Journal of Applied Biosciences 213: 22600 – 22611
ISSN 1997-5902

Hydrochemical characterisation of groundwater in Massakory Area, Chad.

MBAGUEDJE Diondoh[1]* and NGAMBI Victor HINGUE[2]
[1]Department of Geology, Adam Barka University, Abeche/Chad
[2]Laboratory of Geology, Geomorphology and Remote Sensing, University of N'djamena/Chad
*****Corresponding author email: sandrinediondoh@gmail.com

Submitted 05/08/2025, Published online on 31/10/2025 in the https://www.m.elewa.org/Journals/journal-of-applied-biosciences https://doi.org/10.35759/JABs.213.5

ABSTRACT
Objective: The objective of this work is to characterize the physicochemical quality of Massakory groundwater for domestic use.
Methodology and results: The study involved 14 boreholes, a rainfall sample and a well for drinking and irrigation purposes located in the study area. The results obtained show that the electrical conductivity (EC) values in our borehole water range from 1171 to 2590 µS/cm and 2650.0 µS/cm in the well water; the pH values of our water are basic (between 8.1 and 8.9). These pH values comply with international standards for drinking water. The water in the study area has two chemical facies: the calcic and magnesian bicarbonate facies (F1, F3, F5, F7, F8, F9, F10, F11, F12, F13, F14, rain, and wells), and the calcic and magnesian sulphate chloride facies (F2, F4, F10). As far as cations are concerned, the water is calcic, whereas as far as anions are concerned, the water tends to evolve from the bicarbonate pole to the sulphate pole.
Conclusion and Application of results: This result showed that the physicochemical parameters of Massakory groundwater exceed WHO standards. With electrical conductivity significantly higher than the WHO standard, this result confirms that Massakory water is of poor quality and therefore poses a health risk to the population.
Key words : Assessment, physico-chemical quality, groundwater, Massakory and Chad.

INTRODUCTION

Water is a precious but fragile and limited natural resource, essential to life and all human activity (Yapo *et al.,* 2010). Access to water has become one of the major challenges of our time (Bantin & Wang, 2020). According to (ACF, 2018), more than one billion people do not have access to safe drinking water. In response, these unfavorable living conditions lead to the deaths of more than 10,000 people per day. Water is central to human dignity and existence. Water also determines the socio-economic development of populations. Its lack leads to delayed development and, consequently, poverty. Water is not only a significant factor in public health, but it also determines a country's economic development: trade, daily life, livestock farming, industry, and agriculture all depend on access to water in sufficient quantity and quality (Ben-daoud *et al.,* 2013; Allarassem *et al.,* 2024). Chad is a vast country made up of crystalline formations, divided into five massifs (the Tibesti massif in the north, the Ouaddaï massif in the east, the Guéra massif in the center, the Mayo-Kebbi massif in the southwest, and the Mbaibokoum massif in the south). These formations are covered by sediments. These crystalline rocks contain significant groundwater and surface water resources (B.R.G.M, 2010; Moussa *et al.,* 2016). To the east of the study area, Precambrian formations outcrop, consisting mainly of granites, gneisses, migmatites, quartzites, amphibolites, schists, and mica schists. Widely distributed cover formations consist of sands, clays, and silts (B.R.G.M, 2010; Kusnir, 1995; Schneider, 2001). Other recent studies have been carried out on the geology of the study area. These latest studies reveal that the study area is mainly composed of alluvium (B.R.G.M, 2010). From a hydrogeological perspective, the study area is located north of the Lake Chad basin, mainly in the northern Chari Baguirmi region. Based on the work carried out by (Schneider, 2001; SchneiderJ.L & Wolff, 1992), it appears that the aquifer in the study area consists of: (i) the Cretaceous aquifer: this aquifer has been little studied. It lies unconformably on Precambrian formations; (ii) the terminal continental aquifer. This aquifer is confined to the center of the sedimentary basin and around Lake Chad, and is phreatic in the north of the basin, around Bodele (in the lowlands) and in the southern part of Chad; (iii) the Lower Pliocene, located between 250 and 300 m deep. To date, the boundary between the terminal continental aquifer and the Pliocene aquifer has not been clearly defined. The Pliocene aquifer is artesian around Lake Chad. (vi) The water table: the base of the Quaternary aquifer is located at a depth of between 180 and 50 m. This water table is deeper under Lake Chad. The depths relative to the ground of the static levels vary from 5 m at the edge of the Chari to 80 m at the center of the piezometric depression of the Chari Baguirmi aquifer, which is the most depressed. The shallowest levels are located next to watercourses. Numerous piezometric depressions have been identified in Chad (Chari Baguirmi), Niger (Kadzel), Nigeria, and Cameroon (Yaérés). For several decades, activities have been Massakory and its surroundings, like most cities in Chad, face countless problems with access to drinking water (Djoret, 2000). Groundwater, which is the main source of water for the population, is generally of poor quality (Kadjangaba, 2007). Little is known about its physical, chemical, and bacteriological characteristics. The objective of this study is to improve knowledge of the physical and chemical characteristics of groundwater in the city of Massakory and its surroundings.

MATERIALS AND METHODS

The study area is located between 12° and 13° north latitude and between 15° and 16° east longitude. Administratively, the study area is located in the province of Hadjer Lamis, department of Dagana.

