.24mg/L (figure 15), these values in the two seasons comply with the WHO guideline value (500mg/L) but it can be seen that the concentrations found in the rainy season exceed those in the dry season. This high concentration may be due to the phenomenon of runoff during the rainy season. The bicarbonate ions are the most abundant of the anions in the two campaigns; they determine the alkalinity of the medium. These results are similar to those of the works carried out by Tchoumou et al [17], Bernard et al [36] and Akognongbe et al [37].

Calcium: The statistics of the average concentrations of calcium ions during the two seasons (dry season and rainy season) vary respectively between 0.8 and 12mg/L and between 1.6 and 12mg/L, respectively during the dry season and the rainy season, the values found in the two seasons respect the WHO guideline value (250mg/L), (Figure 10) shows that the highest concentrations are found in the rainy season, this may be due to the runoff phenomenon. The presence of calcium in the water can be due to the geology of the environment because the calcium can come from gypsiferous formations ($CaSO_4$, $2H_2O$), which are easily soluble [35]. These results are similar to those of the work carried out by Tchoumou et al [17] and Akognongbe et al [37].

Magnesium: Figure 11 shows that the average magnesium ion values (dry season and rainy season) vary respectively between 0.12 and 2.43mg/L and between 0.36 and 7.53mg/L respectively during the dry season and the rainy season. rainy season, the values found in both seasons respect the WHO guideline value (50mg/L). The highest concentrations are observed during the rainy season and this may be due to the runoff phenomenon during this season. The results are similar to those of the work carried out by Akatumbula et al [15] and Tchoumou et al [17].

Potassium: The average potassium values in the two seasons (figure 12) are low and vary between 0.9 and 4.4mg/L in the dry season and between 0 and 4.5mg/L in the rainy season and comply with the WHO guideline value (12mg/L). These results are similar to those of the work carried out by Dubey et al [13].

Sodium: Figure 13 shows that the average values of sodium ion concentrations in the dry season vary between 14.82 and 31.74 mg/L and in the rainy season between 8.61 and 42.04 mg/L. The highest concentrations are observed in the rainy seasons. These results in both seasons respect the WHO guideline value (150mg/L). These results are similar to those of the work carried out by Akatumbula et al [15].

Dissolved Organic Carbon (DOC): Figure 20 shows that the values of the concentrations obtained are higher in the rainy season, these values are between 31.2 and 124.8 mg/L and between 15.8 and 20mg/L in dry season. These concentrations do not respect the WHO limit value (4.8 mg/L). This increase can be explained by the absence of runoff and infiltration water, during this period when rainfall is abundant, and which tends to cause a great dissolution of minerals or by a reduction in the residence time of the material. organic [39]. These results are similar to those of the work carried out by Yao et al [38] and Meybeck et al [39].

