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Characterizing boreholes and wells water quality in Ferkessédougou, Côte d'Ivoire

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ABSTRACT
Objectives: A good knowledge of water quality can guide policy makers for improved access to drinking water in a context of galloping demography and rapid urbanization. The aim of this study was to characterize the physico-chemical parameters of drinking water from boreholes and wells in Ferkessédougou, Côte d'Ivoire.
Methodology and Results: Wells and boreholes were chosen based on their location and relative importance. Water was collected during the rainy season from 7 wells and 3 boreholes and analysed. Physical parameters (pH, conductivity, turbidity, STD) were measured in situ using multi-parameter probes. Chemical parameters (NO_3^-, NO_2^-, NH_4^+, PO_4^3, Fe^{2+}, Absorbance at 410 nm, Na^+, Ca^{2+}, Mg^{2+}, K^+, SO_3^{2-}) were analysed using a molecular absorption spectrophotometer. Overall, the results indicated that boreholes and wells water were acidic (average pH < 7) and slightly mineralized (EC < 500 µS/cm). Moreover, water from wells and boreholes were not statistically different based on their quality.
Conclusions and application of finding: Concentration values for cations (NH_4^+, Fe^{2+}, Mg^{2+}, Ca^{2+}, Na+ and K^+) and anions (NO_3^-, NO_2^- and PO_4^{3-}) in wells and boreholes water in this study area complied with the WHO guidelines. It is deduced that the quality of groundwater in Ferkessédougou is acceptable based on its physico-chemical characteristics, although nitrates concentrations in the two drinking water sources remain at critical levels for the population health. Such results can serve as a basis for improved control of boreholes and wells water quality in Ferkessédougou. They can also help define better policies and strategies of access to drinking water in urban areas in Côte d'Ivoire.
Keywords: Water quality; Drinking water; Groundwater; Water resources.

INTRODUCTION

Water is vital for all life and essential to sustaining human wellbeing and livelihood. Access to safe water and sanitation is also critical to the success of several socio-economic activities at various levels (from a micro to a macro level) in a country (Mabrouki *et al.*, 2016). The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) estimated that 1.2 billion people still were lacking basic drinking water services in 2020, including 367 million using unimproved water sources (unprotected dug well or spring) and 122 million drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal (WHO and UNICEF, 2021). In the majority of sub-Sahara African countries, it was estimated that less than 50% of the population were using safely managed drinking water services in 2020 (WHO and UNICEF, 2021). Such lack of access to safe drinking water and sanitation results in public health emergencies, with children under five years old paying heavy prices: at least 88% of diarrhea cases causing death in this category of the population were attributed to poor sanitation (WHO, 2020).

In Côte d'Ivoire, access to safe drinking water remains challenging despite the ongoing efforts from Governmental agencies, Non-Governmental Organizations and other international institutions and organizations. In the north of Côte d'Ivoire, more precisely in Ferkessédougou, the arid climate exposes populations to drinking water supply problems. Also, the daily difficulties encountered by housewife in this locality in obtaining drinking water constitute a permanent concern in peri-urban and semi-rural areas. The application of the solutions proposed by this study could help achieve targets 1 and 2 of Sustainable Development Goals 6 in Ferkessédougou.Thus, populations in rural areas, and even in urban areas, most often rely on boreholes and wells to meet their drinking water needs, with in most cases no prior knowledge of the water quality from these sources. Studies dealing with water resources in various regions of Côte d'Ivoire (e.g., Ahoussi *et al.*, 2013; Eblin *et al.*, 2014) revealed numerous sources of pollution for both surface and ground waters, which could impact negatively on the physical, chemical and microbiological quality of water. There have been other studies dealing specifically with the quality of water from boreholes and wells in the city of Abidjan and surroundings (e.g., Savane *et al.*, 2005; Yapo *et al.*, 2010). The authors reported that the waters of some sampled wells are of poor quality and do not meet the drinking water quality standards. These are linked to different endogenous factors such as sewage infiltration, contamination by waste water from pits, the intrusion of lagoon water, leachate from deposits of household waste and rejections industrial. The surface layers, accessible by wells are contaminated with organic matter of human origin, and animal. In this study, specifically the physical and chemical parameters, the chemical facies and the relationships between physico-chemical parameters of boreholes and wells water were determinated in the city of Ferkessédougou, northern Côte d'Ivoire.

MATERIALS AND METHODS

Study area and selection of boreholes and wells. The study was carried out in Ferkessédougou, the administrative capital of the Tchologo region in Côte d'Ivoire (Figure 1). The city consists of 15 districts with a population estimated at 160 267 inhabitants (RGPH, 2021). Several criteria include the location, water use (human or non-human), water treatment before consumption (e.g., disinfection using hypochlorite), water static level, and the protection system of the well or borehole were considered. Out of 30 wells identified, seven wells located in Residential, Pargnonkaha, Zindel, Customs, Mossibougou, Kafalovogo and N'bagnan were retained. Only 3 boreholes in Fangakaha, Tiebigué and Douane were identified (Figure 2).