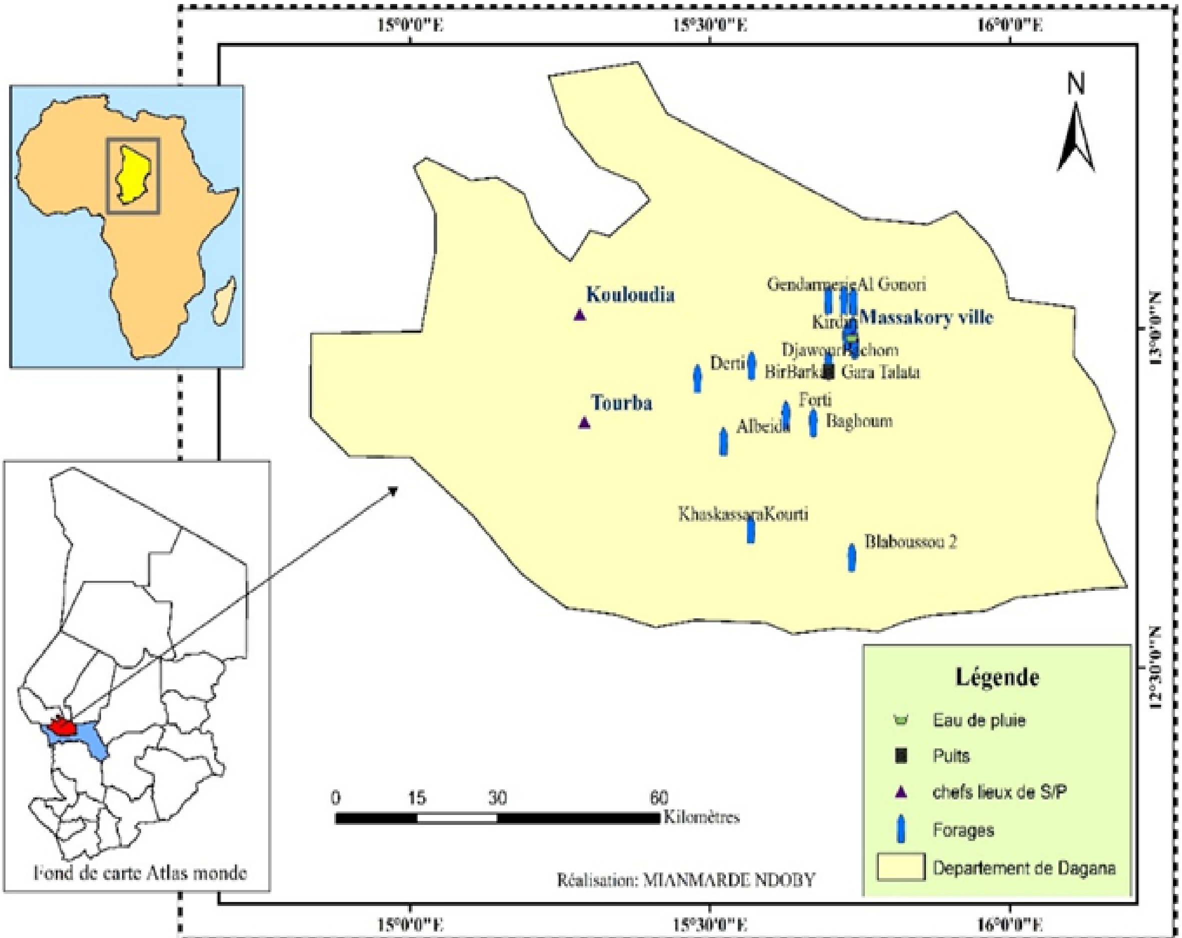

Figure 1: Water sampling map of the study area

As part of this work, we used several cartographic databases:

- Piezometric probe;
- Hach pH meter;
- OAKLON multi-parameter conductivity meter;
- 16 water samples taken during the high water period (October);
- A diverse bibliography constitutes the fundamental material for this work.

Software used: for this work, we used Qgis 3.28, R software, and Excel.

a- **Sampling:** The pH was measured using a Hach pH meter with a measurement uncertainty of ±0.2 units. These absolute errors in physical measurements are linked to several factors, including field conditions (heat, repeated handling of the device), water mineralization (the lower the mineralization, the higher the relative error. Temperature, electrical conductivity, and dissolved salt content are measured using an OAKLON multi-parameter conductivity meter.

b- **Measurement of piezometric levels :** Dynamic levels were measured manually using a piezometric probe at 15 water points located in the study area. The measurements were taken on human-powered pumps by detaching some of their screws, tilting the pump head slightly to submerge the probe electrode, and on a well. Gradually detaching the graduated roller, a sound is emitted upon contact with the water and the dynamic level is read on the graduated roller. To correct for depth, the length of the coping is subtracted from the measured level.

c- **Calculation of the piezometric level :** Measuring the piezometric level is one of the main operations involved in inventorying groundwater resources. It corresponds to measuring the altitudes of the equilibrium water levels in structures. It is calculated by subtracting the ground elevation (reference point on the structure) Z from the depth of the natural water surface H.

It is denoted as: Np = Z -H.