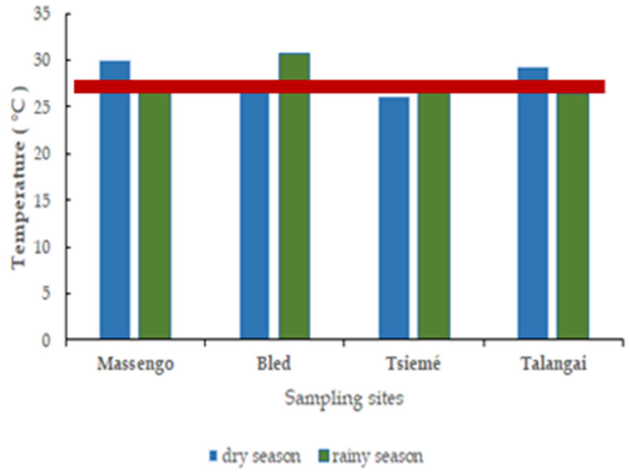

Figure 3. *Seasonal temperature variation.*

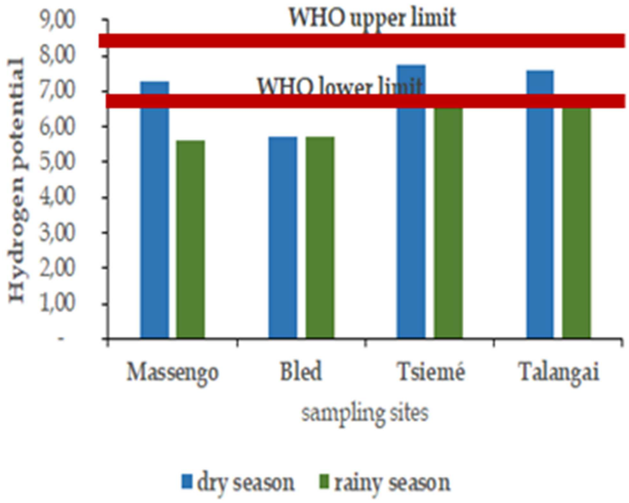

Figure 4. *Seasonal variation of hydrogen potential.*

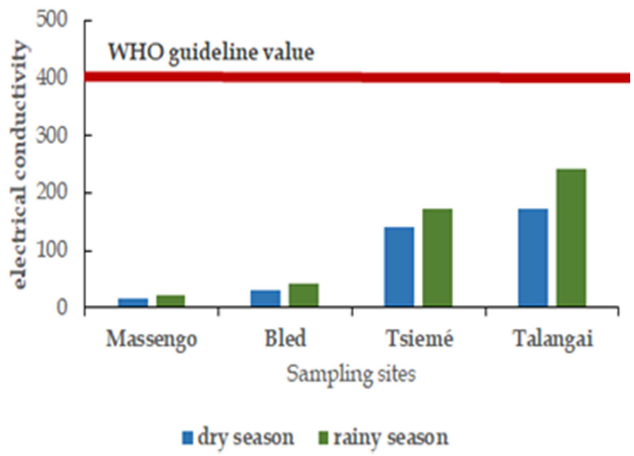

Figure 5. *Seasonal variation in conductivity.*

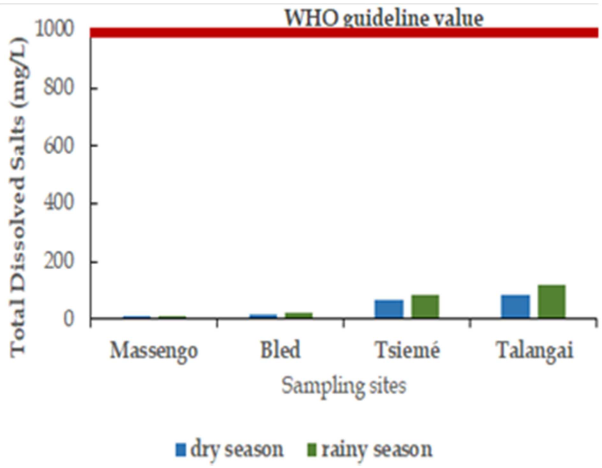

Figure 6. *Seasonal Variation of Dissolved Solids Rate.*

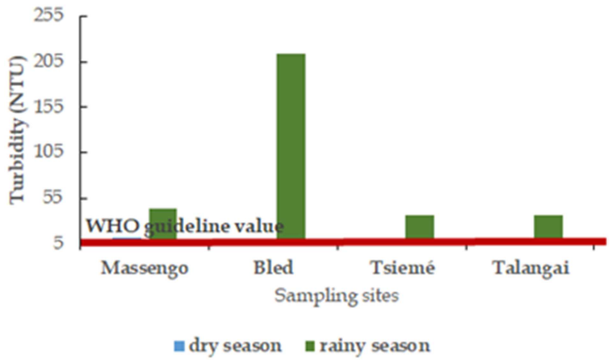

Figure 7. *Seasonal variation of turbidity.*

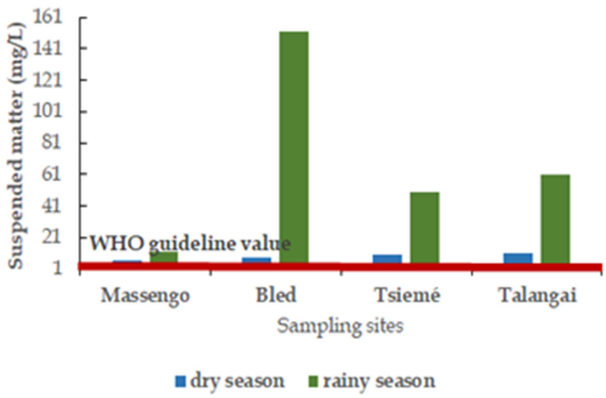

Figure 8. *Seasonal variation of suspended matter.*

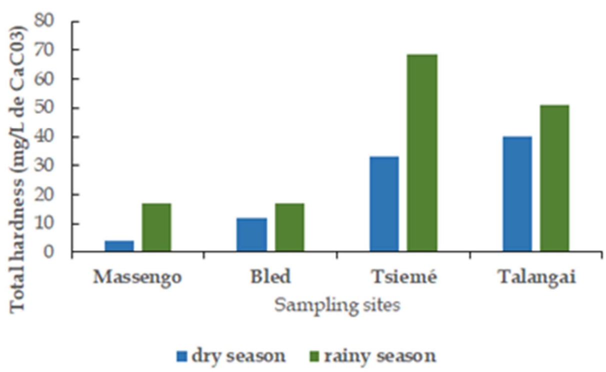

Figure 9. *Seasonal variation in hardness.*

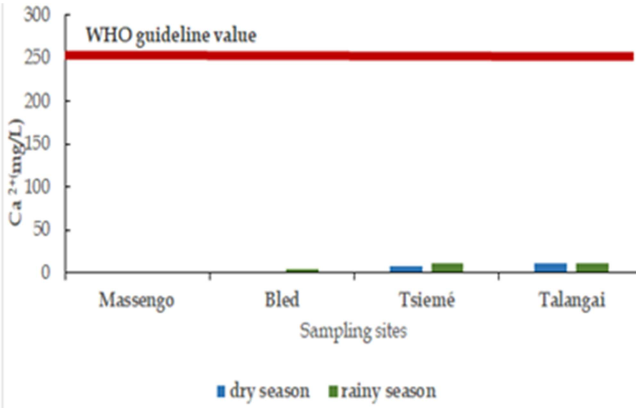

Figure 10. *Seasonal variation in calcium ion concentration.*