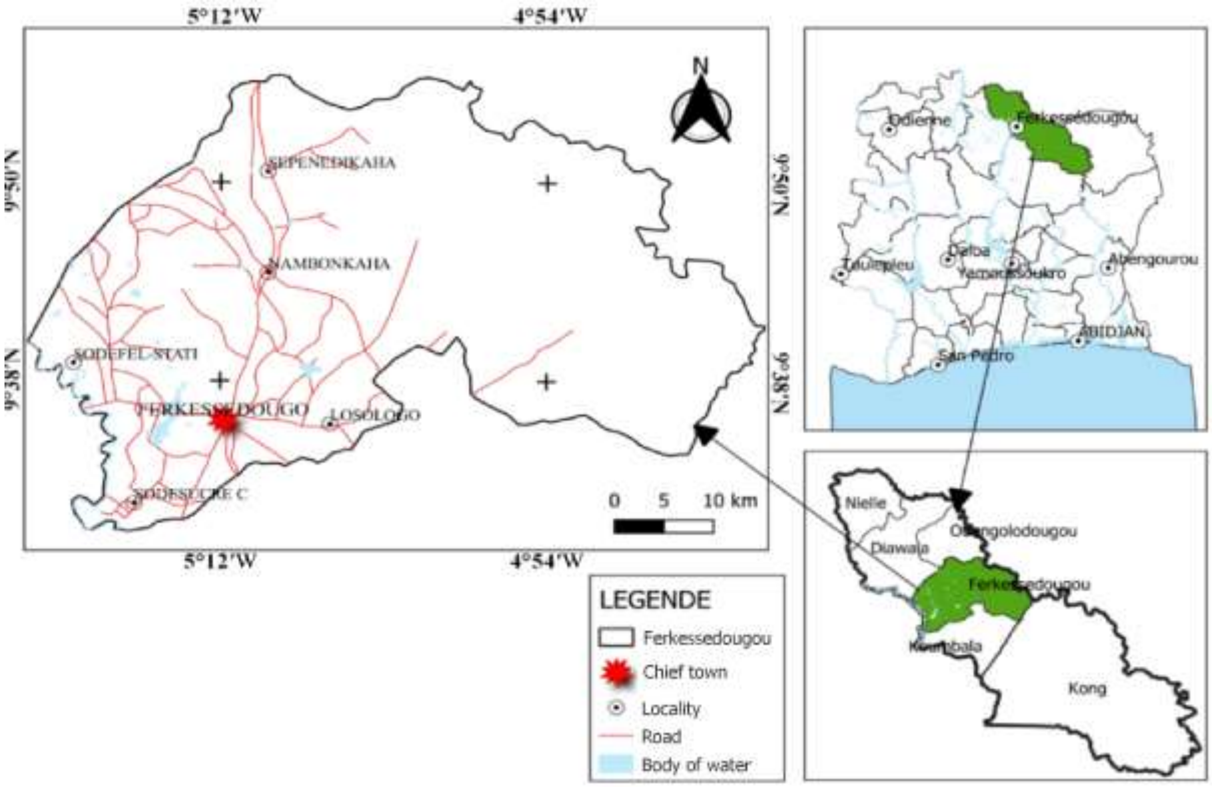

Figure 1: Map of the study area (Ferkessédougou, Côte d'Ivoire)

