Monitoring of the physicochemical and microbiological quality of water produced and distributed by La Congolaise Des Eaux (LCDE) in Brazzaville

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Abstract
Water is an essential element for all living beings and therefore deserves special attention to maintain ~~his~~its quality. The objective of this work is to monitor the physicochemical and microbiological parameters of the water produced and distributed by La Congolaise Des Eaux (LCDE) of Brazzaville in order to evaluate the risk on the health of consumers. Ninety (90) and eighty-five (85) samples were taken respectively in the southern and northern areas of the city of Brazzaville. These different samples were analyzed using physicochemical and microbiological methods. The results obtained show that these waters have high temperature values, ranging from 27.88 to 28.10°C in the southern and northern zones compared to the WHO guide value (25°C) and are moderately acidic (6.20-7.00) in both zones. The turbidity of the water is more pronounced in the southern zone (6.83 NTU) and is reflected in the absence of residual chlorine in the maximum number of sampling points with low mineralization. From a microbiological point of view, these waters show contamination with total germs, total coliforms and fecal coliforms. This contamination is more pronounced in the southern zone than in the northern zone. Thus, the factorial analysis shows contamination by total germs and indicator germs of fecal contamination (total coliforms and fecal coliforms) and reflects the lack of residual chlorine at the consumer's tap.
In view of the results obtained, this study shows that the ageing of the installations and the dilapidated state of the pipes of the LCDE have a negative impact on the quality of the water distributed, which constitutes a high health risk for the consumers.
Keywords: Monitoring, tap water, physico-chemical quality, microbiological quality, Brazzaville, Congo.

Abbreviations :
LCDE: La Congolaise des Eaux; TDS: The total dissolved solids; EC: Electric conductivity; WHO: World Health Organization; NTU: Nephelometric turbidity unit; FMAT: total aerobic mesophilic flora; CT: total coliforms, SA: *staphylococcus aureus*, CF: faecal coliforms, SF: faecal streptococci; E. coli: Escherichia coli;

1. INTRODUCTION
Water is essential for life, and all people should have access to an adequate (sufficient, safe and accessible) water supply. Access to safe drinking water can result in tangible health benefits for people. Every effort should be made to make drinking water as safe as possible [1].
Today, 2.2 billion people, or about 29% of the world's population, do not have access to safely managed domestic drinking water services. In addition, 4.2 billion people, or 55% of the world's population, do not have access to safely managed sanitation services. As a result, unsafe water is estimated to kill 2.6 million of people each year, the majority of whom are children due to waterborne diseases [2].
Population growth is leading to environmental degradation and an increase in the supply and demand for drinking water [3].
Drinking water quality is a universal health issue. Water is essential for life, but it is the primary vector for waterborne diseases worldwide. Ensuring good water quality is an effective measure for human health. In addition, the presence of undesirable substances in drinking water continues to make headlines [4].
Access to safe drinking water also has a significant impact on development at national, regional and local levels. For some regions, it has been shown that investing in water supply and sanitation can lead to a net economic benefit, where the reduction in adverse health impacts and health care costs more than

offsets these expenditures. This applies to both large-scale water supply infrastructure and household water treatment [1].

The Republic of Congo has potentially abundant water reserves, however, it suffers from shortages and unsanitary conditions in urban areas. Drinking water is supplied by La Congolaise Des Eaux (LCDE), which has two distribution networks, one in the southern zone (Usine de Djoué) and the other in the northern zone (Usine de Djiri). In Brazzaville, its collection points are located in the Djiri River in the north and in the Djoué River in the south. The tap water distributed directly to the consumer should be of good quality from a physicochemical and microbiological point of view.

These two networks essentially suffer from pipe problems, a situation that is much more noticeable in the southern network due to the ageing or dilapidated installations and equipment. According to the work carried out by Nkounkou Loumpangou and al [5], the dilapidated installations are partly responsible for the cloudy appearance or poor coloring of the tap water. Similarly, other studies conducted by Louzayadio Mvouezolo and al [6, 7] show metallic (dissolved iron and lead) and bacteriological (FMAT, CT, SA, CF, SF and E. coli) contamination of tap water in the southern zone of Brazzaville. Thus, the main focus of our work is the monitoring of physicochemical and microbiological parameters of water produced and distributed by La Congolaise des Eaux (LCDE) in Brazzaville in order to evaluate the risk of contamination of these waters and its impact on consumer health.

2. MATERIALS AND METHODS

2.1 Study area

Located in Central Africa, the Republic of Congo is bounded on either side of the Equator between 5° South latitude and 4° North latitude and between 11° and 19° East longitude, over a total area of 342.000 km^2. It has a very dense hydrographic network organized around two main basins. The Congo basin and the Kouilou Niari basin, to which are added small coastal basins [8]. Brazzaville, the country's political capital, is located on the right bank of the Congo River and is divided administratively into nine (09) districts [9]. The present study was conducted in the nine (09) districts of the city of Brazzaville and two zones were considered: the Southern zone (Makélékélé, Bacongo, M'filou and Madibou) and the Northern zone (Ouénzé, Talangaï, Poto-Poto, Moungali and Djiri) (Fig.1).