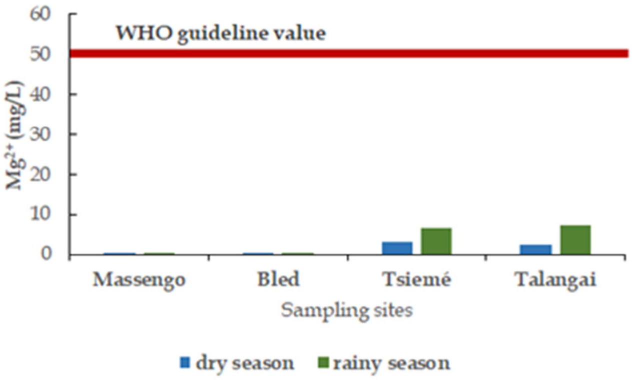

Figure 11. *Seasonal variation of magnesium ion concentration.*

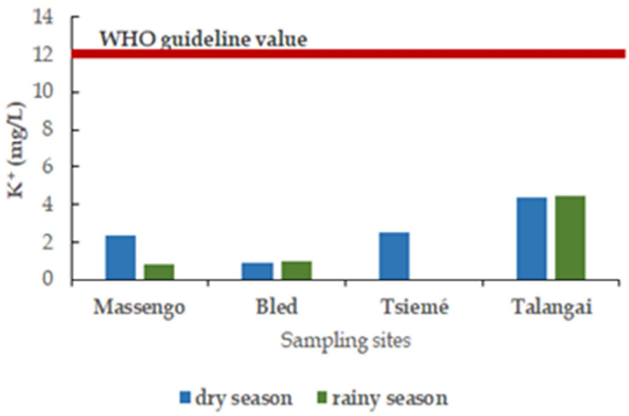

Figure 12. *Seasonal variation in potassium ions concentration.*

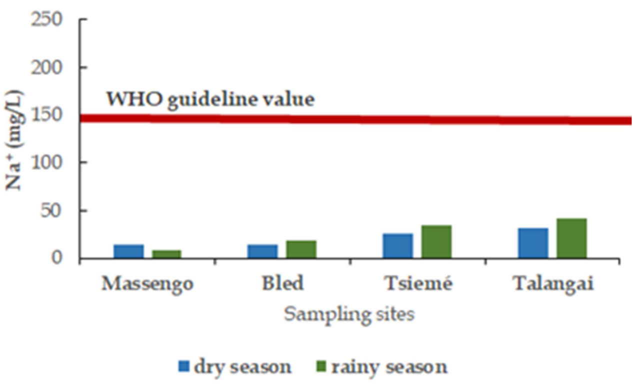

Figure 13. *Seasonal variation in sodium ion concentration.*

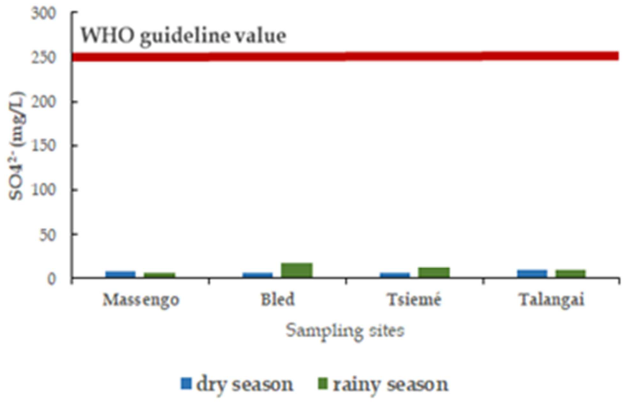

Figure 14. *Seasonal variation in sulfate ion concentration.*

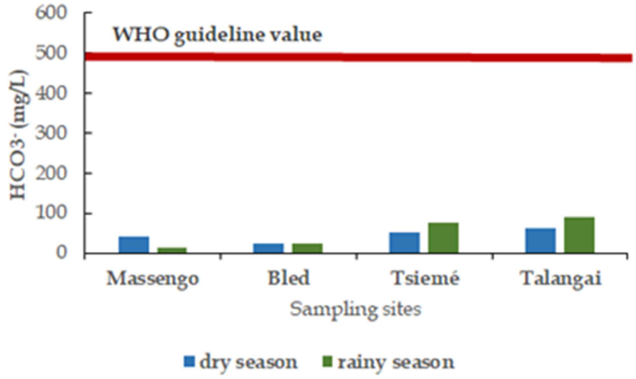

Figure 15. *Seasonal variation in bicarbonate ion concentration.*

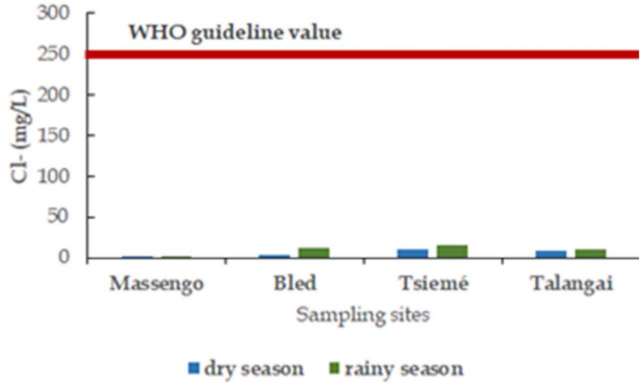

Figure 16. *Seasonal variation in chloride ion concentration.*

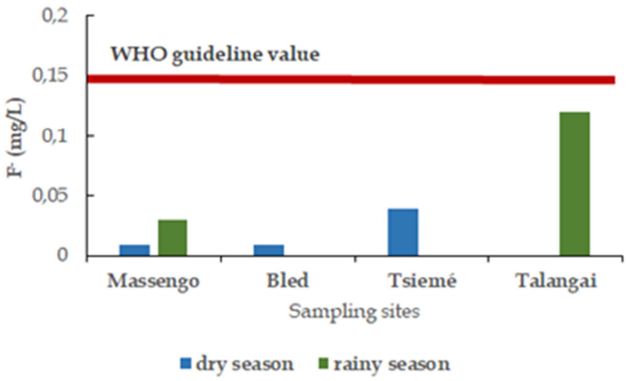

Figure 17. *Seasonal variations in fluoride ion concentration.*

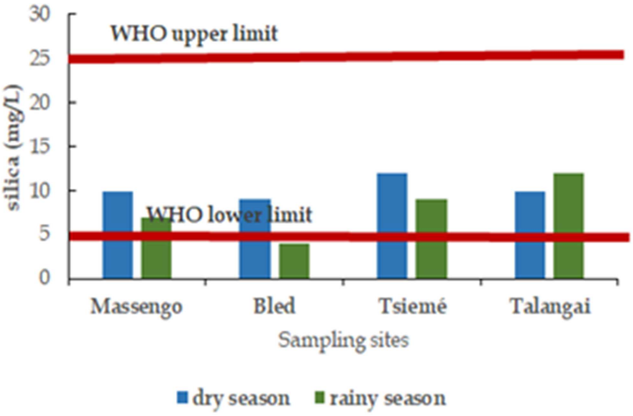