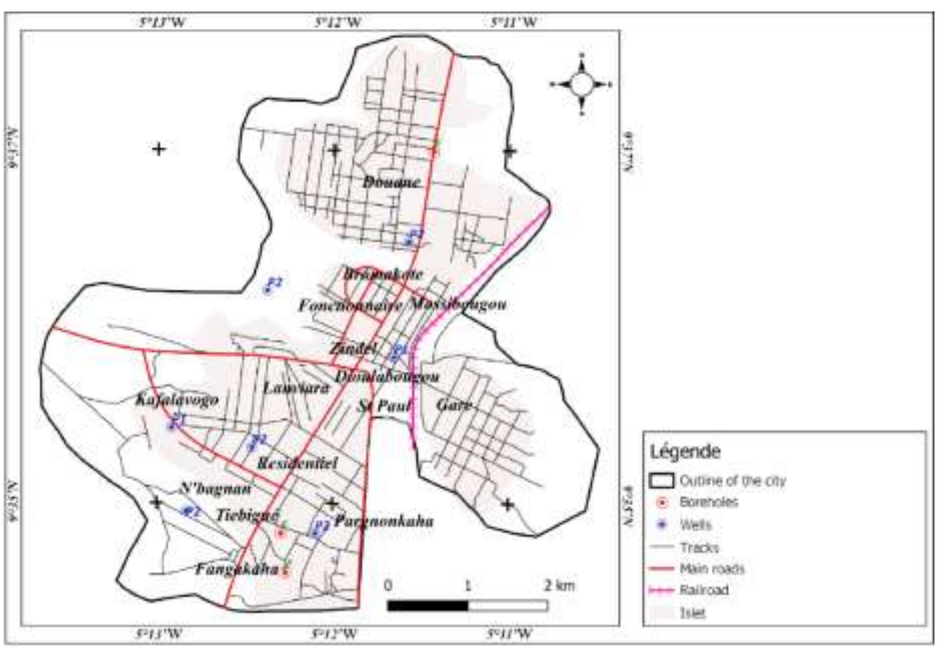

Figure 2: Locations of the sampling wells and boreholes in Ferkessédougou

Water sampling and quality analysis. Water samplings were carried out in August 2021 during the rainy season. Each 1-litre capacity bottle was rinsed three times with the sampled water before being filled and hermetically sealed. The bottles were then transported to the laboratory in coolers containing cold packs at 4 °C. Water static levels for the each of the surveyed boreholes and wells were measured using a piezometric probe. Various physical and chemical parameters were analysed for each of the sampled waters. Measurements pH, electrical conductivity (EC), turbidity, and Total Dissolved Solids (TDS) were carried out in situ. The pH was measured using a glass electrode (electrometric method). After calibrating the Consort C 380 brand pH-meter, the pH value was taken upon stabilization of the reading index. The electrical conductivity and TDS were measured using a HACH (mode) 44600 conductivity meter. Turbidity was measured using a HACH 2100 P turbidimeter in Nephelometric Turbidity Unit (NTU). In laboratory, the different chemical parameters quantified were NO_3^-, NO_2^-, NH_4^+, PO_4^3, Fe^{2+}, Absorbance at 410 nm, Na^+, Ca^{2+}, Mg^{2+}, K^+, SO_3^{2-}. Their values were determined following the designated methods (Table 1).

Table 1: Methods used for analysing ions in sampled borehole and well waters

Parameters	**Method**
Magnesium (Mg^{2+}) and calcium (Ca^{2+})	Titrimetry
Potassium (K^+) and sodium (Na^+)	Flame Atomic Absorption Spectrometry (PHF 90D)
Nitrate (NO_3^-), Nitrite (NO_2^-), Sulfate (SO_3^{2-}), orthophosphate (PO_4^{3-}), ammonium (NH_4^+), and iron (Fe^{2+})	Molecular absorption spectrometry HACH DR 2010.

Physico-chemical characterization of water. The chemical facies of each of the sampled boreholes and wells water were assessed through the Piper diagram. The Piper diagram was produced using the software Diagrams 2.0 (Eblin *et al.*, 2014). Moreover, following similar approach applied in previous studies (e.g. Akatumbila *et al.*; 2016; Orou *et al.*, 2016b), a principal component analysis (PCA) was performed to characterize the correlations between the measured physico-chemical parameters of sampled boreholes and wells water at the study sites. The PCA makes it possible to synthesize and classify large amount of data in order to extract the main factors driving the simultaneous evolution of variables and their reciprocal relationships. The PCA was carried out using Rstudio Desktop.

RESULTS

Static water levels. Water levels in wells during the rainy season at the study sites were relatively close to the surface, with depths ranging from 0.5 to 7.0 m.

Water physico-chemical characteristics measured in situ. Results showed that boreholes water were relatively more acidic than wells water, with average pH values being 5.15 ± 0.26 and 6.08 ± 0.50, respectively (Table 2). EC in wells water were the highest and ranged between 71.2 µS/cm and 1174 µS/cm (average value = 504.73 ± 358.72 µS/cm). Those for boreholes water ranged between 71.2 µS/cm and 362 µS/cm (average value = 206.43 ± 107.95 µS/cm) (Table 2). With the WHO threshold value for EC being 500 µS/cm, these results indicate that EC values were well above standard for some wells at the study sites, unlike boreholes water which were acceptable with respect to EC. Likewise, the water turbidity values in some wells were more than six times the WHO threshold value of 5 NTU; the maximum value measured was 42 NTU and the average for the seven wells was 11.26 ± 11.45 NTU (Table 2). Water turbidity in boreholes was acceptable according to the WHO standards, with values ranging from 1.55 to 4.29 NTU. Differences were also found for total dissolved solids (TDS) values between boreholes and wells. The respective ranges of TDS values were 47 to 232 mg/L and 47 and 750 mg/L, with corresponding averages being 133 ± 63.33 mg/L and 323.71 ± 229.30 mg/L, respectively (Table 2). Values for TDS for both water sources complied with the WHO standards (1000 mg/L).

Table 2: Physico-chemical characteristics of boreholes and wells water measured in situ.