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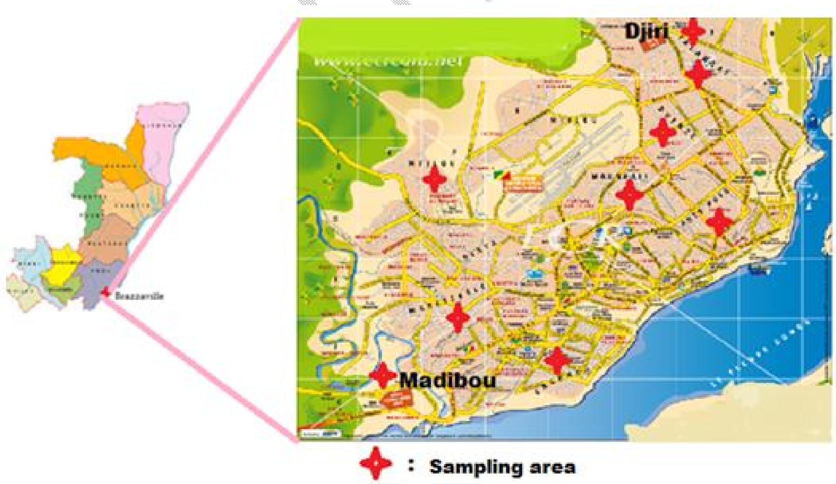

Figure 1: Sample collection areas in the city of Brazzaville [6]

2.2 Choice and coding of sampling points

The choice of sampling points was pre-established by the agents of the Congolaise des Eaux (LCDE) in order to monitor the quality of the water produced and distributed in the two zones. Eighteen (18) and seventeen (17) sampling points were considered respectively in the Southern and Northern zones. Table 1 shows the coded sampling locations in the two areas considered.

Table 1: Coding of sampling points by zone

South zone		North zone	
Sampling location	**Sample code**	**Sampling location**	**Sample code**
Boulevard	R1	Commune Moungali	P1
Diata	R2	Bongo-Nouara	P2
The powder magazine	R3	Massengo	P3
Mfilou Town Hall	R4	Potabloc Djiri	P4
PK Mfilou	R5	Djiri Plant 2	P5
Kinsoundi	R6	Djiri Plant 1	P6
Djoué Factory	R7	Ngamakosso	P7
Potabloc Djoue	R8	Little Thing	P8
Tenrikyo	R9	Ndolo Street	P9
Bifouiti	R10	Mikalou	P10
Mayanga	R11	Tsiemé	P11
Ngangouoni	R12	Talangai	P12
Mpissa	R13	Ouenzé	P13
Matour	R14	Moungali market	P14
Makélékélé	R15	Poto-Poto	P15
Case De gaule	R16	CEO of LCDE	P16
Market Total	R17	Central Laboratory	P17
IFC	R18	-	-

R: tap of the South zone; P: tap of the North zone; DG: General Management; LCDE: La Congolaise des Eaux; IFC: Institut Français du Congo~~; PK: Item Kilometre~~.

2.3 Water sampling

Sampling was carried out in the two zones of the city of Brazzaville considered according to the methods described by Rodier and al. [10], namely the southern and northern zones. Within the framework of this study, a total of ten (10) samples were taken in eighteen (18) and seventeen (17) sampling points respectively in the South and North zones of Brazzaville; that is, five (05) samples in the South zone during the period from 18/09/2019 to 21/10/2019 and five (05) other samples in the North zone during the period from 24/09/2019 to 16/10/2019. Ninety (90) and Eighty-five (85) tap water samples (Figure 1) were collected in the South and North zones, for a total of 175 samples.

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A: Tap in the South zone B: Tap in the North zone

Figure 2: Some sampling points in the South and North zone

2.4~~.~~ Physicochemical analysis methods

The determination of physicochemical parameters in water intended for human consumption is an important step in evaluating ~~his~~its quality. The analyses of physicochemical parameters were measured in-situ. Five (05) parameters were measured, namely temperature, pH, conductivity, turbidity and residual chlorine. Three (03) methods were used to determine the different physicochemical parameters:

- the potentiometric method to determine the temperature (T°) and electrical conductivity (E.C.) ~~made~~ with a Wagtech multi-parameter according to the NFT90-008 standard;
- the colorimetric method to determine the hydrogen potential (pH) and residual chlorine using a Lavibond comparator in accordance with standard NF ISO 7393-2;
- the nephelometric method to determine turbidity using a Lavibond turbidimeter in accordance with standard NF ISO 7027.

2.5~~.~~ Microbiological analysis methods

Microbiological analyses were carried out at the central laboratory of the Congolaise des Eaux in Brazzaville (Congo) according to the ISO 7218 standard [12]. Two (02) methods were used to determine the content of different bacteria in the tap water. These were the membrane filtration method and the agar incorporation method.