Where Z is the elevation, H is the depth of the water relative to the ground, and Np is the piezometric level.

d- **Chemical parameters:** For chemical analysis, the samples collected were taken to the national water analysis laboratory where the following chemical elements were analyzed: Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}, Fe and Mn, and anions (Cl-, NO_3, F-, SO_4^{2-}, and HCO_3^{-}).

RESULTS AND DISCUSSIONS

From a quality perspective, it is very difficult to find "pure" groundwater, as it always contains elements whose stability and concentration depend on the nature of the soil (soil texture), pH, and even environmental hygiene (Yapo *et al.,* 2010).

Piezometry and altitude: Most of the water in the study area flows from the periphery towards the center of the study area. Altitudes are proportional to water depths and vary from 279 m in the village of Bachom Dar salam to 309 m in the Kirdiri district of Massakory center (Fig. 2). The piezometric map, based on piezometric surveys carried out during high water periods, shows two areas:

- The recharge areas or piezometric dome in the northwest, which are the lines from which the flow lines originate, show maximum elevations of 288 m.
- The piezometric depression zones in the center, where the lines converge, show the minimum elevation (200 m) of the depression.

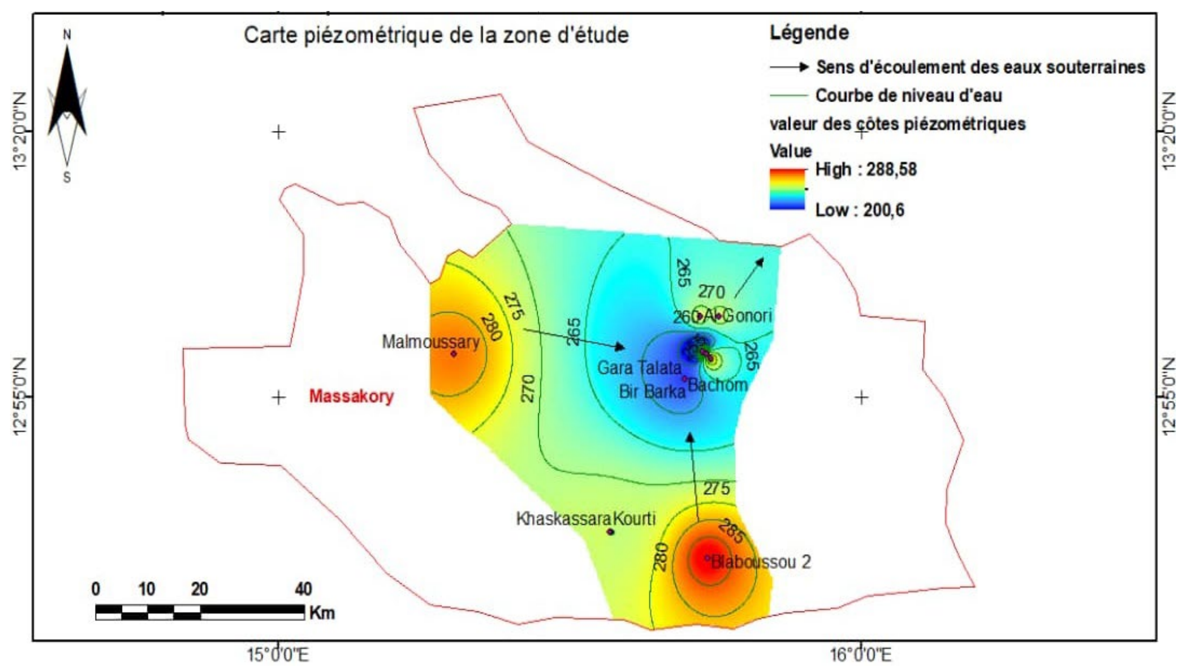

Figure 2: Piezometric map of high water levels.

Physical parameters: The physical parameters measured in the field are: electrical conductivity (EC), temperature (T°), pH, total dissolved solids (TDS), and piezometry. Conductivity (EC) is the property of water that promotes the passage of an electric current. It depends on the ions in solution. Electrical conductivity is one of the criteria used to validate the physical and chemical analyses of water. According to (Bantin & Wang, 2020), conductivity allows the overall mineralization of water to be estimated and monitored. The EC values in our borehole water range from 7.1 to 2590 µS/cm. It is high in well water (2650 µS/cm). The average electrical conductivity of the water in our study area is 28,042.4813 µS/cm. Other researchers have also found similar results (Mahamat *et al.,* 2021). Most EC levels in this study are above the WHO standard, (miunimum= 6,7 and maximum=2650), (WHO, 2004). The total dissolved solids (TDS) or dissolved salt content varies significantly depending on the sampling point (Table 1). The minimum TDS in the waters of the study area is 162 ml/s, the maximum is 4130 ml/s, with an average of 1592 ml/s. The standard deviation value for the waters in our study area is 1172.29. pH is a measure of the acidity of water, i.e., the concentration of hydrogen ions (H^+). The hydrogen potential depends on the nature of the water, the nature of the geological materials it passes through, and the contamination of the water by pollutants. The pH of our water is basic (between 8.1 and 8.9), with an average of 8.4 (Table 1). These pH values comply with international drinking water standards. Temperature plays a crucial role in the solubility of salts and gases. It varies depending on the outside temperature (air), seasons, geological nature, and depth of the water level relative to the ground surface (Loukman *et al.,* 2017). Temperature affects the growth and development of living organisms in water, especially microorganisms. The temperature of borehole water in our study area is generally too high in boreholes and wells (30.5-35.5°C), while it is low in rainwater (21.2°C). The average water temperature in our study area is 31.50°C (Table 2). The temperature of borehole and well water is above the WHO standard.