Water source		**pH**	**EC (µS/cm)**	**TDS (mg/L)**	**Turbidity (NTU)**
Borehole	Average	5.15	206.43	133	2.74
	Minimum	5.66	71.2	47	1.55
	Maximum	6.1	388	232	4.29
	Standard deviation	0.268	107.955	63.33	7.411
Well	Average	6.08	504.73	323.71	11.26
	Minimum	5.15	71.2	47	0.68
	Maximum	6.9	1174	750	42
	Standard deviation	0.502	358.726	229.306	11.557

Water physico-chemical characteristics measured in laboratory. There was no difference between nitrites (NO_2^-) and ammonium (NH_4^+) concentrations in each of the drinking water sources at the study area. Average concentrations values were 0.08 ± 0.07 mg/L and 0.01 ± 0.004 mg/L in wells water and boreholes water, respectively (Table 3). These values were below the WHO threshold values (3.00 mg/L and 0.50 mg/L for nitrites and ammonium, respectively). Different ranges of concentrations were found for the remainders of the water quality parameters assessed (NO_3^-, PO_4^3, Fe^{2+}, Na^+, Ca^{2+}, Mg^{2+}, K^+, SO_3^{2-}, Absorbance at 410 nm). The average concentrations of NO_3^-, Na^+, Ca^{2+}, Mg^{2+}, and K^+ in wells water were lower than those in boreholes water (Table 3). For both water sources, the values found were within WHO standards for the thresholds provided by WHO are 50 mg/L for NO_3^-, 50 mg/L for Mg^{2+}, 300 mg/L for Ca^{2+}, 200 mg/L for Na^+ and 12 mg/L for K^+. In wells water, the average concentrations of Fe^{2+} (0.20 ± 0.04 mg/L) and PO_4^3 (1.44 ± 1.86 mg/L) were lower than those found in boreholes water, (0.48 ± 0.62 mg/L and 1.45 ± 0.6 mg/L, respectively) (Table 3). Compared to the WHO threshold value (0.3 mg/L), wells water were acceptable with respect to iron content (boreholes water were not). However, drinking water from both sources had their concentrations in ortho-phosphate higher than the WHO threshold value (0.2 mg/L). There was no WHO standard for the absorbance at 410 nm. Values found for this parameter were 0.15 ± 0.13 mg/L and 0.02 ± 0.02 mg/L on average for wells water and boreholes water, respectively (Table 3).

Table 3: Physico-chemical characteristics of boreholes and wells water measured in laboratory.

	Wells			**Boreholes**		
Parameters (mg/l)	Min	Max	Mean ± ± standard deviation	Min	Max	Mean ± standard deviation
NO_3^-	0.90	42.60	20.3 ± 11.45	1.70	6.10	3.73 ± 1.57
NO_2^-	0.02	0.34	0.08 ± 0.07	0.00	0.01	0.013 ± 0.005
NH_4^+	0.02	0.34	0.08 ± 0.07	0.01	0.02	0.01 ± 0.004
PO_4^{3-}	0.01	6.40	1.44 ± 1.86	0.76	2.48	1.45 ± 0.68
Fe^{2+}	0.13	0.27	0.20 ± 0.04	0.01	1.43	0.48 ± 0.62
Abs	0.02	0.40	0.15 ± 0.13	0.00	0.061	0.020 ± 0.020
Mg^{2+}	2.12	7.85	4.02 ± 1.47	3.10	9.02	5.77 ± 2.16
Ca^{2+}	16.2	109	31.31 ± 22. 22	16.80	82.3	45.43 ± 24. 57
Na^+	5.12	22.3	11.08 ± 5.90	5.30	16.2	12.36 ± 4.71
K^+	2.16	6.34	3.56 ± 1.10	3.20	7.56	5.32 ± 1.48

Chemical facies of wells and boreholes water: Figure 3 shows the chemical facies of wells and boreholes water. The drinking water from wells and boreholes in Ferkessédougou had identical chemical facies given only one group of facies was found through the Piper diagram. Their chemical facies were magnesium sulphate chloride.