- the membrane filtration method to search for total coliforms and faecal coliforms using a culture medium (chromogenic coliform agar) according to the ISO 9308-1 standard
- the agar incorporation method was used to test for total germs using a culture medium (agar extract) according to ISO 4833-2.

2.6~~.~~ Methods of analysis and data processing

Two software packages were used to process the results of the analyses: Microsoft Excel 2010 was used to produce the curves and histograms and to determine the distribution of the parameters studied according to the sampling campaign. We also used the explanatory method of Principal Component Analysis (PCA) using Statistica 7.1 software. This method is widely used to interpret hydrochemical data [11].

3~~.~~ RESULTS AND DISCUSSIONS

3.1 Comparative study of the temporary variation of physico-chemical parameters in the north and south zone

Temperature: Temperature is an important factor in water treatment processes from a microbiological point of view. It affects the physical and chemical properties of water; in particular, its density, viscosity, solubility of gases (especially oxygen) and the rate of chemical and biochemical reactions [12]. In the southern zone, the temperature values vary between 23.80 and 31.40°C with an average of (27.88 ±

1.48) °)°C, and between 23.50 and 30.70°C; in the northern zone, the average is (28.1± 1.42) °)°C. Compared to the WHO guide value (25°C), the majority of samples did not comply during the five sampling campaigns, with a non-compliance rate of 92.22 and 95.29% in the southern and northern zones respectively (Figure 23 and Figure 34). The results obtained corroborate those found by Louzayadio and al [6] in the southern zone.
This increase in temperature values in both study areas could be explained by the variation in ambient temperature throughout the day during sample collection. This could lead to the proliferation of microorganisms in the distribution system and unpleasant odors [12, 13, 14].

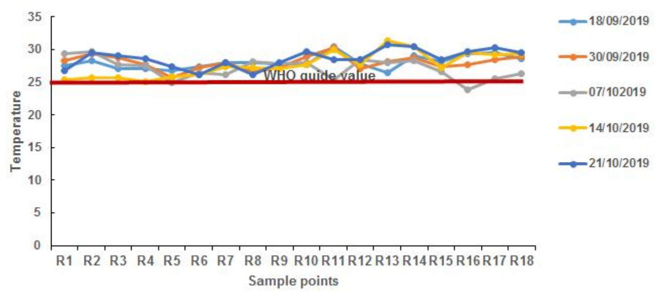
Hydrogen Potential: pH is one of the most important operational parameters of water quality, all water treatment processes are pH dependent [15].
The pH values obtained in the South and North zone vary from 6.20 to 7.00 and 6.20 to 7.00 respectively with averages of (6.50 ± 0.19) and (6.55 ± 0.20). Analysis of the curves (Figure 45) shows that in the southern zone, twenty-one (21) samples do not comply with the WHO guide value (6.5-8.5) and eleven (11) samples in the northern zone (Figure 56), i.e. a non-compliance rate of 23.33 and 12.94% respectively. The rate of non-compliance is higher in the southern zone than in the northern zone. We note that the majority of the water samples taken in both zones had acid pH values during the five sampling campaigns. According to the literature, the presence of organic matter in the drinking water supply network could be responsible for the acidity of the water, however, the lack of caslco-carbonic equilibrium of the water at the outlet of the plant could also cause this acidity. Acidic pH water distributed through pipes would be aggressive (corrosive) and is likely to release lead or other metals into the pipes [16;, 17].

Turbidity: This refers to the cloudy state of water, the measurement of turbidity provides visual information on the water and reflects the presence of suspended particles. Turbidity is not dangerous in itself, but its increase with values above 5 NTU has an impact on the other parameters that define water quality from a bacteriological and chemical point of view [18]. In the southern zone, the minimum and maximum turbidity values during the five sampling campaigns ranged from 0.99 to 18.9 NTU with an average of (6.83 ± 4.31) NTU and in the northern zone (0.8 and 28 NTU) with an average of (3.80 ± 28) NTU. The analysis of the curves (Figure 49) in the southern zone shows that fifty (50) samples do not comply with WHO standards (≤ 5 NTU) and fourteen (14) samples in the northern zone (Figure 910), i.e. respective non-compliance rates of 55.56 and 16.47%. This increase in turbidity in both zones could be due to a lack of treatment or to the presence of suspended or colloidal matter due to the problem of infiltration of run-off water and/or wastewater into the drinking water distribution network [19].

Chlorine residual: Chlorine is a disinfectant with a persistent effect that prevents bacterial revival. The values of residual chlorine in the southern zone during the five sampling campaigns vary from (0 to 0.5 mg/L) with an average of 0.08 mg/L and from 0 to 1 mg/L with an average of 0.19 mg/L in the northern zone. The analysis of the curves (figures 1011 and 1112) respectively in the two zones shows that forty-three (43) samples in the southern zone do not comply with the WHO standard (0.2 to 1 mg/L) and 74 samples in the northern zone, which translates into a non-compliance rate of 82.22 in the northern zone and 50.59% in the southern zone and 58.59% in the northern zone. The non-compliance rate is higher in the southernnorthern zone than in the northernsouthern zone. The absence and/or decrease of chlorine in the drinking water distribution network could be due to the distance and time of delivery (residence time) of the water to each of the subscribers, which is a factor that influences the residual chlorine content in the drinking water, to the inefficiency of treatment, to the presence of organic matter and to the presence of leaks in the pipes [20, 21].