Figure 18. *Seasonal variation in silica ion concentration.*

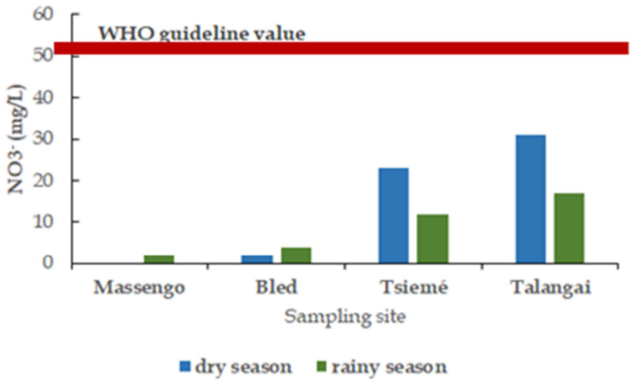

Figure 19. *Seasonal variation in nitrate ion concentration.*

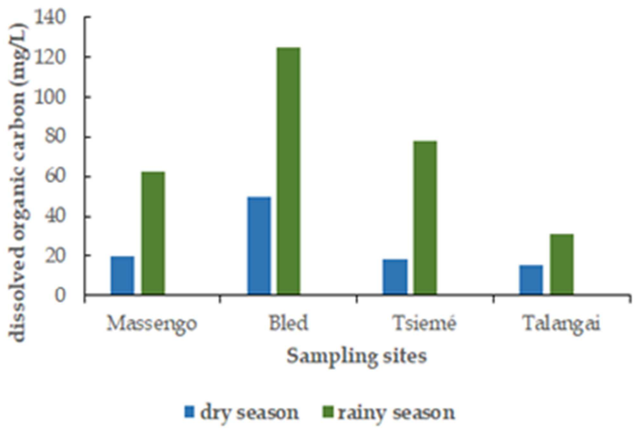

Figure 20. *Seasonal variation of concentration of dissolved organic carbon.*

Chemical Facies end Irrigation Suitability of the Tsiémé River

3.1. Determination of the Main Chemical Facies

To determine the chemical families and facies of the Tsiémé River in Brazzaville, the data from the chemical analyzes were projected onto the triangular Piper and Schoeller-Berkaloff diagrams [40].

For the two campaigns, we observe on the one hand, a predominance of sodium and potassium bicarbonate waters, except for the water sample (Bled-P) characterized by a sodium and potassium chloride facies. However, in the triangular anion diagram, the water points show a predominance towards the bicarbonate pole where almost all the water points are concentrated, and only one point (Bled-P) evolves towards the mixed facies pole. (no predominance of one anion over the other). Finally, in the triangular cation diagram, all the water points are concentrated towards the sodium and potassium pole (figure 21). Analysis of the Schöller-Berkaloff diagram (figure 22) shows a strong increase in sodium and potassium ions as well as bicarbonate ions, which confirms the sodium and potassium bicarbonate facies observed in the Piper diagram, except for the Bled sample which exhibits an increase in chloride ions and sulfate ions during both seasons.