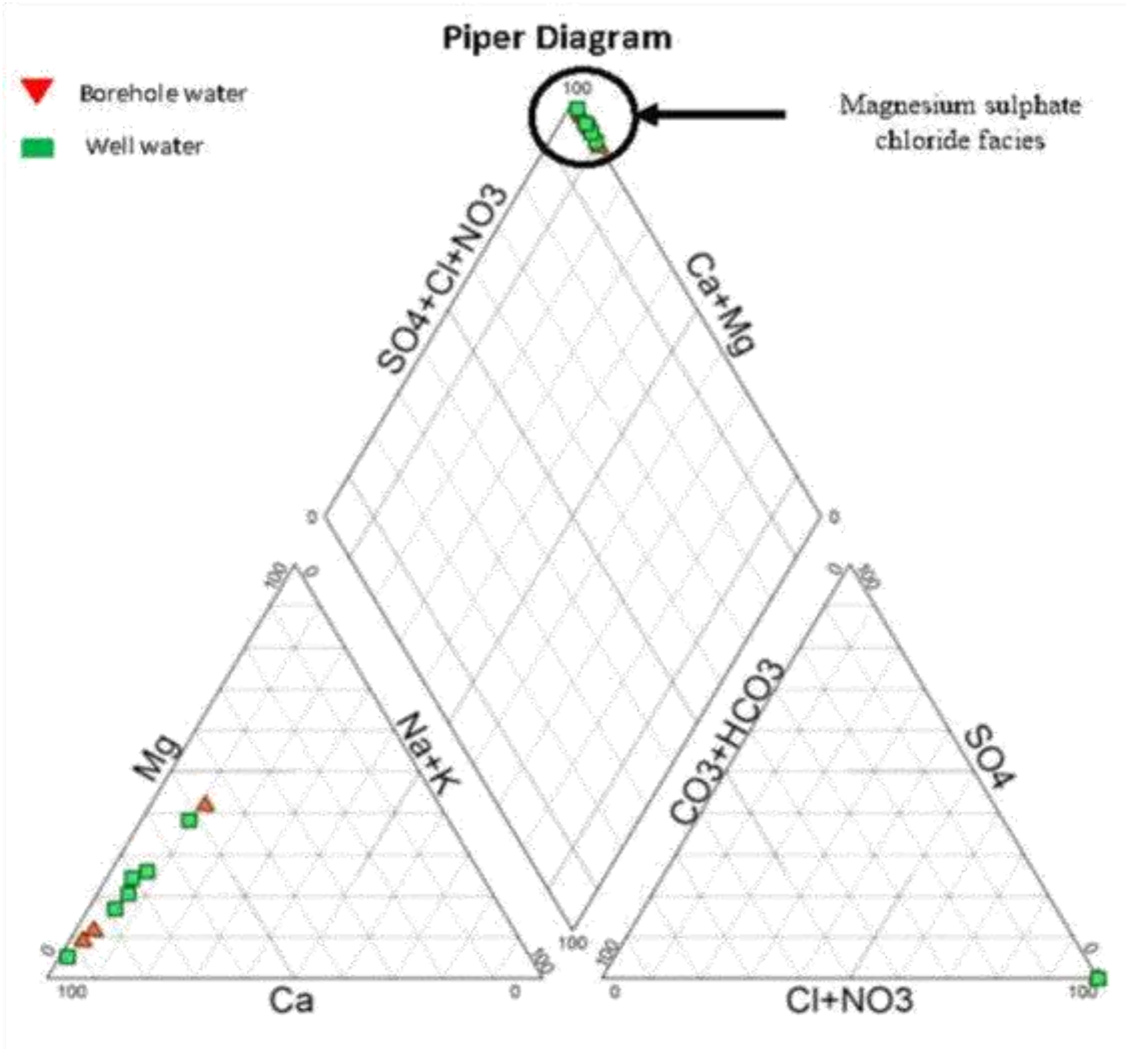

Figure 3: Chemical facies of drinking water from boreholes and wells during the rainy season at the study area.

Relationships between physico-chemical parameters. The analyses of correlations between all the physico-chemical parameters assessed in this study matrix indicated that in borehole waters sodium was strongly correlated to pH (0.80) and calcium (0.70); it was moderately correlated to electrical conductivity (0.60), iron (0.50), turbidity (0.50) and absorbance at 410 nm (0.50) (Table 4). Ammonium was strongly correlated to nitrate (0.80), magnesium (0.80), potassium (0.80), orthophosphate (0.70). Total dissolved solids were strongly correlated to electrical conductivity (0.90). Turbidity was strongly correlated to iron (0.90) and absorbance at 410 nm (0.90). In well waters, strong correlations (≥ 0.70) were found between ammonium and nitrite, ammonium and iron, magnesium and potassium, calcium and sodium, calcium and absorbance, TDS and electrical conductivity, TDS and magnesium, and TDS and potassium (Table 5). Moderate correlations (0.50-0.69) were found between pH and total dissolved solids, electrical conductivity, orthophosphate, between nitrite and nitrate, nitrite and iron, and calcium and orthophosphate.

Table 4: Correlation matrix of the physico-chemical parameters measured in borehole waters. Values in bold font are statistically significant ($p < 0.05$).