Electrical conductivity: Conductivity is the property of water to allow an electric current to flow through it. It is due to the presence in the water of ions that are mobile in an electric field. The measurement of conductivity is a good indicator of the degree of mineralization of a water, where each ion acts through its concentration and specific conductivity [22].
During the five sampling campaigns, the conductivity values in the southern zone oscillated between 21 and 42 µS/cm with an average of 28.28 and between 16 and 40 µS/cm with an average of 29.11 µS/cm in the northern zone. We note that all the samples from the two zones comply with the WHO guide value (400 µS/cm), i.e. a compliance rate of 100% in each zone over the five sampling campaigns. We note that

the conductivity is low in the South and North zones, which could be due to the mineralogy of the raw water of the Djoué and Djiri rivers, which is naturally low.



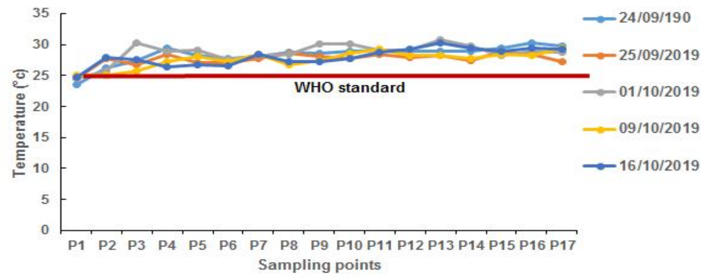
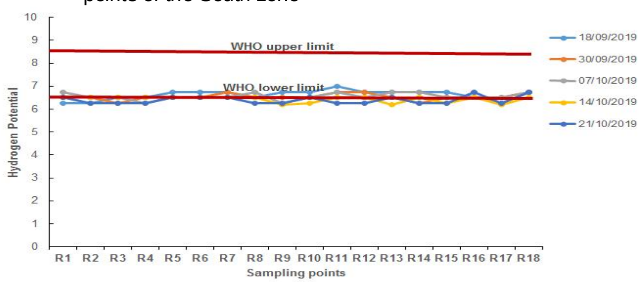


Figure 3: Temporal variation of the temperature according to the sampling points of the South zone

Figure 4: Temporal variation of the temperature according to the sampling points of the North zone



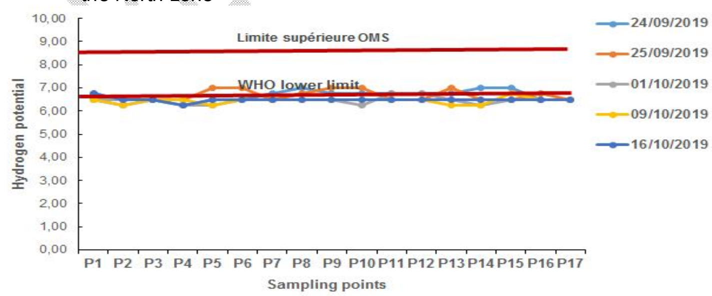


Figure 5: Temporal variation of the Hydrogen potential according to the sampling points of the South zone

Figure 6: Temporal variation of pH as a function of points collection from the North zone

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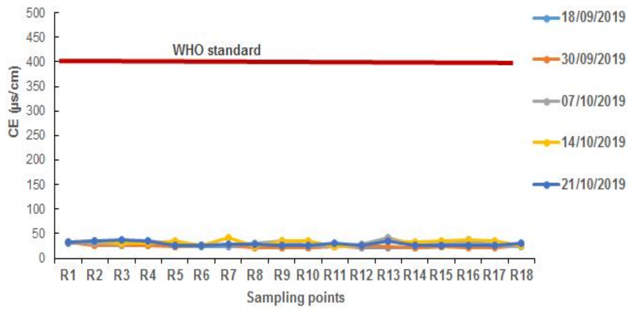


Figure 7: Temporal variation of the conductivity according to the sampling points of the South zone

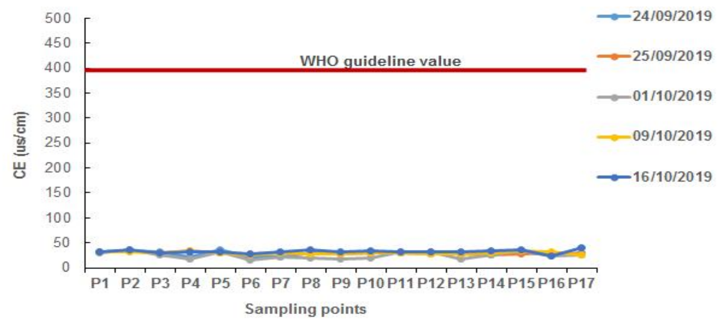


Figure 8: Temporal variation of the conductivity according to the sampling points of the North