Table 1: Statistics on physical parameters

	Minimum	Maximum	Average	Standard
CE	6.7	48100	28042.4813	19354.3496
TDS	162	4130	1596.26875	1168.66733
T°C	21.2	34.5	31.50625	2.96231188
Ph	6.7	8.9	8.46875	0.51989582

Chemical parameters of water: The chemical parameters analyzed are listed in the table below.

Abundance of chemical elements: The chemical elements present in the waters of the study area can be presented as cations (Ca^{2+}, Mg^{2+}, and K^+) (Fig. 3a) and anions (HCO_3^-, Cl^-, SO_4^{2-}, and NO_3^-) (Fig.3b).The order of abundance of cations is as follows: Ca^{2+} (61%) > Na^+ (20%) > Mg^{2+} (16%) > K^+ (16%). The abundance of anions is as follows: HCO_3^-, (37%)> Cl^-(31%)> SO_4^{2-}18%)> NO_3^-(13%).

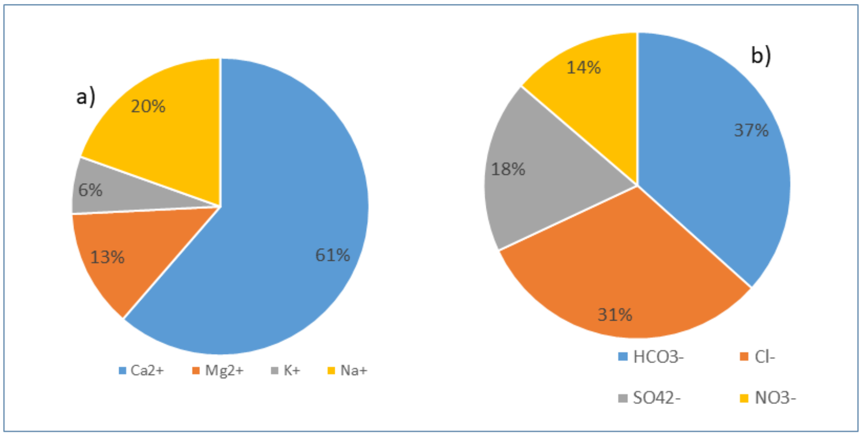

Figure 3: Distribution of chemical elements

Chemical facies of the waters: The major ions are: cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+})and anions (Cl^{-}, NO_3^{-}),SO_4^{2-}, HCO_3^{-},)Table 3. These different chemical elements are plotted in the Piper diagram (Fig. 4). The waters in the study area fall into two chemical facies:

- calcium and magnesium bicarbonate facies (F1, F3, F5, F7, F8, F9, F10, F11, F12, F13, F14, rain, and wells);
- calcium and magnesium chloride-sulphate facies (F2, F4, F10).

In terms of cations, the waters are calcium-rich, while in terms of anions, they tend to evolve from the bicarbonate pole towards the sulphate pole.

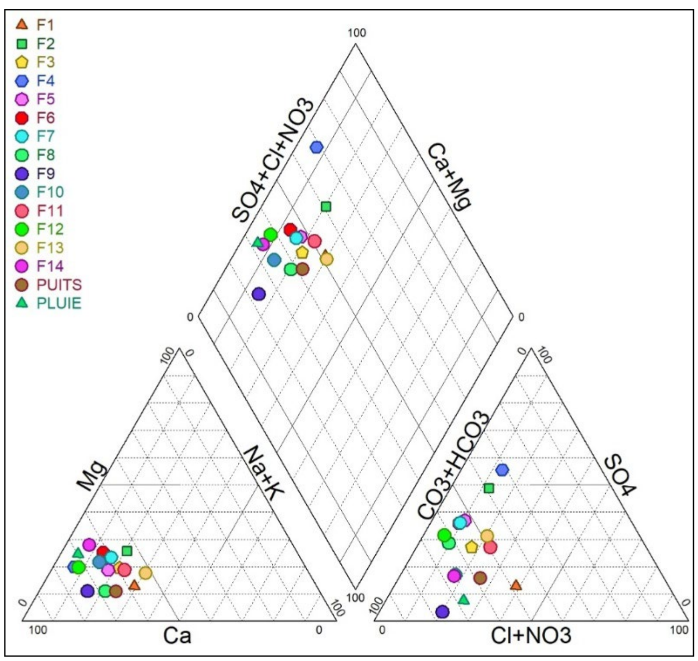

Figure 4: Piper diagram of the waters in the study area

Water suitability for drinking: At the scale of the Lake Chad watershed, this chemical result corroborates those of numerous authors who have worked on hydrochemistry and obtained results indicating that most of the groundwater is in the bicarbonate facies (Al-qawati *et al.,* 2015; Amadou *et al.,* 2014; Constantine *et al.,* 2023; Soro & Soro, 2009; Vassolo *et al.,* 2015; Mahamat *et al.,* 2016.