	Mg	Ca^{2+}	Na^{+}	K^{+}	pH	CE	TDS	Turbidity	NO_3^{-}	NO_2^{-}	NH_4^{+}	PO_4^{3-}	Fe^{2+}	Abs
Mg^{2+}	1.00													
Ca^{2+}	-0.00	1.00												
Na^{+}	-1.00	**0.70**	1.00											
K^{+}	1.00	-0.00	-1.00	1.00										
pH	-1.00	0.10	**0.80**	-1	1.00									
CE	-1.00	-0.00	**0.60**	-0.90	1.00	1.00								
TDS	-1.00	-0.00	**0.60**	-0.90	1.00	**0.99**	1.00							
Turbidity	-0.00	1.00	**0.50**	-0.10	-0.20	-0.46	-0.46	1.00						
NO_3^{-}	1.00	-0.00	-1.00	1.00	-0.90	-0.80	-0.81	-0.14	1.00					
NO_2^{-}	0.20	-1.00	-1.00	0.10	0.10	0.41	0.41	-0.99	0.20	1.00				
NH_4+	**0.80**	0.20	-1.00	**0.80**	-0.90	-0.99	-0.99	0.48	**0.80**	-0.43	1.00			
PO_4^{3-}	1.00	-1.00	-1.00	1.00	-0.90	-0.67	-0.68	-0.33	1.00	0.38	**0.70**	1.00		
Fe	-0.00	1.00	**0.50**	-0.00	-0.20	-0.48	-0.47	**0.99**	-0.00	-0.99	**0.50**	-0.31	1.00	
Abs	-0.00	1.00	**0.50**	-0.10	-0.20	-0.44	-0.43	**0.99**	-0.00	-0.99	**0.50**	-0.35	**0.99**	1.00

Table 5: Correlation matrix of the physico-chemical parameters measured in well waters. Values in bold font are statistically significant ($p < 0.05$).

	Mg	Ca	Na	K	pH	CE	TDS	Turbidity	NO3¯	NO2¯	NH4+	PO43¯	Fe	Abs
Mg	1.00													
Ca	-0.036	1.00												
Na	0.07	**0.74**	1.00											
K	**0.94**	0.17	0.1	1.00										
Ph	-0.47	-0.22	0.12	-0.55	1.00									
CE	0.10	-0.37	0.27	-0.08	**0.68**	1.00								
TDS	0.10	-0.37	0.27	-0.08	**0.68**	**0.99**	1.00							
Turbidity	-0.40	-0.20	-0.14	-0.52	-0.2	-0.09	-0.09	1.00						
NO3¯	-0.05	-0.45	-0.35	-0.08	-0.3	0.03	0.03	0.18	1.00					
NO2¯	-0.21	-0.12	-0.05	-0.24	0.04	-0.06	-0.06	-0.20	**0.61**	1.00				
NH4+	-0.36	-0.23	-0.31	-0.35	0.19	-0.16	-0.16	-0.30	0.47	**0.91**	1.00			
PO43¯	-0.33	**0.51**	0.41	-0.13	**0.55**	0.11	0.11	-0.60	-0.41	0.04	0.18	1.00		
Fe	-0.67	-0.34	-0.50	-0.68	0.42	-0.20	-0.20	0.00	0.10	**0.53**	**0.78**	0.18	1.00	
Abs	-0.70	-0.10	-0.23	-0.76	0.11	-0.24	-0.24	**0.82**	-0.15	-0.22	-0.10	-0.25	0.40	1.00

Results of the PCA are presented in Tables 6 and 7. For borehole waters, two factors explained 100% of the variance: F1 (57.11%) and F2 (42.88%) (Table 6). For well waters about 71.34% of the variation was explained by the first three F1 (29.73%), F2 (22.20%) and F3 (19.40%) (Table 7).

Table 6: PCA summary - Importance of components for the physico-chemical parameters of borehole waters.

	F1	F2
Eigenvalues	7.99	6.00
Proportion of variance (%)	57.11	42.88
Cumulative proportion (%)	57.11	100.00

Table 7: PCA summary - Importance of components for the physico-chemical parameters of well waters.

	F1	F2	F3	F4	F5	F6
Eigenvalues	4.163	3.108	2.716	2.477	1.171	0.362
Proportion of variance (%)	29.73	22.20	19.40	10.58	17.69	8.36
Cumulative proportion (%)	29.73	51.93	71.34	89.04	97.40	100.00

Biplot of the first two axes F1-F2 of the principal component analysis summarizing the relationships between the different physico-chemical parameters measured in borehole waters in Ferkessédougou are presented in Figure 4. Biplot of the axes F1-F2 and F1-F3 of the principal component analysis summarizing the relationships between the different physico-chemical parameters measured in well waters in Ferkessédougou are presented in Figure 5.