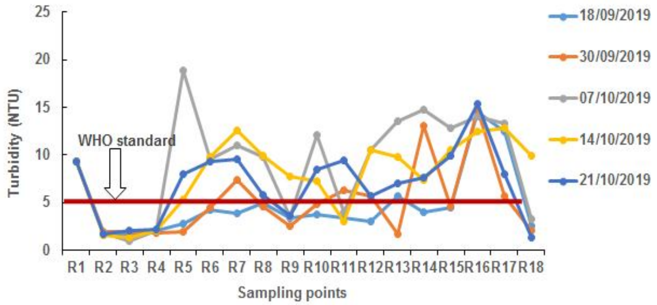


Figure 9: Temporal variation of turbidity according to points sampling from the South zone

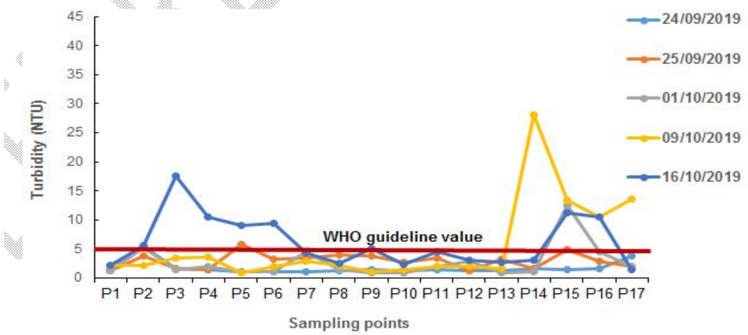


Figure 10: Temporal variation of turbidity according to sampling points in the North zone

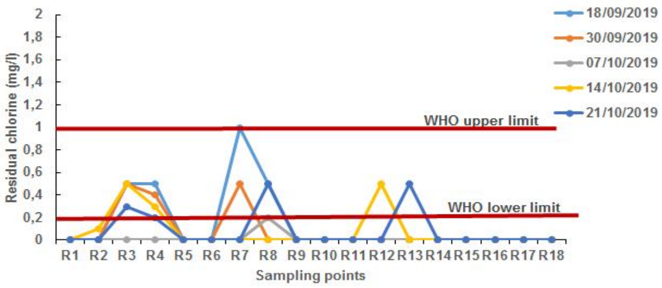


Figure 11: Temporal variation of residual chlorine according to sampling points in the South zone

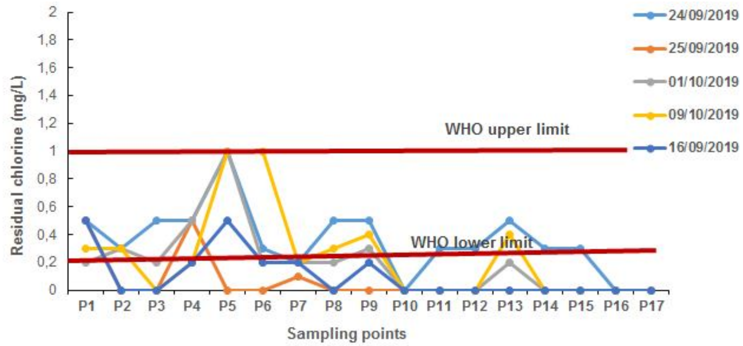


Figure 12: Temporal variation of residual chlorine according to sampling points in the North zone

3.2 Comparative study of the temporary variation of microbiological parameters in the north and south zone

Total germs: Total germs are germs that develop under aerobic conditions. Their presence is indicative of possible bacterial contamination of the water. The presence of these germs provides information on the hygienic quality of the water intended for human consumption [23]. The values obtained during the five sampling campaigns vary from 0 to 145 CFU/mL and from 0 to 204 CFU/mL in the southern and northern zones respectively. In the southern zone, the analysis of the curve shows that 55.55% of the water samples are contaminated and do not comply with the WHO guide value (10 CFU/mL) (Figure 13), whereas in the northern zone, 23.35% of the water samples are contaminated. We note that the water samples taken in the southern zone are more contaminated than those in the northern zone. This could be explained by the ageing of the drinking water production facilities in the southern zone, a lack of treatment and the absence of residual chlorine observed during the five sampling campaigns. According to the literature, the presence of these non-pathogenic germs in the drinking water indicates possible bacteriological contamination, the ineffectiveness of the disinfectant in the distribution network due to biofilm formation and lack of hygiene [24]. The values obtained are lower than those obtained in the work of Louzayadio in the southern zone [7, 24]. Thus, these waters require additional treatment at home before consumption.