Distribution of elements: Principal Component Analysis (PCA): Principal Component Analysis (PCA) is a statistical technique that establishes relationships between the various physical and chemical parameters studied and between individuals (water points studied). This makes it possible to identify groups of parameters that may have a similar type of variation (Amadou *et al.,* 2014). For the ACP, 13 parameters were taken into account (Fig. 5). The two axes represent 48.7% and 15.7% respectively. Axis 1 is determined by conductivity, $CaCO_3$, Ca, Mg, K, Na, HCO_3, Cl, NO_3, TDS, and SO_4. It represents the overall mineralization of the water in our study area. Axis 2 is represented by pH and Mn (Fig. 5).

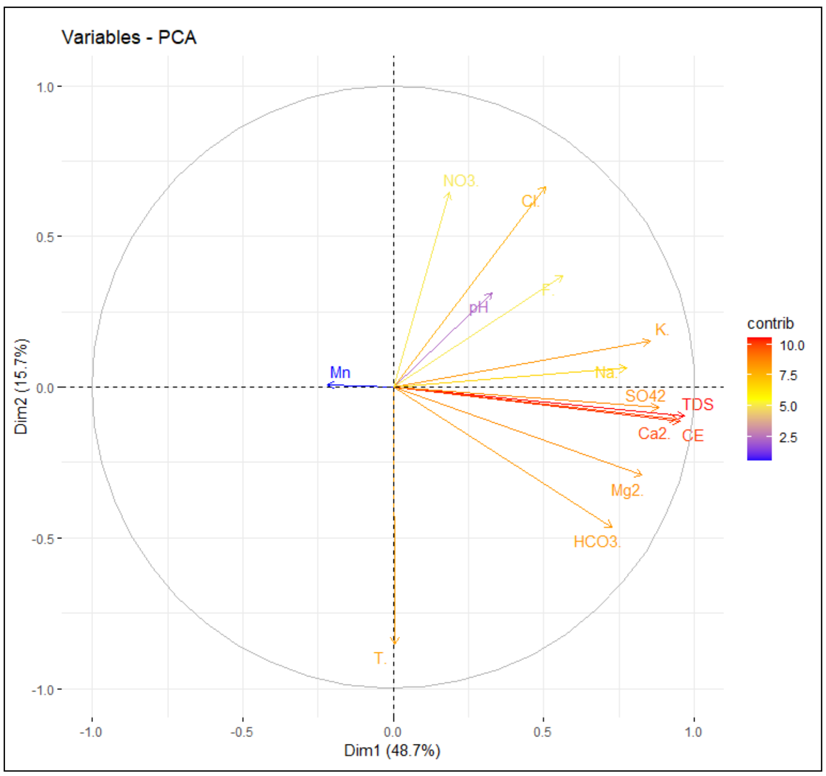

Figure 5: Principal component analysis of waters in the study area.

Origin of mineralization: The Gibbs diagram (1970) allows us to distinguish between waters whose mineralization is controlled by evaporation and those whose mineralization is due to the influence of water-rock interaction (WRI) processes. Plotted on this diagram, the analysed waters occupy almost the entire evaporation domain, with the exception of rainwater (Fig. 6).

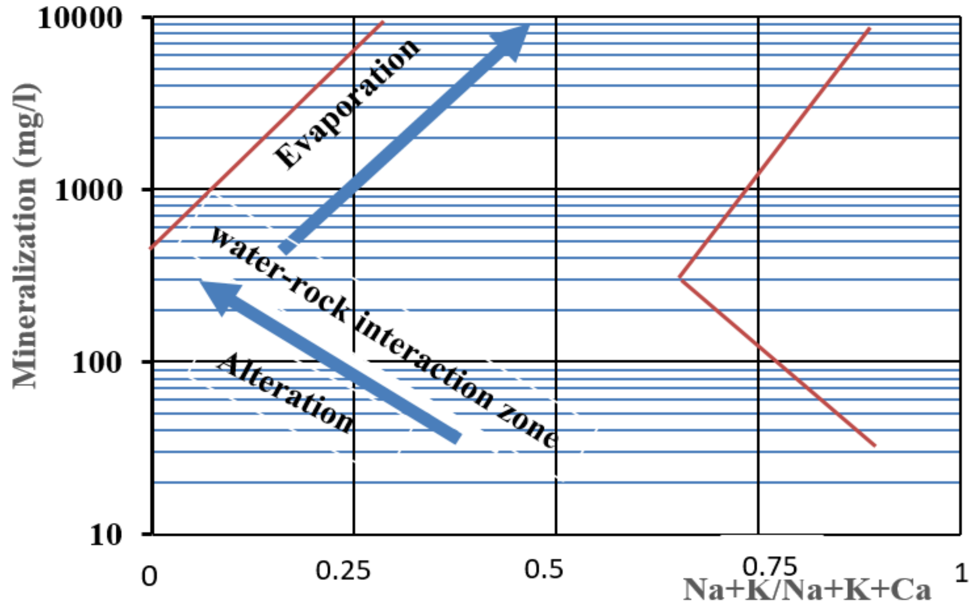

Figure 6: Giggs diagram, 1970

The correlation established from 16 water samples (Table 4) shows a more or less close relationship between the chemical elements. In the waters studied, Mg^{2+}, K^{+}, and Na^{+} are moderately correlated with each other. This weak correlation between chemical elements can be explained by the nature of the geology of the study area, which is dominated by clays and sands (low interaction between sand, silt, and clay), contamination of certain chemical elements, and the aquifer's vulnerability to evaporation.