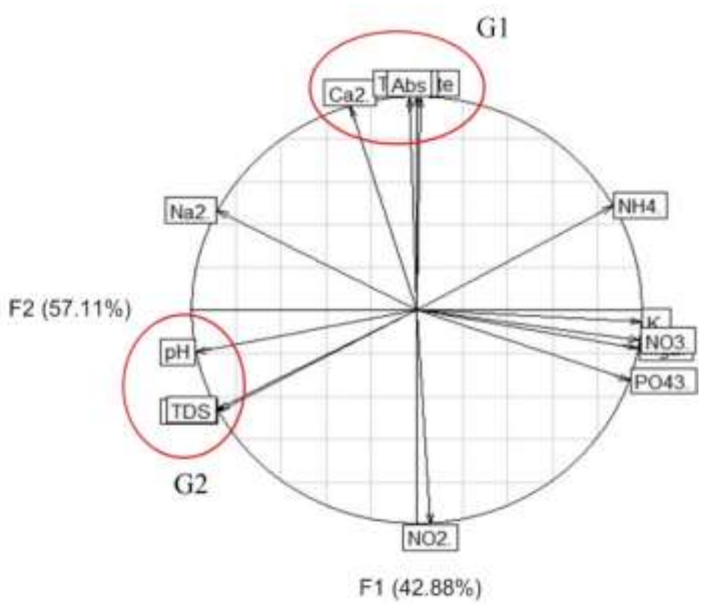

Figure 4: Biplot of the first two axes of the principal component analysis summarizing the relationships between the different physico-chemical parameters measured in boreholes water in Ferkessédougou.

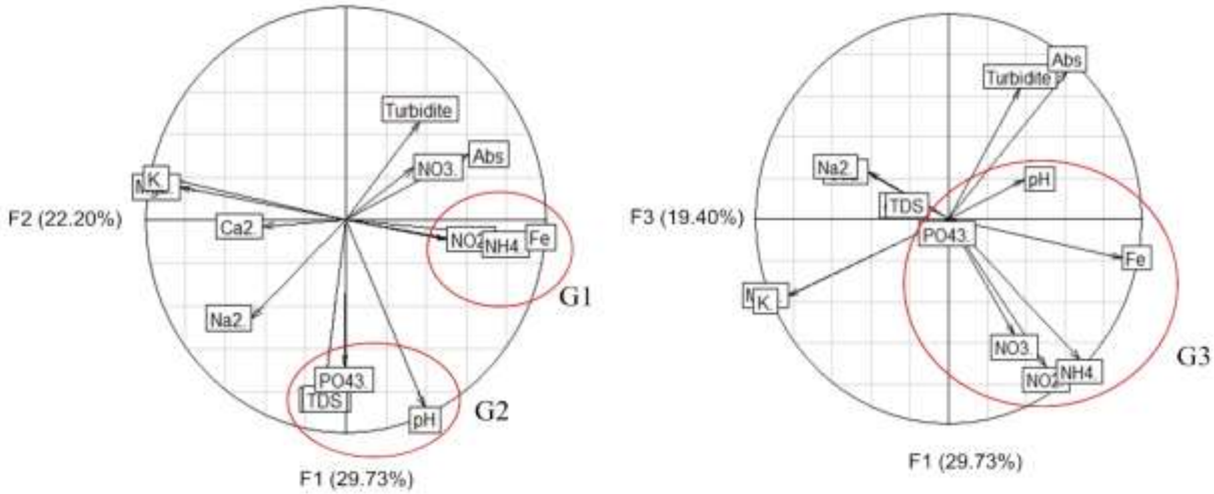

Figure 5: Biplot of the axes F1-F2 (left) and F1-F3 (right) of the principal component analysis summarizing the relationships between the different physico-chemical parameters measured in wells water in Ferkessédougou.

DISCUSSION

Boreholes and wells used for drinking water in Ferkessédougou were surveyed during the rainy season to evaluate their water quality. Physico-chemical characteristics of these water were quantified and compared to corresponding WHO thresholds. Results of the physico-chemical parameters measured in situ indicated that the groundwater in Ferkessédougou was acidic, therefore corrosive. Such groundwater acidity levels were in line with the levels found in other regions in Côte d'Ivoire (Savané, 2001). According to Biemi (1992), pH is one of the characteristic elements of groundwater in Côte d'Ivoire. This acidity comes mainly from the decomposition of plant organic matter, characterized by CO_2 production in the first soil layers (Ahoussi *et al.*, 2010). The hydration of CO_2 produces carbonic acid (H_2CO_3) which ionization results in production of H^+ ions. Our results met also those of Fatoumata *et al.*, (2023), who conducted a similar study on certain wells and boreholes in Bamako, with pH values between 4.45 to 7.48 for the borehole waters and 4.45 to 7.14 for the well waters. This acidity is due to the siliceous and lateritic terrain of Bamako. For these authors, water with a pH of 7.2 to 7.8 is ideal for maintaining good health. Consuming liquids that are too acidic or too basic can upset this delicate balance, and lead to the development and growth of bacteria, viruses, fungi, yeasts and parasites.Water from boreholes and wells at the study area were mineralized (low electrical conductivities found), with boreholes water highly mineralized than wells water. The high mineralization of boreholes water implies that they are more conductive than wells water. These results are consistent with Poulichet *et al.* (2002), and Orou *et al.* (2016), who argued that the typical acidic character of groundwaters mineralization fault can be explained by the conjunction of two factors: the nature of the surrounding rock, namely when it mostly consists of SiO_2 (> 60%), and the contact time between water and minerals. Similar mineralization property of groundwater was reported in studies carried out in other Ivorian cities, e.g., Agboville (Goné *et al.*, 2005; Orou *et al.*, 2016), Daloa (Ligban *et al.*, 2010), Tiassalé (Oga *et al.*, 2009), and Tortiya (Soro, 2014). These results are also in line with those of Tchoumou *et al.*, 2023, who worked on the physicochemical characterization of water from wells, boreholes and springs consumed in the Massissia District in Brazzaville, Republic of the Congo. The high conductivities obtained during their study may be linked to anthropogenic activities which are diversified and intensified in the study area, and cause water mineralization by surface inputs.