Total coliforms: Total coliforms are gram-negative, aerobic or facultative anaerobic bacilli. The majority of coliform bacteria belong to the genus Escherichia coli, nitrobacter, etc. [10, 23]. [10, 23]. In the southern and northern zones, the values obtained vary from 0 to 400 CFU/100mL with an average of 11.9 CFU/100 mL and from 0 to 50 CFU/100 mL with an average of 0.59 CFU/100 mL respectively. Analysis of the curve (Figure ~~14~~15) shows that twelve (12) water samples are contaminated and do not comply with the WHO standard (0 CFU/100mL), whereas in the northern zone (Figure ~~15~~16), only one water sample was contaminated during the five sampling campaigns. This contamination is more pronounced in the southern zone than in the northern zone. This could be due to the presence of organic matter that forms biofilms in the network and leads to the reduction or total absence of chlorine, to intrusions of run-off water and wastewater in the pipes and tanks, and to the increase in the residence time of the water in the network [6; 25].

Fecal coliforms: Fecal coliforms belong to the subgroup of coliforms, which ferment lactose within 24 hours, the main representative of which is the bacterium Escherichia coli, of exclusively fecal origin. Escherichia coli is considered an indicator of recent fecal contamination and the possible presence of pathogenic micro-organisms [10, 23]. The fecal coliform values obtained during the five sampling campaigns in the southern zone varied from 0 to 100 CFU/100 mL with an average of 2.53 CFU/100 mL and from 0 to 50 CFU/100 mL in the northern zone, with an average of 0.59 CFU/100 mL. The analysis of the different curves (Figure ~~16~~17) shows that seven (07) water samples are contaminated and do not comply with the WHO guide value (0 CFU/100 mL) with a non-compliance rate of ~~7.78~~8.23%, whereas in the North zone, contamination is observed at only one sampling point with a non-compliance rate of 1.~~18~~11%. We note that the contamination is much more noticeable in the southern zone, which could be related to the problems of wastewater intrusion at the level of the piping and the increase in water residence time.

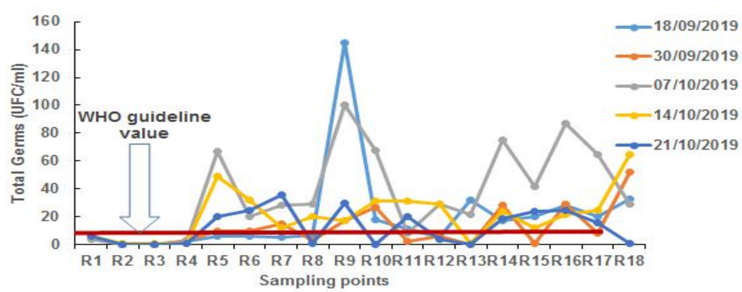


Figure 13: Temporal variation of total germs according to sampling points in the South zone

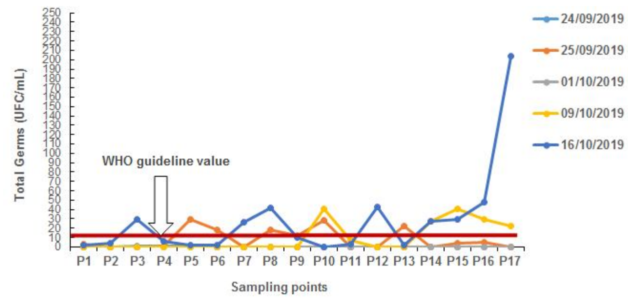


Figure 14: Variation of total germs according to points collection from the North zone

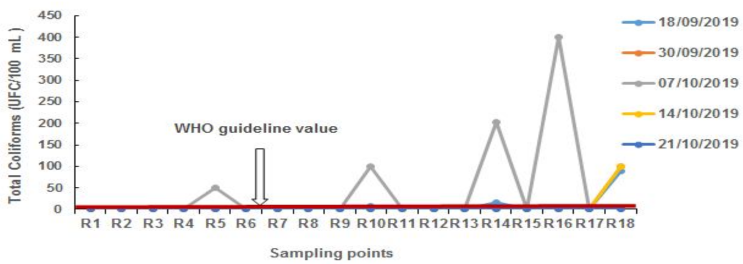


Figure 15: Temporal variation of total coliforms according to sampling points in the South zone

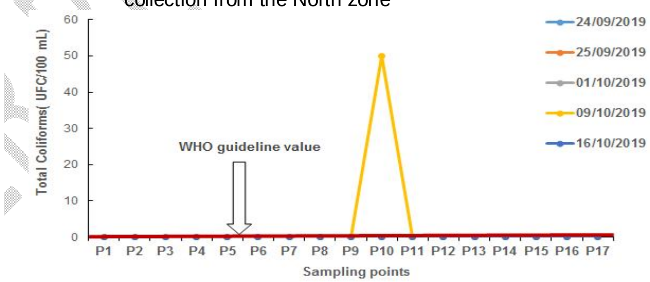
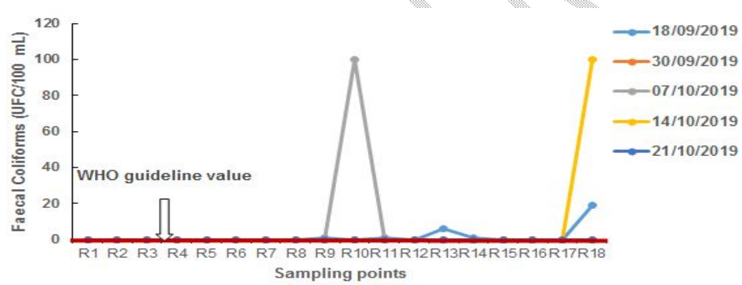