Table 2: Correlation matrix

Correlation	pH	EC	TDS	$CaCO^{-}_{3}$	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	NH_4	HCO3 -	Cl^{-}	NO_3^{-}	F
pH	1												
EC	1	1											
TDS	-0.11	-0.11	1										
$CaCO_3$	-0.08	-0.08	0.08	1									
Ca^{2+}	-0.07	-0.07	0.98	0.27	1								
Mg^{2+}	-0.13	-0.13	0,1	0.09	0.05	1							
K^{+}	-0.16	-0.16	0.00	0.08	-0.04	0.95	1						
Na^{+}	-0.08	-0.08	0.20	0,08	0.16	0.91	0.74	1					
NH4	-0.16	-0.16	0.21	0.10	0.18	0.91	0.87	0.83	1				
HCO^{-}_{3}	-0.28	-0.28	0,03	0.06	-0.00	0.94	0.90	0.86	0.91	1			
Cl^{-}	-0.33	-0.33	-0.09	-0.24	-0.12	0.01	0.07	-0.07	0.00	0.13	1		
NO_{-3}	-0.15	-0.15	0.09	0.08	0.04	0.99	0.94	0.91	0.93	0.94	-0.01	1	
F	-0.06	-0.06	0.27	0.11	0.23	0.84	0.81	0.07	0.84	0.78	-0.04	0.84	1

In the binary diagram (Fig. 7), mineral dissolution is proportional. In the Mg^{2+} vs Ca^{2+} diagram, Mg $^{2+}$ is the most enriched element compared to Ca^{2+} (Fig. 7a), while in the Cl^{-} vs Ca^{2+} diagram (Fig. 7b), Ca^{2+} is the most dissolved. This dissolution is thought to be linked to the crystallization of calcite; in the Cl^{-} vs Na^{+} diagram, Na^{+} is the most enriched element (Fig. 7c); however, in the HCO_3^{-} vs Ca^{2+} diagram, Ca^{2+} is the most dissolved. This dissolution would imply the crystallization of calcium minerals (Fig. 7d).

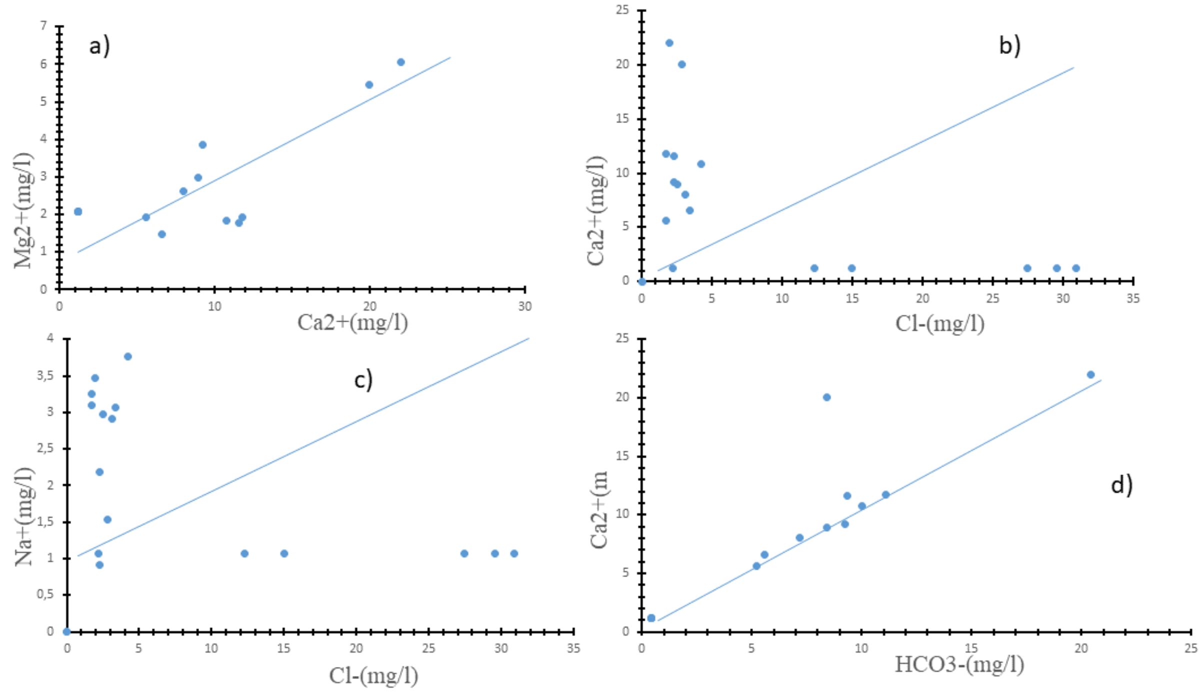

Figure 7: Binary diagram of chemical elements specifying the origin of mineralization