Turbidity is the material in water that affects the transparency or light-scattering capacity of the water. It is the reflection of the total suspended solids or particles contained in water (Oladipo *et al.*, 2023). Turbidity and absorbance were positively related: the greater the water turbidity, the greater its absorbance value. Boreholes and wells water turbidities are influenced by various factors including suspended particles (e.g., clay, silt), chemical precipitates (e.g., manganese, ferrous irons oxidation, etc.), organic particles (e.g., plant residues), and the well or borehole static water level and subsequent anthropogenic pollution (WHO, 2020). The characteristic colour and cloudy appearance of the sampled water during the study period can be related to ferrous iron oxidation of (Fe^{2+} into Fe^{3+}) under the action of air (Rodier, 1996), and the presence of organic and inorganic particles. Boreholes water are generally well protected from anthropogenic pollution, unlike wells water given their static levels. Shallow or poorly constructed wells readily are contaminated by surface runoffs, namely after heavy rain events (Health Canada, 2011). Anthropogenic pollution of wells with low static water levels during the rainy season were also reported by Onodera *et al.* (2008) in their study in Bangkok and Jakarta, and Degbey *et al.* (2008) in Benin, thus corroborating these results. According to Nebbache *et al.* (2001), it is likely that wastewater infiltrate the soil and reach the water table without effective filtration process. The spatial distribution of wells across Ferkessédougou (relatively close to each other; Figure 2) suggests that they would be under the influence of the same anthropogenic activities responsible for the presence of nitrates and orthophosphate. Abbou *et al.* (2014) and Heriarivony *et al.* (2016) in their works in Morocco and Madagascar, respectively, denoted that the high levels of nitrates and presence of orthophosphate in groundwater was related to recent chemical pollution of anthropogenic origin. Nitrates typically come from fertilizers, faecal or animal matters, and detergents or cleaning products (Olivier, 2005). Although the nitrate concentrations found in this study were within the WHO standards, they remain critical for health since they can cause methemoglobinemia in children and carcinogenic diseases in adults (Unter, 2003); Cidu *et al.*, 2009). According to Unter (2003), nitrate concentrations ≥ 10 mg/L can cause health issues in children. For Sunita *et al.*, (2023), Fatoumata *et al.*, (2023), the best alternative to reduce water insecurity is to regularly monitored and properly treated groundwater before usage. Boreholes and wells water had both a calcium-magnesian sulphate chloride facies, highlighting the hydrogen carbonate facies on waters found in other regions in the country (e.g., in Tiassalé (Oga *et al.*, 2009) and Man (Goné *et al.*, 2005) regions). Boreholes and wells water qualities are undoubtedly linked to the importance of the clayey-sandy superficial soil layer, which acts as good water filtering soil layer. This layer might have reduced pollutants concentrations and slow the progression of pollution plume towards deep soil layers where complex biochemical reactions take place, as well as reducing (Brun *et al.*, 2001).

CONCLUSION AND APPLICATION OF RESULTS

The water quality of boreholes and wells used for drinking purpose during the raining season were assessed in Ferkessédougou, northern Côte d'Ivoire. Overall, results indicated that boreholes and wells water were acidic and mineralized and had both a calcium-magnesian sulphate chloride facies. Although there were differences between their ranges of physico-chemical parameters values measured in situ, further analyses in laboratory showed that water from boreholes and wells at the study sites were similar in terms of quality. Moreover, comparisons against the WHO standards indicated that the chemical property of drinking water from boreholes and wells was acceptable, unlike their physical properties which varied depending on the parameter considered. With low static water levels, wells are highly exposed to anthropogenic pollution, compared to boreholes. Such results can serve as a basis to better manage the potential pollution sources (i.e., agriculture). The study can help to improve the control of boreholes and wells water quality in Ferkessédougou and help define better policies and strategies of access to drinking water in urban areas across the country.

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