Figure 16: Variation of total coliforms according to points collection from the North zone



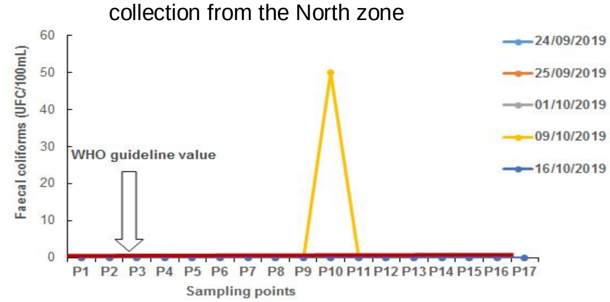


Figure 17: Variation of fecal coliforms according to points collection from the ~~North~~South zone

Figure 18: Variation of fecal coliforms according to points collection from the North zone

3.3. Multivariate statistical analyses of physicochemical and microbiological parameters

The correlation matrix, factorial analysis and hierarchical ascending classification were applied to the average of the five sampling campaigns carried out for each physicochemical and microbiological water quality parameter considered, i.e. eight (08) variables and 35 individuals.

3.3.1. Correlation matrix

Table 2 presents the multiple correlation matrix of physicochemical and microbiological parameters at the 5% threshold. It can be seen that temperature is negatively correlated with residual chlorine, which shows that these two parameters are antagonistic. Similarly, a negative correlation (r = -0.42) was observed between residual chlorine and turbidity, which reflects and confirms the absence of residual chlorine observed in the majority of water samples taken in the North and South zones of the city of Brazzaville. A positive (r = 0.45) and negative (r = -0.53) correlation was observed between total germs and turbidity and between total germs and residual chlorine, respectively. These results prove that an increase in turbidity in the drinking water distribution network could cause the contamination of water by microorganisms. Furthermore, a positive correlation (r = 0.45) is observed between turbidity and total coliforms. This confirms the presence of total coliforms when the turbidity level increases in the drinking water. Similarly, a negative correlation (r = -0.53) is observed between residual chlorine and total germs, which shows that there is a lack of residual chlorine in the drinking water, which leads to the proliferation of microorganisms, hence the presence of total germs. Then, another positive correlation (r = 0.48) is observed between total germs and total coliforms which certifies the presence of total germs in the water, which leads to the presence of total coliforms (TC) in this medium.

Finally, a positive correlation (r = 0.44) is observed between total coliforms and fecal coliforms. The latter could be explained by the fact that total coliforms is a group of enterobacteria that is used as an indicator of microbial quality that contains bacteria of fecal origin [26].

Table 2: Correlation matrix of physicochemical and microbiological parameters

Parameters	pH	T	CE	Turbidity	Residual Cl_2	GT	CT	CF
pH	1.00							
T	0.09	1.00						
CE	-0.26	-0.20	1.00					
Turbidity	-0.09	0.06	-0.12	1.00				
Residual Cl_2	-0.06	**-0.35**	0.20	**-0.42**	1.00			
GT	-0.04	0.15	-0.30	**0.45**	**-0.53**	1.00		
CT	0.17	0.14	-0.09	**0.45**	-0.29	**0.48**	1.00	
CF	0.23	0.16	-0.23	-0.05	-0.24	0.29	**0.44**	1.00

Significant correlation in **red** at $p < 0.05$

3.3.2. Factor analysis

Three factors (F1, F2 and F3) were extracted by Principal Component Analysis (PCA) according to the criteria described by Kaiser [27]. Factors F1, F2, and F3 represent respectively 33.88, 17.48 and 12.90%, or 64.26% of the total variance expressed (Table 3).

The analysis of Table 3 shows that the first main factor F1 is positively controlled by chlorine residual and negatively controlled by total germs (TG) and total coliforms (TC). This factor justifies the vulnerability of tap water to total germs, total coliforms and the lack of residual chlorine at the consumer's tap. This factor appears to be a factor in the pollution of tap water by microorganisms and reflects the lack of hygiene and monitoring of drinking water distribution facilities by La Congolaise des Eaux (LCDE), but also the lack of sanitation in the city of Brazzaville [7]. The second factor (F2) negatively controls the hydrogen potential (pH) and explains the importance of this parameter in water treatment. It should be noted that the majority of tap water samples taken show pH values that are at the lower limit of the WHO guide value (6.5). This shows the acidity of these waters which would be linked to the presence of organic matter in the water distribution network. The F3 factor is moderately negatively controlled by temperature and suggests the importance of this parameter in the majority of chemical reactions that take place in water.