CONCLUSION AND APPLICATION OF RESULTS

The objective of this study was to perform a hydrochemical characterization of the groundwater in Massakory and its surroundings. Field and laboratory work yielded a number of results. The average electrical conductivity of the water in our study area is 28042.4813 µS/cm. This value exceeds the accepted standards for drinking water. From a chemical point of view, the waters studied belong to the calcium and magnesium bicarbonate facies (F1, F3, F5, F7, F8, F9, F10, F11, F12, F13, F14, rain, and water well) and to the calcium and magnesium chloride sulfate facies (F2, F4 and F10). The chemical elements are weakly correlated with each other. This poor interaction between these elements is due to the nature of the soil in the environment and the vulnerability of the aquifer to evaporation. Given the very high electrical conductivity values and the dominance of calcium and magnesium bicarbonate facies in the study area, it would be preferable to consider searching for the source of mineralization using detailed mapping based on geochemistry and geophysics in order to remedy this problem.

ACKNOWLEDGEMENTS

This work was funded by the CHAD LAKE REGION REVITALIZATION AND DEVELOPMENT PROJECT (PROLAC).

REFERENCE

ACF. (2018). *Eau assainissement*. Rapport.Paris. 36p

Al-qawati, M., Idrissi, Y. A., Alemad, A., Belhaili, I., Marc, I., & Baichouti, F. (2015). *Analyse et Contrôle de la qualité physico-chimique des eaux souterraines De la région SIDI ALLAL TAZI-Gharb-MAROC [Physico-chemical analysis and quality control of groundwater from the region SIDI Allal Tazi-Gharb-MOROCCO]. 13*(2), 420-429.

Allarassem, Lutian, Andossa, L., & Hamit, M. N. A. A. (2024). Hydrochemical characterization of the superficial aquifer of doba, southern Chad. *International Journal of Engineering Sciences & Research Technology*, *3*(3), 13.

Amadou, H., Laouali, M. S., & Manzola, A. S. (2014). *Caractérisation hydro chimique des eaux souterraines de la region de Tahoua (Niger)*. 7161-7172.

B.R.G.M. (2010). *Carte des formations géologiques. Echelle 1/1500 000. Planche 1*.

Bantin, A. B., Wang, H., & Jun, X. (2020). Analysis and control of the physicochemical quality of groundwater in the chari baguirmi region in chad. *Water (Switzerland)*, *12*(10). https://doi.org/10.3390/w12102826.

Ben-daoud, M., Mouhaddach, O., Essahlaoui, A., Kestemont, M., & Jaafari, S. El. (2013). *Evaluation de la vulnérabilité des eaux souterraines à la pollution à l ' aide des systèmes d ' information géographique*. *3*(2), 7-13.

Constantine, M., Domaine, M., Fili, V., Sp, E., Le, M. B., Lila, S., Constantine, U. F. M., Laid, T., Constantine, U. F. M., Karima, K., & Constantine, M.-U. F. M. (2023). *Caractérisation et évaluation des eaux de quelques hydrosystèmes dans le Nord-Est algérien* . 2022-2023.

Djoret, D. (2000). *Etude de la récharge de la nappe du Chari baguirmi par les méthodes chimiques et isotopiques*.Ths. doct. univ d'Avignon et des Pays de Vaucluse.186p

Kadjangaba, E. (2007). *Etude hydrochimique et isotopique du systeme zone non saturee – nappe dans la zone urbaine de n'djamena : impact de la pollution*. Université d'Avignon et des Pays de Vaucluse.These.fr

Kusnir, I. (1995). *Géologie, ressources minérales et ressources en eau du Tchad ; Travaux*. centre national de recherche.

Loukman, B., Nakolendousse, S., Nour, A. M., & Memti, M. N. (2017). *Caractérisation hydrochimique de la nappe de Yao et ses environs : relations entre eaux de surface (lac-Fitri) et eaux souterraines Hydrochimical characterization of the tablecloth of Yao and its surroundings : relation between surface water and subsoil*. *11*(June), 1336-1349.

Mahamat, N. A., AbderamanE, H., Mousa, A., & Moussa, B. (2021). Assessment of the physico-chemical and bacteriological quality of the waters of the quaternary aquifer of the city of Mao in Chad. *International Journal of Water Resources and Environmental Engineering*, *13*(3), 184-195. https://doi.org/10.5897/ijwree2021.1012

Mahamat, S. A. M., Maoudombaye, T., Abdelsalam, T., Ndoumtamia, G., & Loukhman, B. (2016). Évaluation de la qualité physico-chimique des eaux d'adduction publique de la Société Tchadienne des Eaux à N'djamena au Tchad. *Journal of Applied Biosciences*, *95*(1), 8973. https://doi.org/10.4314/jab.v95i1.7

Moussa, A, A, N., AE, L., Decarreau A, Fontaine C, B., & D, B. M. (2016). Lake Chad sedimentation and environments during the late Miocene and Pliocene: New evidence from mineralogy and chemistry of the Bol core sediments. *ournal of African Earth Sciences*, 192-204.