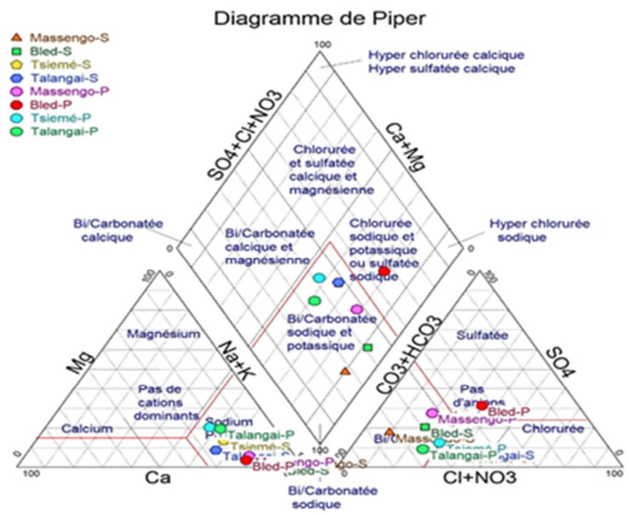

Figure 21. *Piper diagram of the Tsiemé river.*

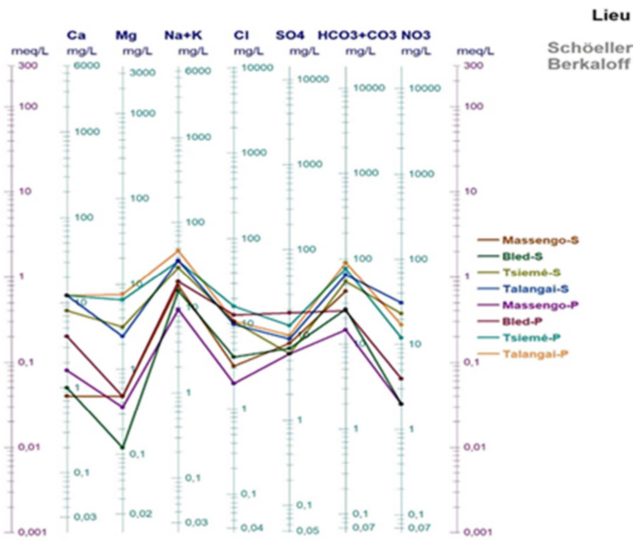

Figure 22. *Schoeller-Berkaloff diagram of the Tsiemé river.*

3.2. Suitability for Irrigation of the Tsiémé River

3.2.1. Sodium Adsorption Ratio (SAR)

Table 1 shows that the water of the Tsiemé is weakly mineralized and has a conductivity varying between 18 and 172 µS/cm in the dry season and between 22 and 241 µs/cm in the rainy season. Based on the classification of water according to the conductivity of each sampling point, it appears that the samples taken have average values of less than 250 µS/cm, they therefore belong to class C1, which means that they have a low salinity which causes low mineralization. However, the average concentration of adsorbable sodium, determined from the SAR, varies from 2.88 to 5.33 meq/L in the dry season and from 0.2 to 2.78 meq/L in the rainy season. These waters belong to class S1 (SAR < 10). It can be said that the water of the Tsiémé River contains a small amount of sodium and can be used for irrigation in almost any soil without fear of difficulties arising from the alkalinization point of view.

Table 1. *Conductivities and SAR (Sodium Adsorption Index) of the water of the Tsiémé.*

Sampling sites	Conductivités (µs/cm)	SAR (méq/L)
Massengo-S	18	4,96
Bled-S	31	5,33
Tsiemé-S	142	2,88
Talangai-S	172	3,33
Massengo-p	22	1,61
Bled-p	42	2,4
Tsiemé-p	172	2,78
Talangai-p	241	0,2

S: dry season; P: rainy season

3.2.2. Percentage of Sodium (% Na) According to Wilcox

Table 2 shows that during the dry season the percentage of sodium oscillates between 66.22 and 83% and between 65.5 and 82.72% during the rainy season. The highest percentage is observed during the dry season. According to the classification of the percentage of sodium, a water which presents a % Na > 80 is rich in sodium, it appears that in the dry season as in the rainy season, the percentage of sodium exceeds 80% in Massengo and Bled. This could be due to atmospheric precipitation in the rainy season or to the geological nature of the land crossed by this river. A high sodium concentration can affect soil permeability and water infiltration. Sodium also contributes directly to the total salinity of the water and can be toxic to sensitive crops like carrots, beans, strawberries, raspberries, onions, etc. [40-41]. Large amount of sodium combined with chloride gives water a salty taste. The Wilcox diagram (Figure 23) shows that overall these waters are within the range of excellent quality for irrigation despite the high sodium concentration at the points listed.