Table 3: Factor weights of physico-chemical and microbiological variables

Parameters \ Factors	F1	F2	F3
pH	-0.209176	**-0.714929**	0.144408
T	-0.407706	-0.224900	**-0.667766**
CE	0.455220	0.415247	0.301787
Turbidity	-0.593404	0.575325	0.046174
Cl2 residual	**0.730099**	-0.169551	0.310137
GT	**-0.783406**	0.247005	0.042815
CT	**-0.715599**	0.045784	0.490809
CF	-0.531207	-0.491690	0.364627
Eigenvalues	2.710364	1.398746	1.031838
Percentage of variance	33.88	17.48	12.90
Percentage of cumulative variance	33.88	51.36	64.26

3.3.3. Hierarchical ascending classification (HAC) of descriptors

The bottom-up hierarchical analysis shows five (05) distinct classes (C1, C2, C3, C4 and C5) (Figure 1819). The first class includes the sampling points R14, R16 and R18 in the southern zone, which are moderately contaminated by total germs (TG) and total coliforms (TC) with pH values within the range of the WHO guide values (6.5-8.5). This class confirms the polluted character of these waters by GT and TC bacteria which are caused by the pronounced absence of residual chlorine in the network. Class C2 includes two sampling points (R9 and P17) in the southern and northern zones with turbidity values below 5 NTU, with significant contamination by GT bacteria and a total absence of residual chlorine. The third class (C3) largely indicates turbidity that exceeds the WHO guide value (5 NTU) and a moderately high level of total germs. Class C4 represents sampling points R2, R3, R4 in the southern zone and P1, P2, P4, P6, P7, P9, P11, P13 in the northern zone. This class could be assumed to be good quality water with turbidity values below 4 NTU, low presence of GT and absence of CT and CF. The last class (C5) gathers waters with a low contamination of total germs (GT) with a turbidity relatively higher than the WHO guide value in most cases.

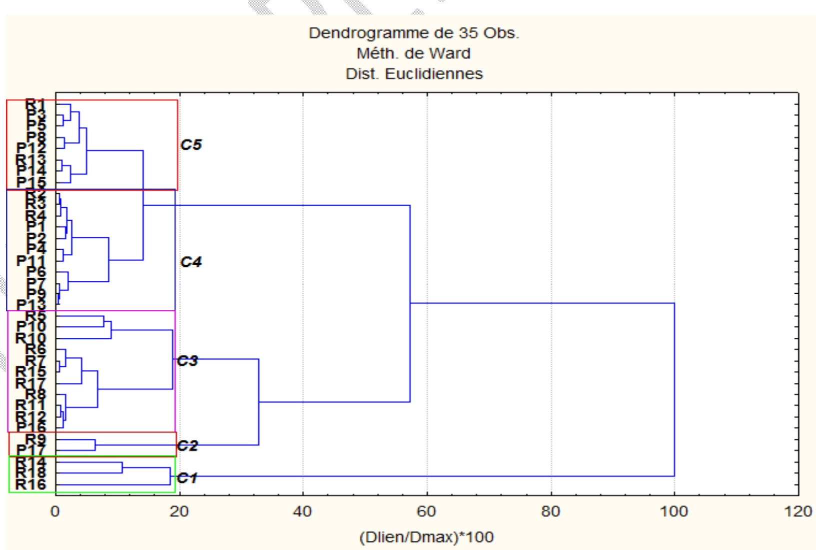


Figure 19: Classification dendrogramdendrogramme of tap water sampling points

4~~.Conclusion~~ CONCLUSIONS

This study allows the evaluation of the physicochemical and microbiological quality of the water produced and distributed in the South and North zones of Brazzaville. The results of physicochemical analyses of 175 water samples in the two zones showed that the average values for temperature and turbidity are higher than the standards set by the WHO. When comparing temperature to the WHO guide value (25°C), the majority of samples were non-compliant during the five sampling campaigns, with a non-compliance rate of 92.22 and 95.29% in the southern and northern zones respectively. Turbidity non-compliance rates of 55.56 and 16.47% were obtained in the southern and northern zones of Brazzaville. These waters are slightly acidic with very low mineralization, and residual chlorine levels are very low compared to the WHO standard (0.~~5~~2-1) mg/L. This decrease is more marked in the southern zone than in the northern zone.

The factorial analysis carried out justifies the vulnerability of tap water to total germs, total coliforms and the lack of residual chlorine at the consumer's tap and reflects the lack of hygiene and monitoring of drinking water distribution facilities by La Congolaise des Eaux (LCDE), as well as the lack of sanitation in the city of Brazzaville. The contamination of samples with various bacteria is more marked in the southern zone than in the northern zone, which shows the precariousness of the installations in the southern zone and the dilapidated condition of the LCDE pipes in both zones. Thus, the bacterial proliferation observed constitutes a potential danger for the health of the population that uses them as drinking water and could cause waterborne diseases. The water produced and distributed by Congolaise des Eaux poses a serious public health problem and additional treatment of the water at home is necessary before any consumption.

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