Yao K.A.F., Ahoussi K.E., Tivoli L.M.S., Salze D. & Lopez – Ferber M. (2023). Caractérisation Hydro-Chimique et Évaluation de la Qualité des Eaux Souterraines de l'Environnement Minier du Canton Afema (Sud-Est de la Côte d'Ivoire). *European Scientific Journal*, ESJ, 19 (6), 248. https://doi.org/10.19044/esj.2023.v19n6p248

OMS. (2004). *Liens entre l'eau, l'assainissement, l'hygiène et la santé faits et chiffres - mise à jour de novembre 2004*.

Paul, L. (1970). *Contribution de la géophysique à la connaissance géologique du bassin du lac Tchad*.

Schneider, J. L. (2001). *Géologie, Archéologie, Hydrogéologie de la République du Tchad.. Carte de valorisation des eaux souterraines de la République du Tchad, 1/1500000, Direction de l'hydraulique, N'djamena.* https://www.sciepub.com/reference/372321

SchneiderJ.L, & Wolff, J. . (1992). Carte géologique et cartes hydrogéologiques à 1/1 500 000 de la République du Tchad. Mémoire explicatif. In *Documents - B.R.G.M*. Bureau de recherches géologiques et minières.

Soro, N., & Soro, G. (2009). *Caractérisation de la qualité physico-chimique et bactériologique des eaux de puits de la ville d ' Abidjan (Côte d ' Ivoire) Bingerville Physicochemical and bacteriological characterization of Bingerville groundwater*. *January*.

Vassolo, S., Schuler, P., Guero, A., Rabé, S., Mounkaila, M., & Menge, S. (2015). *Caractérisation des eaux souterraines de la région de*.

Yapo, O., Mambo, V., Seka, A., Ohou, M., Konan, F., Gouzile, V., Tidou, A., Kouame, K., & Houenou, P. (2010). Evaluation de la qualité des eaux de puits à usage domestique dans les quartiers défavorisés de quatre communes d'Abidjan (Côte d'Ivoire) : Koumassi, Marcory, Port-Bouet et Treichville. *International Journal of Biological and Chemical Sciences*, *4*(2), 289-307. https://doi.org/10.4314/ijbcs.v4i2.58111.

ANNEXE

Table 1: Results of chemical analyses

Sample name	Ca^{2+} *mg/L*	Mg^{2+} *mg/L*	K^{+} *mg/L*	Na^{+} *mg/L*	HCO_3^- *mg/L*	Cl *mg/L*	SO_4^{2-} *mg/L*	NO_3^- *mg/L*	F^- *mg/L*	Fe *mg/L*	Mn *mg/L*
F1	132.0	17.7	10.4	70.5	341.6	120.0	71.0	68.0	0.03	0.01	0.01
F4	400.0	65.6	8.8	35.4	512.4	100.0	711.0	44.0	0.14	0.20	0.01
F8	232.0	21.4	7.4	50.4	571.0	80.0	208.3	12.0	0.02	0.01	0.01
F10	160.0	31.6	11.2	66.9	436.8	110.0	189.4	20.0	0.03	0.20	0.02
F11	235.2	23.3	12.4	75.0	678.3	60.0	247.8	0.0	0.02	0.20	0.02
F12	440.0	72.9	12.1	80.0	1244.4	70.0	498.0	15.0	0.01	0.01	0.00
F13	112.0	23.1	7.7	71.2	317.2	60.0	160.0	30,0	0.02	8.10	0,09
F14	184.0	46.2	6.2	21.2	563.6	80.0	110.0	11.0	0.01	4.10	0.08
water well	216.0	21.9	13.4	86.5	610.0	150.0	130.0	15.0	0.01	0.01	0.01
F3	178.4	35.7	8.9	68.5	514.8	90.0	198.7	9.5	0.02	0.02	0.23
F2	23.6	25.0	24.9	24.8	25.1	531.9	70.0	250.0	44.0	0.03	0.30
F5	23.6	25.0	24.9	24.8	25.1	1098.0	110.0	602.0	26.0	0.14	0.01
F6	23.6	25.0	24.9	24.8	25.1	976.0	90.0	503.0	10.0	0.02	0.50
F7	23.6	25.0	24.9	24.8	25.1	1049.2	90.0	546.0	26.0	0.03	0.30
F9	23.6	25.0	24.9	24.8	25.1	436.8	60.0	90.0	13.0	0.02	0.30
Rain	23.6	25.0	24.9	24.8	25.1	78.1	16.0	7.0	1.0	0.01	0.00

Tableau 2 : measurement of physical parameters

Sample name	CE	TDS	T	pH
	µS/cm	*mg/L*	*° C*	*[H3O+]*
F1	1171	579,4	31,1	8,7
F4	41700	1819,3	31,8	8,8
F8	24500	1264,0	32,9	8,4
F10	1599	737,4	32,8	8,7
F11	48100	1298,5	32,8	8,7
F12	39100	2097,8	34,5	8,4
F13	44100	558,3	34,5	8,9
F14	31700	803,4	31,5	8,7
water well	2650,0	1327,7	30,5	8,9
F3	1953,0	978,5	31,9	8,4
F2	41700	1531,0	32,3	8,4
F5	48100	4130,0	31,3	8,1
F6	39100	3220,0	31,6	8,6
F7	44100	3790,0	31,8	8,4
F9	39100	1243,0	31,6	8,7
Rain	6,70	162,0	21,2	6,7