Table 2. *Results of the mean values of % Na of Tsiemé.*

Sampling sites	Conductivités (µs/cm)	%Na (mg/L)
Massengo-S	18	83
Bled-S	31	93,35
Tsiemé-S	142	72,69
Talangai-S	172	66,22
Massengo-p	22	82,72
Bled-p	42	81
Tsiemé-p	172	65,5
Talangai-p	241	70,44

S: dry season; *P*: rainy season

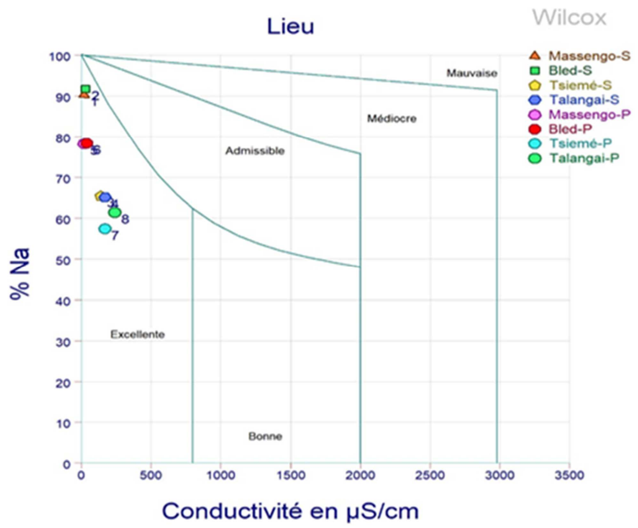

Figure 23. *Wilcox diagram of the different sampling sites in the Tsiémé River.*

3.2.3. Permeability Index (PI)

Table 3 shows that all the samples present an IP>75 %, class I characteristics in the dry season as well as in the rainy season except Talangai and Tsiemé which present an IP < 75% respectively in the dry season and in the rainy season which corresponds to class II. In general, the IP values show that the water in the tsiemé is suitable for irrigation.

Table 3. *Results of the average values of the % IP of the Tsiéme water.*

Sampling sites	%IP
Massengo-S	> 75 %
Bled-S	> 75 %
Tsiemé-S	> 75 %
Talangai-S	< 75 %
Massengo-p	>75 %
Bled-p	>75 %
Tsiemé-p	< 75 %
Talangai-p	>75 %

4. Conclusion

This study made it possible to evaluate the seasonal variation of the physico-chemical parameters of the water of the Tsiémé River in Brazzaville.

The physicochemistry of the Tsiémé water showed a high temperature which oscillates around 26.7 and 30°C during the first campaign in 2021 (dry season) and between 26.5 and 30.7°C during the second campaign. in 2022 (rainy season), mild in nature, low mineralization in both seasons (low concentrations of minor and major ions) with low and variable electrical conductivity values, ranging from 18 to 172 µs/cm during the first campaign and from 22 to 241 µs/cm during the second campaign, high turbidity with high amounts of suspended solids and dissolved organic carbon. The piper diagram essentially highlights two chemical families: sodium and potassium bicarbonate waters and sodium and potassium chlorinated waters. The physico-chemical characteristics of the Tsiemé River show a remarkable seasonal variation in chemical elements of natural origin or of anthropogenic origin (pollution). Irrigation water quality indicators generally show that the majority of water samples from the Tsiemé are of good quality and therefore suitable for irrigation for most crops. The Schoeller-Berkaloff diagram confirms the nature of the facies observed in the piper diagram. Except for temperature, turbidity, suspended solids and dissolved organic carbon which do not meet the standard, the other physico-chemical parameters comply with WHO standards.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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